ENVIRONMENT 2010

THE STATE OF THE ENVIRONMENT REPORT

VOLUME II

Environmental Resource Characterization Reports

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ENVIRONMENT 2010

Washington Environment 2010

State of Washington
October, 1989

Washington Environment 2010
State of the Environment Report
Volume II

Environmental Resource Characterization Reports

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THE STATE OF THE ENVIRONMENT REPORT

VOLUME II
Part 1

Air Resource Characterization Report

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EXECUTIVE SUMMARY

The air resource is essential to the existence of life on earth. Yet for years, we have treated it as if it were a garbage dump with unlimited capacity. Prior to the industrial revolution, marked by the zealous use of abundant fossil fuels, such a view of the air resource caused few air quality problems.

But as our population grew and our demand for energy grew, particularly in industrialized countries such as the United States, it became all too apparent that the air resource, like our water, and our land, and trees, and fish, and all our other natural resources, did indeed have limited capacity, and that our air was becoming unhealthy. By the middle part of this century, after "killer" fogs in London and Pennsylvania killed or hospitalized thousands, and when skies were so darkened by dense clouds of black smoke that street lights remained on during the day in some industrialized communities, it became abundantly clear that the air resource is vital to our health and well-being, but that, unlike other resources, we could not help but breathe the air resource no matter how polluted it was. We began to understand that as we continued to dump pollutants into the air, we were profoundly impacting the health and well-being of all living things.

Perceived by many as a state immune from such problems, a land of blue skies and clean air, Washingtonians expect to see Mt. Rainier and the Olympic Mountains on a clear day. In recent years, there has been a migration of people moving from more polluted parts of the country to the Northwest in search of clean air - a migration of people who will unavoidably bring with them more cars to clog our highways, more demand for lumber, paper, gasoline, and a host of other goods and services that on the one hand, help our economy to thrive, but on the other hand either directly or indirectly stress the state's environmental resources.

This report summarizes the condition of the air resource in Washington - its past and present condition, and an educated guess as to its possible future in the year 2010. We report with confidence on the past and present. Regarding our prediction of the future, however, we are not so confident. What we can say is that the predictions used in this report are consistent with the status quo scenario used in all the Environment 2010 Resource Characterization reports.

We set out in this report to answer four basic questions, which are summarized below:

1. <u>What is the current condition of the resource?</u>

Monitored values of most pollutants have declined over the past ten years. There are still a number of areas, however, that experience persistent air quality problems. This is especially true in densely populated areas.

2. <u>How has the condition changed over recent years?</u>

Though most monitoring sites have shown a decrease in air pollution concentrations over the longterm, the rate of decrease has generally dropped off in the last few year.

3. <u>What are the key threats to the resource?</u>

Major air pollution sources in Washington include motor vehicle emissions, woodburning (woodstoves, wood fired boilers, slash burning), vehicle refueling emissions, pulp mills, aluminum smelters and agricultural burning.

4. <u>How is the resource likely to change in the future?</u>

As the population increases, in the absence of additional air pollution control strategies, air quality will decline. In areas which already exceed health-based standards, the intensity and frequency of those exceedances will likely increase. Areas currently near but not exceeding standards will likely soon do so. Concentrations of pollutants in the ambient air are projected to increase by an average of nearly 25%.

Though the picture we paint of the future is gloomy, it should be noted that the Environment 2010 scenario of "existing levels of controls without increasing air pollution control resources" is a particularly pessimistic outlook given that air pollution prevention is, in many ways, in its infancy and is today rapidly maturing. We fully expect to see impressive technological improvements in the coming 20 years.

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Washington ENVIRONMENT 2010
A Report Characterizing the Air Resource in Washington State

I. General Description of Resource

With its natural beauty and abundant resources, the state of Washington is perceived by many as a pristine environment in which to live. Indeed, the northward pilgrimage of Californians is but one example of how many hold the quality of life in the northwest in such high esteem. The fact is, however, that from an environmental standpoint, we in Washington are faced with many of the same concerns as are the residents of even the most polluted cities in the country. This report characterizes the air quality in Washington State - the air that we have no choice but to breathe and that we must look through to see those much-acclaimed natural resources.

How pure is our air? How pure does it need to be, and are there things we can do to keep from fouling our air? The answers are not as obvious today as they were in the middle of this century when high levels of air pollution were blamed for thousands of deaths during a single episode in London, or when a similar event hospitalized hundreds and killed 20 in Pennsylvania. The hazards are more subtle, often taking years before the effects can be detected, but it is quite apparent that our air is not "pure", that it is contaminated, and that it can be a cause of illness in humans and can impact virtually every aspect of our ecosystem. In this report, we will discuss the past, present and possible future of Washington's air quality.

A. DEFINITIONS

1. The Air Resource

As the name implies, we define the air that we breathe, and that sustains the animals and plants with which we share the planet, as a resource - the air resource. This is a relatively new way to look at the air. For years, we treated the air as a dumping ground with unlimited capacity. In fact, it is a resource in the same way as Puget Sound is a resource. Its dimensions are finite, its capacity to "treat" contaminants is limited, and its dependance on mankind's benevolence is undeniable, just as mankind depends on an abundant supply of air for its very survival. The air resource includes the entire, interconnected universe of the air supply, from the basements and the attics of our homes to the very limits of the stratosphere. Workplace air, for the purpose of this report, is excluded from this definition.

2. Threats to the Air Resource

Any airborne contaminant could be considered a threat to the air resource. A number of threats were analyzed in the Environment 2010 comparative risk exercise, and are summarized below.

Ambient Air Pollutants. This threat includes both criteria air pollutants (those for which National Ambient Air Quality Standards have been set under the federal Clean Air Act) and toxic air pollutants. A complete list of the ambient air pollutants characterized in this report can be found in section I.C. List of Contaminants. This characterization will also include a discussion of certain air pollution "consequences" (i.e., visibility degradation, acid deposition, and global warming) which, for the purpose of the Environment 2010 project were treated as separate threats.

Indoor Air Pollutants. This category applies to exposure to accumulated indoor air pollutants, primarily from sources inside buildings and homes. Pollutants that are indoors as a result of diffusion from outdoors and indoor radon are not included in this category.

Radioactive Releases. This category includes such sources of radiation as radiation from nuclear power operations, radiation from hazardous "mixed waste", high-level and low-level radioactive waste (e.g., spent nuclear reactor fuels and radiopharmaceuticals), emissions from radioactive waste from abandoned hazardous waste sites, and radiation resulting from nuclear accidents.

Indoor Radon. Radon is a radioactive gas produced by the decay of radium, which occurs naturally in varying amounts in almost all soil and rock. A problem develops when radon enters a building through small gaps, cracks and sumps where the building contacts the soil. The gas can be trapped by building materials and become concentrated. When inhaled, the radon decay products accumulate in lung tissue and can cause cancer. This category covers indoor radon only, as outdoor concentrations are much lower.

Nonionizing Radiation. This threat includes consumer exposure to nonionizing radiation beyond natural background levels. Sources of radiation included in this category are: radio frequencies, television towers, power lines, radar, lasers, etc.

Airborne Pesticides. This threat includes short-range aerial drift, and is considered both a human health risk and a threat to plants and animals due, in part, to airborne drift of both the pesticide aerosol and windblown dust particles from fields treated with pesticides.

Sudden and Accidental Releases. This category focuses on catastrophic events with acute impacts, often requiring some sort of emergency response. Toxic chemicals are accidentally released into the environment in a variety of ways during transport, production, storage or use. For example, an industrial unit may catch fire or explode and emit toxic contaminants into the air.

Hazardous and Nonhazardous Waste Sites, and Material Storage. Each of these categories poses a threat to the air resource. Emissions of toxics and volatile organic compounds from waste disposal sites, and leakage from storage tanks are examples.

The following, though not really threats to the air resource, are impacts resulting from air contamination which threaten other resources.

Global Warming. Atmospheric concentrations of carbon dioxide (CO2) are projected to increase over the next century due to increased fossil fuel burning and a decrease in tropical rain forests. Concentrations of CO2 account for approximately 50% of the known greenhouse gases. This phenomenon may raise temperatures globally and cause the sea-level to rise.

Acid Deposition. This problem area applies to damages caused by wet or dry deposition of acidic compounds from the atmosphere. Some gases emitted into the atmosphere interact with either sunlight, water vapor, or oxygen to form acidic compounds. Wet deposition occurs when the acidic compounds fall as acid rain or snow. These acidic compounds may also combine with dust or other dry particles and fall as dry deposition.

Stratospheric Ozone Depletion. The stratospheric ozone layer shields the earth's surface from harmful ultraviolet radiation. Releases of chlorofluorocarbons and nitrogen dioxide from industrial processes and solid waste sites could significantly reduce the ozone layer.

B. GENERAL DESCRIPTION OF AIR RESOURCE

1. Meteorology and Air Circulation

From a meteorological standpoint, the State of Washington is actually two states in one, separated by the Cascade Mountain Range. The two areas have distinctly different land use patterns, a different degree of urbanization, and somewhat different climate. Though from a meteorological perspective, Washington is characterized as having a marine-type climate (that is the air mass found over the state is generally of a marine origin), "continentality", a measure of the modification of a marine air mass, significantly changes the climate on the east side of the Cascades from a relatively wet and humid climate to a dry one.

Temperature ranges also vary considerably between the east and west side. Summertime temperatures are generally higher on the east side, while winter temperatures are considerably colder. Precipitation is higher on the west side (the Seattle area averages nearly 40 inches while Spokane averages 20 to 25 inches[1]). In addition, the number of days with greater than 0.01 inches of rain is considerably higher on the west side, which helps to explain Seattle's reputation as a rainy city - though the total rainfall is comparable to many other large metropolitan areas, there are an average of about 150 days with greater than 0.01 inches of rainfall[2].

Wind speeds and direction are very important factors when considering air pollution. Figures 1 and 2 show typical wind directions in July and December, respectively[3]. Figure 3 shows the surface wind roses for several meteorological monitoring sites throughout the state[4]. Figures 1, 2 and 3 will give a general sense of the direction one can expect air contaminants to travel.

Figure 1

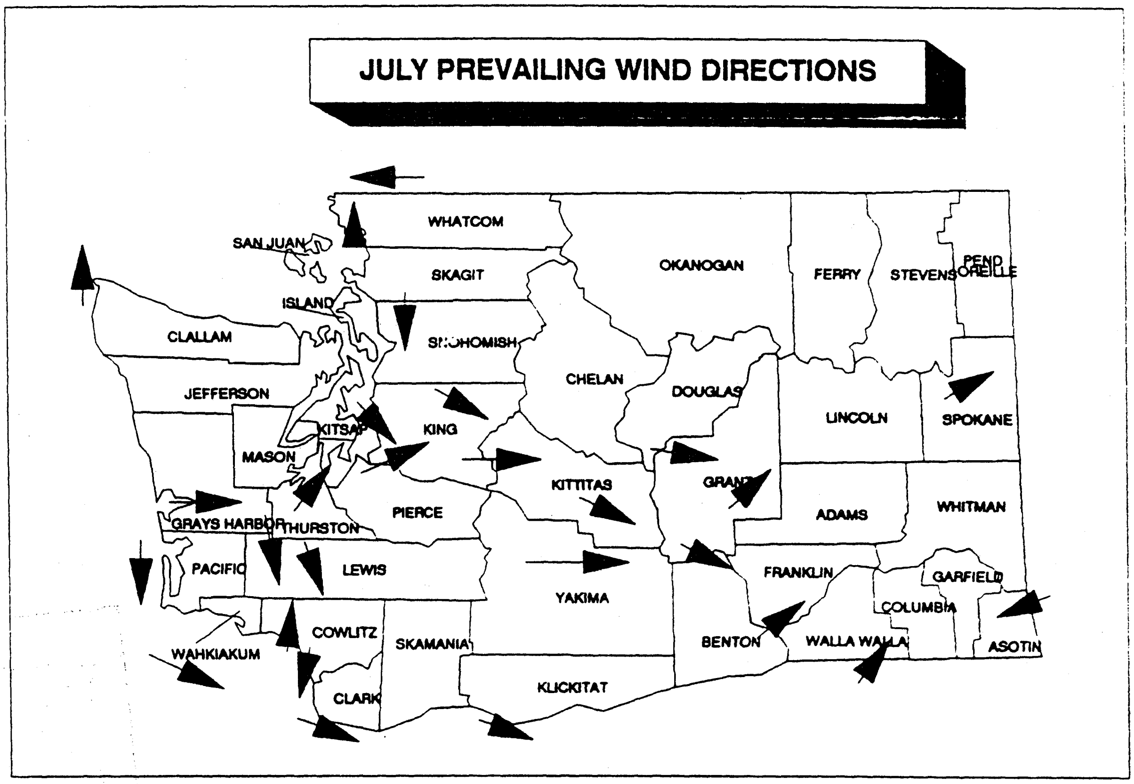
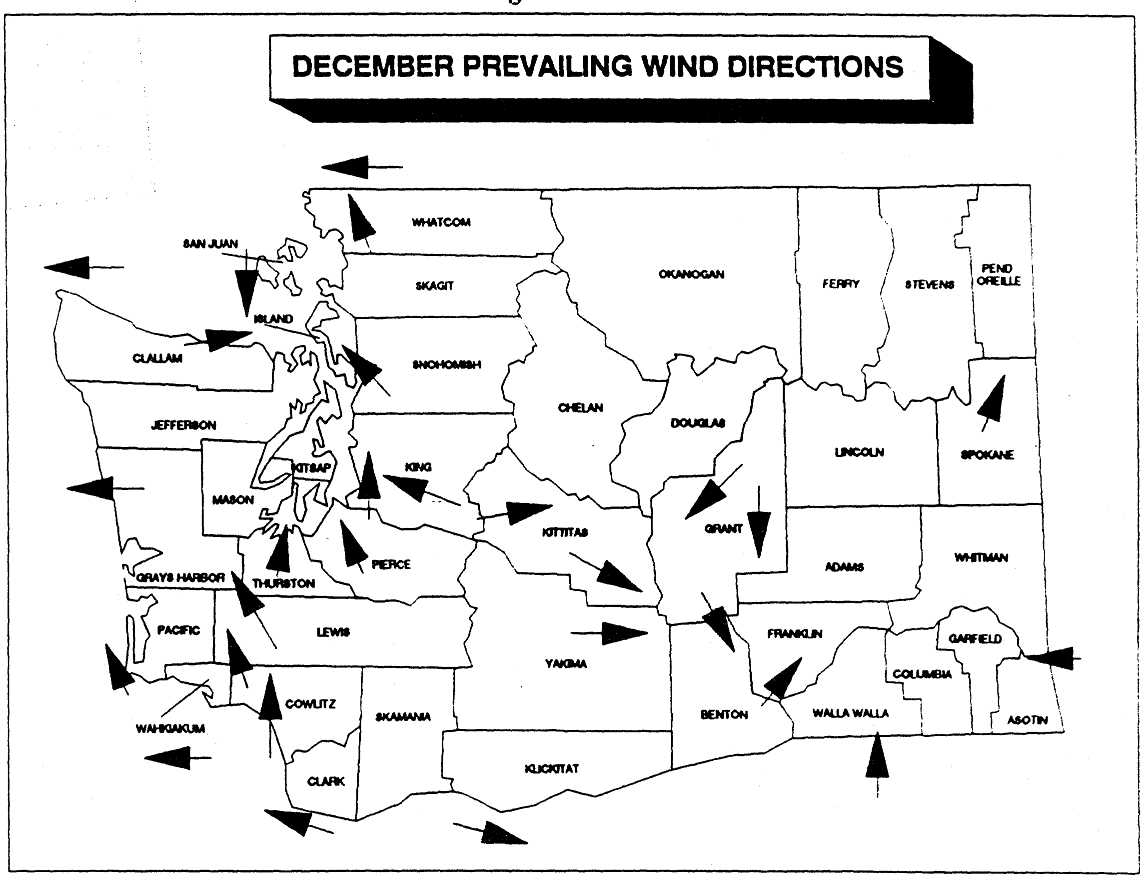
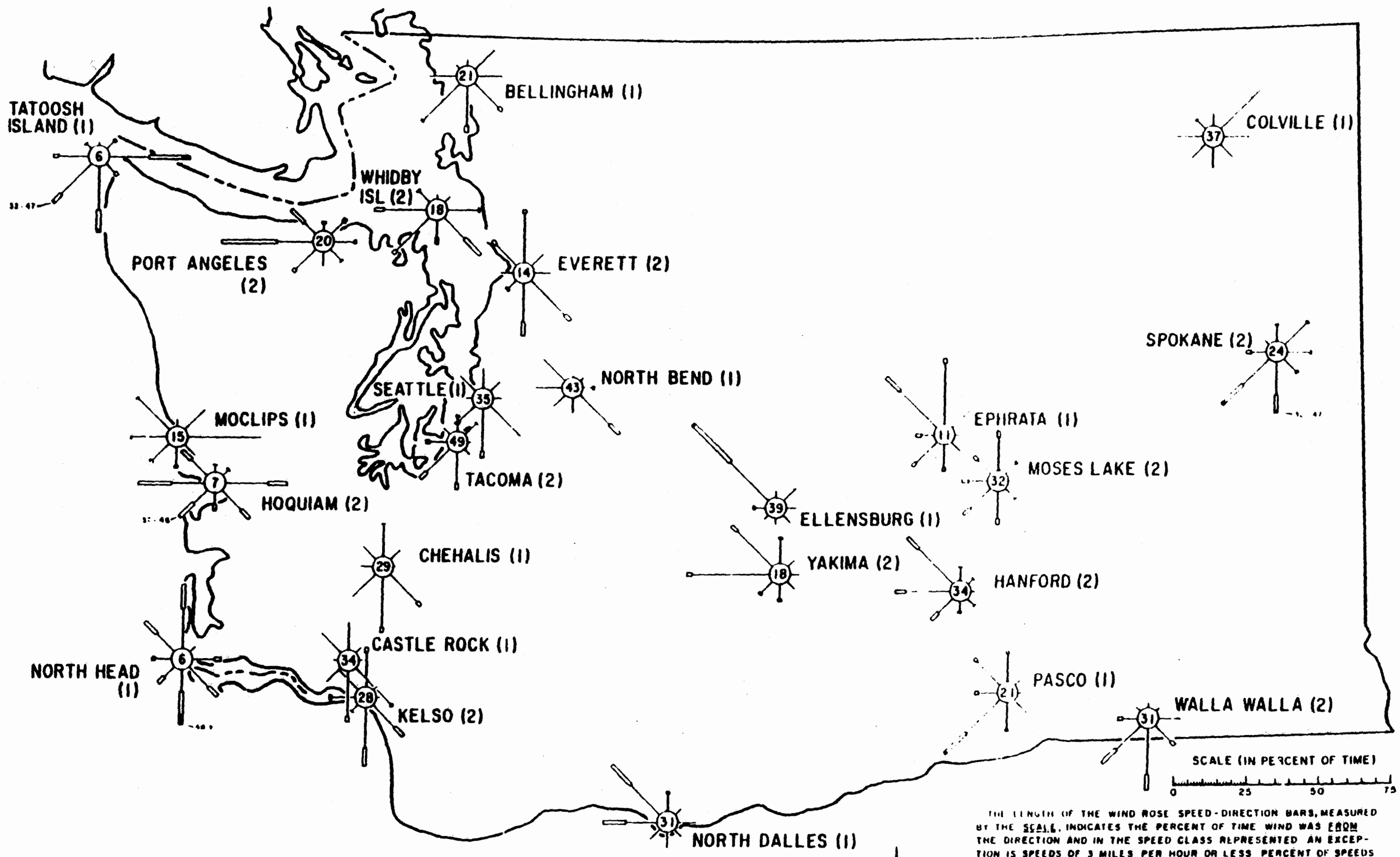


Figure 2



ANNUAL SURFACE WIND ROSES FOR WASHINGTON STATIONS



THE LENGTH OF THE WIND ROSE SPEED-DIRECTION BARS, MEASURED BY THE SCALE, INDICATES THE PERCENT OF TIME WIND WAS FROM THE DIRECTION AND IN THE SPEED CLASS REPRESENTED. AN EXCEPTION IS SPEEDS OF 3 MILES PER HOUR OR LESS. PERCENT OF SPEEDS IN THIS RANGE IS SHOWN IN THE CENTER CIRCLE OF THE WIND ROSE. VARIOUS SOURCES OF DATA MADE IT NECESSARY TO ASSIGN SLIGHTLY DIFFERENT SPEED CLASSES TO THE WIND ROSES. THE FIGURE FOLLOWING THE STATION NAME IS AN INDEX TO THE SPEED CLASS FOR THAT STATION AND IS DEFINED IN THE LEGEND.

LEGEND

SPEED SYMBOL	INDEX	CLASS	INDEX	CLASS
	(1)	4-15	(2)	4-12
	(1)	16-31	(2)	13-31
	(1)	32-47	(2)	32-46
	(1)	48+	(2)	47+
(5)	FOR THIS CLASS ALL STATIONS HAVE THE SAME RANGE OF 0-3 M P H			

INDEX NUMBERS AND SPEED CLASSES

Branch of Power Operations · Bonneville Power Administration, U S Department of the Interior

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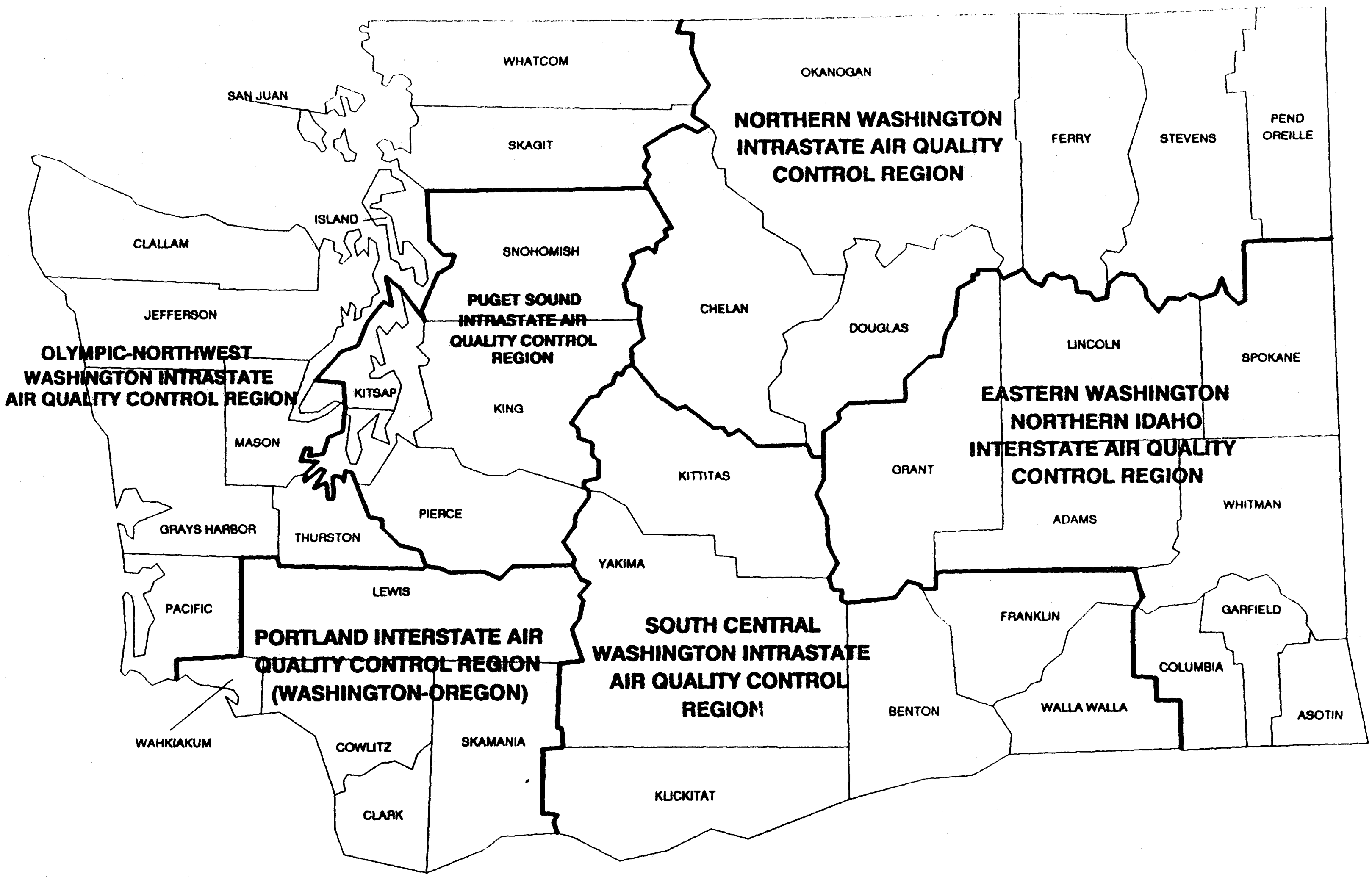
Finally, atmospheric stability is the tendency to resist or enhance vertical mixing, which plays a very important part in th dispersion of pollutants. Very stable conditions, or inversions, are conducive to the buildup of pollutants in the atmosphere. High pressure systems producing low level stability and light winds may be found during any season, but are most apt to persist for longer than three days in the spring and fall. Very stable conditions may be found occasionally in the winter, but two to four days is the usual duration. Valley locations on both sides of the Cascades are particularly susceptible to this phenomenon.

2. Air Quality Control Regions

Air pollution does not stop at a particular elevation, nor are there geological features or county boundaries that completely stop the horizontal dispersion of pollutants. Because such features do influence the distribution of ambient air pollutants, however, for the purpose of this report we have broken the state into six air quality control regions (AQCR). Figure 4 is a state map showing the location of each of the regions.



WASHINGTON STATE AIR QUALITY CONTROL REGIONS

(FIGURE 4)

The following is a general description of each, along with a brief description of the air pollution control jurisdiction(s) and principle pollutant sources within each region. Appendix F includes information about population and population densities, while Appendix A lists the major source catagories within each region.

Eastern Washington Interstate AQCR

The Washington portion of the Eastern Washington-Northern Idaho Interstate Air Quality Control Region consists of eight counties - Adams, Asotin, Columbia, Garfield, Grant, Lincoln, Spokane and Whitman. The largest city within the region is Spokane with a 1986 population of 172,700. The Eastern Washington sector of the region is served by two local air pollution control agencies: the Spokane County Air Pollution Control Authority (SCAPCA), serving only Spokane County and the Grant County Clean Air Authority (GCCAA), serving only Grant County. The remainder of the counties are under the jurisdiction of the Department of Ecology.

The Spokane County Air Pollution Control Authority was established in 1967. Major industrial sources of air pollutants in the county include an aluminum plant, lumber mills, a gypsum plant, steam generator, grain mills and a foundry. The Spokane metropolitan area encounters severe air pollution problems during the winter months due mainly to air stagnations, motor vehicles use and woodburning.

The Grant County Clean Air Authority was established in 1972. A diatomaceous earth plant and a titanium plant (closed during 1987) are significant air contaminant sources within the county. Other sources of air pollutants within the region include the wood products industry, field burning, woodstoves and field burning for grass seed production.

Northern Washington Intrastate AQCR

Six counties make up the Northern Washington Intrastate Air Quality Control Region: Chelan, Douglas, Okanogan, Ferry, Stevens and Pend Oreille. The largest city within the region is Wenatchee with a 1986 population of 17,980.

Significant sources of air pollution in the region are orchard heaters, wood fired boilers and several industrial plants, including a ferro-silicon plant and aluminum smelter.

Only one county in the region is served by an air pollution authority, the Douglas County Air Pollution Control Commission (DCAPCC). The other 5 counties are within the Department of Ecology's jurisdiction.

Olympic-Northwest Washington Intrastate AQCR

The Olympic-Northwest Washington Intrastate Air Quality Control Region consists of ten counties which are served by two local air pollution control agencies: the Olympic Air Pollution Control Authority (OAPCA) which has jurisdiction in Clallam, Grays Harbor, Jefferson, Mason, Pacific and Thurston counties and the Northwest Air Pollution Authority (NWAPA) which serves Whatcom, Skagit and Island counties. San Juan county is under the jurisdiction of the Department of Ecology.

The Olympic Air Pollution Control Authority was formed in 1968. Major industrial sources of air pollutants within the area include pulp mills, lumber mills, veneer dryers, and sand and gravel companies.

The Northwest Air Pollution Authority was formed in 1967. Oil refineries, pulp and paper mills, sawmills, municipal waste incinerators, a cement plant and a sulfuric acid plant are among the major industrial sources of air pollutants within the region.

The largest city in the Olympic-Northwest Region is Bellingham with a 1986 population of 46,380.

Puget Sound Intrastate AQCR

The Puget Sound Air Quality Control Region is comprised of four counties: King, Kitsap, Pierce and Snohomish. The largest city in the region is Seattle with a 1986 population of 488,200. The Puget Sound Air Pollution Control Authority (PSAPCA) was formed in 1967 and has jurisdiction in all four counties of the region.

Major point sources of air pollutants in the Puget Sound Region include steel plants, cement plants, sawmills, pulp and paper mills, an aluminum smelter, and veneer dryers. With a majority of the state's population residing within these four counties, motor vehicles and woodstoves are significant area sources of pollutants.

A vehicle inspection and maintenance (I/M) program has been operating in the region since 1982 under Department of Ecology oversight.

South Central Washington Intrastate AQCR

The counties of Yakima, Kittitas, Klickitat, Benton, Franklin and Walla Walla combine to form the South Central Washington Intrastate Air Quality Control Region. Two local air quality control agencies serve four of the six counties within the region: The Yakima County Clean Air Authority (YCCAA) covering only Yakima County; and the Tri-County Air Pollution Control Authority (TCAPCA) serving Benton, Franklin and Walla Walla counties. The counties of Kittitas and Klickitat are within the Department of Ecology's jurisdiction and are not served by any local air quality control agencies.

The Yakima County Clean Air Authority was formed in 1967. It serves the largest city in the region, Yakima, with a 1986 population of 49,500. The major sources of air pollutants in Yakima County include lumber mills, veneer dryers, sand and gravel companies and a steam power plant.

The Benton-Franklin-Walla Walla Counties Air Pollution Control Authority (also referred to as the Tri-County APCA) was formed in 1971. The major sources of air pollution in the area include power boilers, lumber yards, asphalt plants, chemical plants, grain terminals and oil storage tanks.

Southwest Washington Interstate AQCR

The Southwest Washington sector of the Portland-Southwest Washington Interstate Air Quality Control Region includes the counties of Clark, Cowlitz, Lewis, Skamania and Wahkiakum. The region is served by the Southwest Air Pollution Control Authority.

The Southwest Air Pollution Control Authority was established in 1968. The largest city within the Washington portion of the region is Vancouver with a 1986 population of 42,740.

The region's major industrial sources of air pollutants include: aluminum mills, pulp and paper mills, silicon carbide manufacturing, a coal fired power generator, sawmills and plywood mills.

C. LIST OF CONTAMINANTS

Air in its purest form is a colorless, odorless, tasteless gaseous mixture made up of mainly nitrogen and oxygen, with lesser amounts of several other gases including argon, neon, helium, carbon dioxide and water vapor. Other gases and solid or liquid particles are contaminants. Some are harmless, others deadly in even minute amounts. In this report, we will focus on those contaminants which have, or are likely to have an adverse impact on human health, the environment, or the well-being of Washington's citizens.

The ambient air pollutants we chose to study were:

- Acetaldehyde
- Arsenic
- Asbestos
- Benzene
- Beryllium
- Cadmium
- Carbon Monoxide
- Carbon Tetrachloride
- Chloroform
- Chromium (VI)
- Dichloromethane
- Dioxin 2,3,7,8 TCDD
- Ethylene Dichloride
- Ethylene Dibromide
- Fluoride
- Formaldehyde
- Lead
- Manganese
- Mercury
- Nickel
- Nitrogen Dioxide
- Ozone
- Particulate Matter
- Perchloroethylene
- Pesticides
- Phenols
- POM's (BaP)
- Sulfur Dioxide
- Toluene
- Trichloroethylene
- Xylene

The indoor air pollutants we studied included environmental tobacco smoke, benzo(a)pyrene, volatile organic compounds, formaldehyde, asbestos, nitrogen dioxide and biological organisms. Radon, studied separately in the comparative risk component of the Environment 2010 project, is another indoor air contaminant.

Several pesticides were considered for inclusion in this report as possible air contaminants. Very little information could be found to characterize either emissions or airborne concentrations in the state. Those pesticides analyzed by the Environment 2010 sub-committee responsible for characterizing the risks from exposure to airborne pesticides include:

- Aldicarb
- Atrazine
- Paraquat
- 2-4,D
- Malathion
- Carbonyl
- Tributyltin
- Clyphosate
- Diazinon
- Ethyl Parathion
- Dursban
- Strychnine
- Methyl Parathion
- Alachlor
- Pichloram
- Velpar/Garlon

Non-ionizing radiation, such as microwave emissions, radio frequencies and high tension lines were studied as contaminants in the Comparative Risk Project.

Finally, radioactive releases of ionizing radiation (both high-level and low-level radioactive wastes) are contaminants which are human health, ecological and economic risks.

D. THREATS TO AIR QUALITY

For years, air pollution control was based on the principal that dilution was the solution to pollution. Tall smokestacks emitting clouds of smoke into the air were common sights just a few years ago. The basic idea was to send it away, not to clean it up. Owing largely to this short-sighted approach to air pollution control, we will hand down to future generations a legacy of stunted trees and sterile lakes in the eastern part of our nation.

For years, we thought that the key to cleaning up the air was strict control over emissions from factories, refineries, steel mills and the like. While our regulatory efforts focused on these larger sources, we built our homes further and further out in the suburbs, where effectively the only transportation system that made any sense was the personal car. On the west side of the state, with its abundant supply of trees, home builders were more than willing to give potential buyers the cozy fireplace or woodstove they were demanding in which they could burn some of that abundant wood supply. We find now that our personal cars and woodstoves are two of the largest contributors to Washington's air pollution problem.

We thought that nuclear fission would replace fossil fuel combustion as the primary energy source for electric utilities. We have since learned about the potential hazards associated with this form of energy production - hazards that many feel pose unacceptable risks.

We knew that smoking was a health risk, but we thought we were safe if we didn't smoke. Recent studies have shown that breathing someone else's cigarette smoke (i.e., passive smoking) may by itself be responsible for more than 100 excess cancers annually in the state (see Environment 2010 Comparative Risk Report, Indoor Air). When combined with the inhalation of excess levels of asbestos, the cancer risk can increase nearly 100-fold[6].

And finally, in perhaps the ultimate irony of air pollution control, we thought that if we could develop the perfect combustion process, there would be no carbon monoxide or unburned hydrocarbon emissions, and that we would be safe to burn all the fossil fuels we wanted to. Unfortunately, the more efficient we are at reducing hydrocarbon and carbon monoxide emissions, the more we add to what is already an alarming level of carbon dioxide, which many believe will ultimately cause a profound change in the earths climate - that is, global warming.

In summary, as the population grows, and our demand for more energy grows, we cannot help but to further stress a limited air resource that many feel is already overburdened. We are faced with the challenge of balancing the need for our economy and society to prosper against the possibility that we may overburden the air resource. In order to find this balance, the citizens of the state must give the policy-makers some sense of how they value economic prosperity relative to the value of being healthy, or how they value a high standard of living from an economic standpoint relative to being able to view Mt. Rainier on a clear day.

The following summary of Environment 2010 Comparative Risk Reports on threats to the air resource is meant to give the reader an idea of the extent to which the applicable risk is impacting human health and the environment, and the economic damages resulting from the threat. The reader is referred to Section I.A. for a definition of each of these threats.

Threat: AMBIENT AIR POLLUTION

Human Health Risk

Cancer MEI probability (risk of contracting)	10^{-3} to 10^{-2}	Chromium, Whatcom Co B(a)P, Pierce Co Trichloroethylene, King Co Dioxin, Stevens Co
Excess cancers (number of cancers)	.2 - 150	
Non-cancer effects (# people at risk)	4+ million	severity 1-3 (O3)
	3+ million	severity 4-5 (O3)
	175,000	severity 6-7 (CO, PM10)

Significant Ecological Risks

Animals	Fluoride at current levels may nave minor impacts on some animal species; air pollution may be significant polluter of Puget Sound microlayer
Plants	Ozone in concentrations which have been monitored in the Cascades is likely damaging some tree species
Other	Visibility degradation

Economic Damages

<reserved>

In addition to those direct threats to ambient air quality listed in the foregoing table, numerous other sources of air quality degradation exist. Several of these were analyzed as part of the Washington Environment 2010 risk analysis process. In the paragraphs that follow, all the risks to ambient air quality analyzed in the 2010 project are reviewed and summarized.

Organizationally, the summaries will present the ecological, human health and economic damages risks to the resource associated with each threat. The intent of this section is to impart to the reader a comprehensive understanding of the interaction of the air resource and risks to it.

D.1. Ambient Air Pollution

Ecological damages are associated with elevated ozone levels throughout the state. Ozone levels are high enough to damage sensitive tree species, which account for at least 10% of the total tree species in Washington.

There are likely to be corresponding health impacts on animal species where human health impacts from ambient air pollution are known to occur.

There are likely to be impacts on plants other than trees where ambient air pollution is causing tree damage.

There are significant human health risks associated with ambient air pollution. In fact, the probability of the maximum exposed individual contracting cancer from air pollution in Washington is as high as 1 in 100 to 1 in 1,000 at several locations in the state.

The number of excess cancers from toxic air pollutants is estimated at 15 per year.

The entire population of Washington is at risk from either chronic and/or acute exposure to several pollutants resulting in minor to moderate health impacts (e.g., headache, asthma, chronic bronchitis), while 180,000 people are at risk of severe health impacts (e.g. aggravated angina, mortality).

Ambient air pollution causes economic damage. The total cost of air pollution is likely to be hundreds of million dollars annually due to primary and secondary health care costs, materials damage, soiling cleanup costs and the decrease in land values and tourism resulting from visibility degradation.

For example, in the case of cancers RCG/Hagler, Bailey Inc. report the average cost per case to range between $69,573 and $100,118. That means the annual cancer cost due to ambient air pollution in Washington state attributable to the pollutant subcategory of air toxics alone is between $1,043,595 and $1,501,770.

D.2. Indoor Air Pollution

There are no known ecological impacts to the air resource resulting from indoor air pollution.

The major impacts of indoor air pollution are found in the human health arena. Washington Environment 2010 analyzed the risk of cancer associated with 5 cancer and 5 non-cancer pollutants. Exposure assumptions included all time spent indoors, including work hours. The indoor air analysts caution that the results of their work should not be used out of context with the total set of assumptions as defined in their paper.

Indoor air contamination was determined to cause a range of between 95 and 2800 annual excess cancers.

Non-cancer, chronic and acute risks were estimated qualitatively due to a lack of data and were expressed in terms of the number of people potentially exposed to levels which may cause a given health effect. This approach concluded that indoor air pollution risks are generally higher risks from ambient air pollution since 1) people spend most of their time indoors 2) concentrations of contaminants are generally higher indoors.

The primary source of economic damages associated with indoor air contamination are from excess cancers. The cost of health care is estimated to be from 10-250 million dollars.

D.3. Indoor Radon

There are no known ecological effects associated with indoor radon.

Concentrations of indoor radon vary throughout Washington State based on local geology.

Estimates of annual excess cancers range from 78 to 441.

There are no known non-cancer health effects associated with indoor radon.

The primary source of economic damages from indoor radon are the health care costs associated with excess cancers. Those costs are estimated to be between 5 and 44 million dollars.

D.4. Radioactive Releases

There are no measurable effects on the air resource from radioactive releases.

Exposure to naturally occurring radiation is the primary contributing factor to population exposure.

The maximum annual excess cancers associated with radioactive releases are less than one. The maximum individual cancer risk is estimated to be less than one in ten thousand.

Economic damages associated with excess cancer risks are estimated to be less than $100,000 annually. It is unclear, however what the primary pathway (i.e. air or water) for population exposure is.

D.5. Active Hazardous Waste sites

There are no known ecological impacts transmitted through the air pathway from active hazardous waste sites.

With regard to human health, regulated hazardous waste disposal sites pose less of a risk than facilities that generate or handle hazardous wastes.

A qualitative measure of risks could not be performed due to lack of data.

Generally, older facilities pose more of a risk than newer facilities which are built under stricter environmental standards.

RCG /Hagler, Bailey Inc. state that, "While it has not been possible to estimate the economic damages associated with active hazardous waste sites in Washington, available data suggests that these damages could be substantial." The principal sources of economic damages are property value decrements and ground water contamination.

D.6. Non-Hazardous Waste Sites

Probably the greatest threat to the air resource from non-hazardous waste sites, that has any ecological consequence, is the secondary impact resulting from methane emissions. Methane is a "greenhouse" gas.

Human health risks are incurred by the maximum exposed individual from exposure to contaminated ground water via inhalation of vapors while showering. Excess cancer estimates range from 4 in 1000 to 4 in 10,000 cases. This, however, is probably more of an impact to the water resource.

The number of excess annual cancers associated with these sites via airborne exposure is negligible.

Property decrements in Washington State, due to proximity to these sites, are likely to total $50,000,000.

D.7. Pesticides (airborne)

Airborne drift of pesticides unavoidably results in exposure to non-target plant and animal species. The extent of damage is impossible to estimate.

At this time no quantitative risk assessment can be done for human health risk associated with pesticide drift. It is probable that pesticide drift occurs frequently and the potential severity of the health endpoints are substantial.

The air pathway may be the most significant route of exposure to household pesticides. The use of pesticide aerosols, vapor emissions from continuous emitting products and the concentration of pesticides on particulates are significant sources.

Economic damages were not analyzed.

D.8. Non-Ionizing Radiation

There are no ecological impacts from non-ionizing radiation that are transmitted through the air pathway.

Additional research is necessary to judge the health risk from non-occupational exposure to non-ionizing radiation.

No economic damages analysis was conducted.

D. 9. Material Storage

No ecologic effects are attributable to airborne releases from material storage facilities.

The cancer risk to the maximum exposed individual from exposure to gasoline vapors released from leaking underground storage tanks is estimated at 2 in 1000.

In the worst case, less than one annual cancer would be expected from breathing vapors from leaking tanks.

There are probably acute exposure risks from gasoline vapors, but data was not available to make a quantitative estimate.

Economic damages were not assessed.

D. 10. Accidental Releases

Air related impacts on the ecosystem from accidental releases are not anticipated.

All human health risks from sudden and accidental releases to the air are expected to be negligible except acute risks.

An estimated 50 injuries annually can be expected from this source, ranging in severity from headaches to death. Examples include the release of toxic gases from train derailments and vapor releases.

Economic damages associated with evacuations based on the number of accidental release incidents could be significant for large urban areas.

D. 11. Ozone Depletion

In general and for all types of impacts, the national risk speculation cannot be interpreted reliably for state specific effects. Thus the Ozone Depletions and report did not address these issues quantitatively.

Ecologic impacts are expected to adversely effect crop yields and marine phytoplankton, the base of the marine food chain.

Reduction of the protective ozone layer will increase UVB light exposure for humans, which is major factor in skin cancer.

High cumulative exposure levels of UVB radiation increases the risk certain types of cataract formation and other degenerative eye damage.

Economic damages are likely to occur from reductions in crop yields due to decreases in atmospheric ozone. Also, reductions in phytoplankton at the base of the marine food chain will probably cause reductions in other marine species.

D. 12. Inactive Hazardous Waste Sites

No documented evidence of ecological damage due to airborne contaminants from inactive hazardous waste sites exists.

Human health risks from hazardous waste site emissions to the air are, however, very high. Contamination exposure to the maximum exposed individual are in the 10-2 to 10-4 range. It is unclear what percentage of the total estimated 1 to 10 excess cancers per year would result from airborne exposure (probably less than 1) The same is true for non-cancer risks to the population, where a total of 5,000 to 20,000 people are at risk, some via the air pathway.

Economic damages associated with inactive hazardous waste sites occur in the form of property value decrements as well as the direct and indirect cost of health care associated with excess cancers.

D. 13. Global Warming

Global warming will shift the distribution of plant and animal species northward. Plant and animal species may also migrate to higher elevations. Washington forests, for example, might begin to resemble those of present day northern California and salmon may be replaced by other fish species.

It is difficult to predict specific regional human health impacts attributable to global warming. In a macro sense, however, warming may provide new geographic areas for and/or climate conditions conducive to the survival and increase of certain disease organisms.

Net economic damages are uncertain. Negative impacts are projected to be offset by beneficial impacts. An increase in global temperature will cause sea level rise due to expansion of sea water, profoundly impacting Washington's Shoreline and coastal wetlands.

D. 14 Conclusions

The following threats to the air resource are expected to decline in coming years, despite population growth, energy demand and changes in the labor market; radioactive releases, active hazardous waste sites, non-hazardous waste sites, non-ionizing radiation, materials storage, inactive hazardous waste sites. Indoor air risks are expected to remain stable.

The following threats are expected to increase with population and energy demand growth and changes in the labor market; ambient air pollution, indoor radon (specifically cancer cases in residents of unprotected older homes), pesticides (airborne), accidental releases, ozone depletion, global warming.

Of the threats likely to increase the most dangerous are found in certain air toxics. This group of contaminants has an extremely high cancer risk associated with it and is currently under regulated in the opinion of 2010 air resource analysts.

II. Current Status of the Resource

A. HISTORY OF AIR POLLUTION IN WASHINGTON

In this section, we will use historical data to determine if there are any discernible trends in pollutant levels and source emission rates throughout the state. The sources of these data summaries include Washington's criteria pollutant monitoring network (carbon monoxide, ozone, sulfur dioxide, nitrogen dioxide, lead and particulate matter), emission rate estimates from the Washington Emission Data System, and additional monitoring of non-criteria parameters such as visibility, meteorology and toxic air pollutants.

1. Ambient Air Quality Monitoring Network

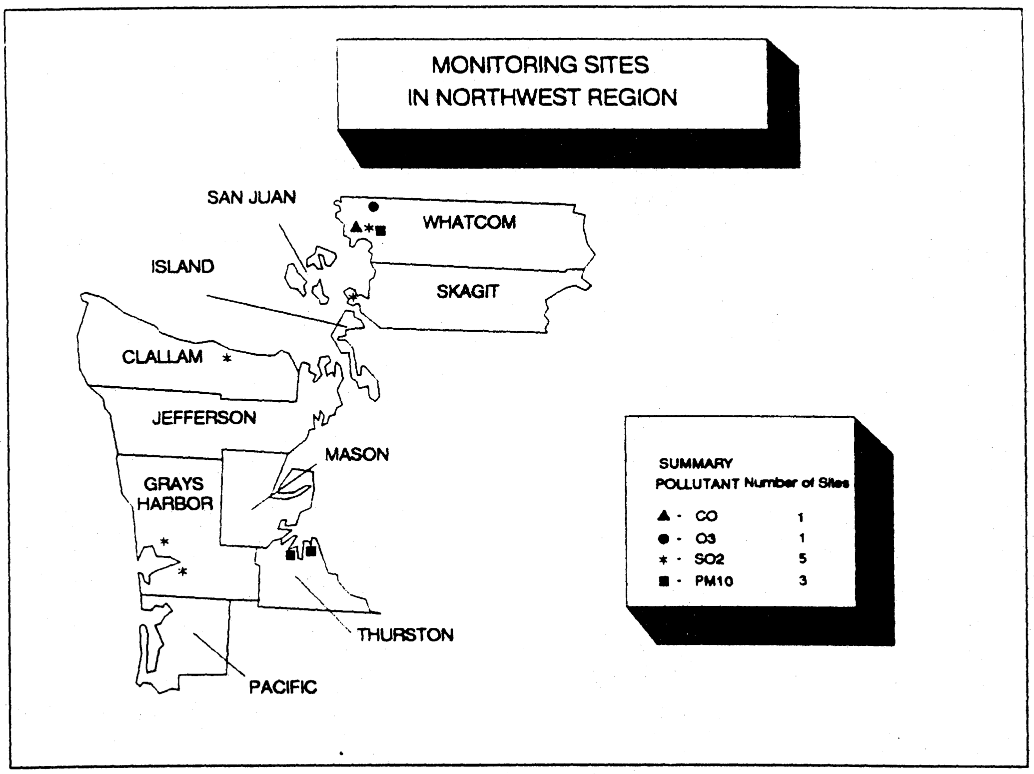
Air quality data is collected at over a hundred monitoring sites throughout the state which are concentrated primarily in population centers and in industrialized areas - the most likely sources of air contaminants. There is no set pattern as to where to locate an air pollution monitor. Monitors are sited in such a way as to be representative of several different types of locations - residential, rural or commercial/industrial. Some pollutants are emitted at ground level, others from smokestacks a hundred feet or more in the air. Some pollutants change properties given the proper meteorological conditions (e.g., ozone), while others are deposited and still others washed with rainfall.

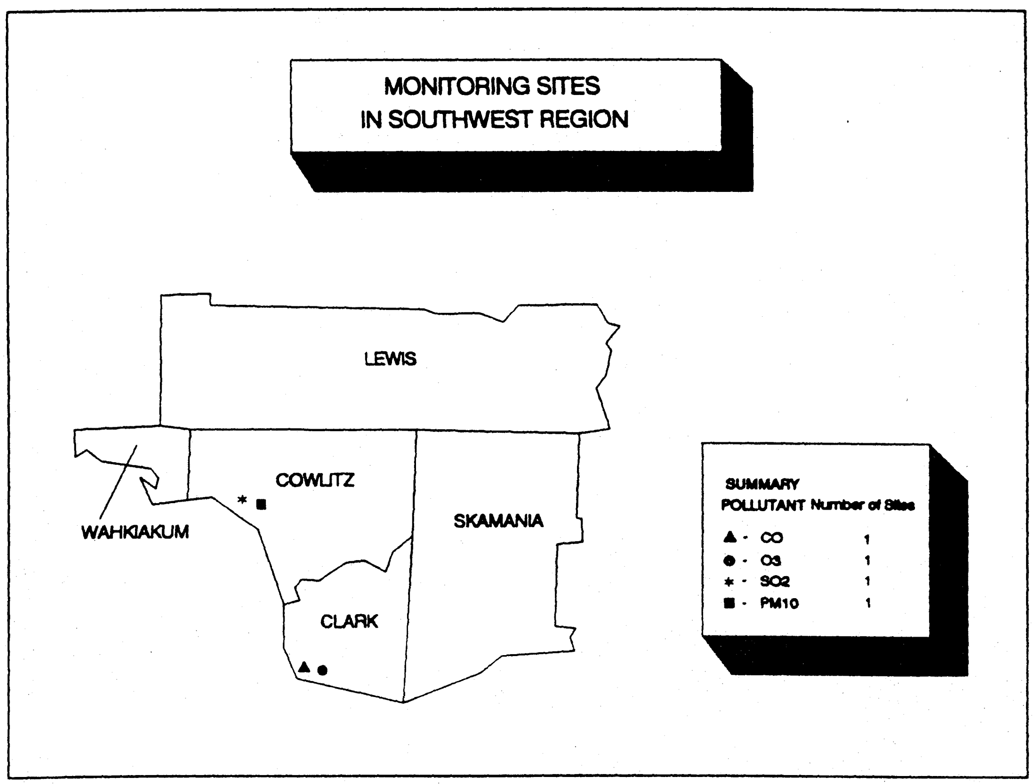
The Department of Ecology, with assistance from the EPA, reviews the ambient air monitoring network on an annual basis to determine if it is still appropriate, and the most efficient use of the monitoring resource.

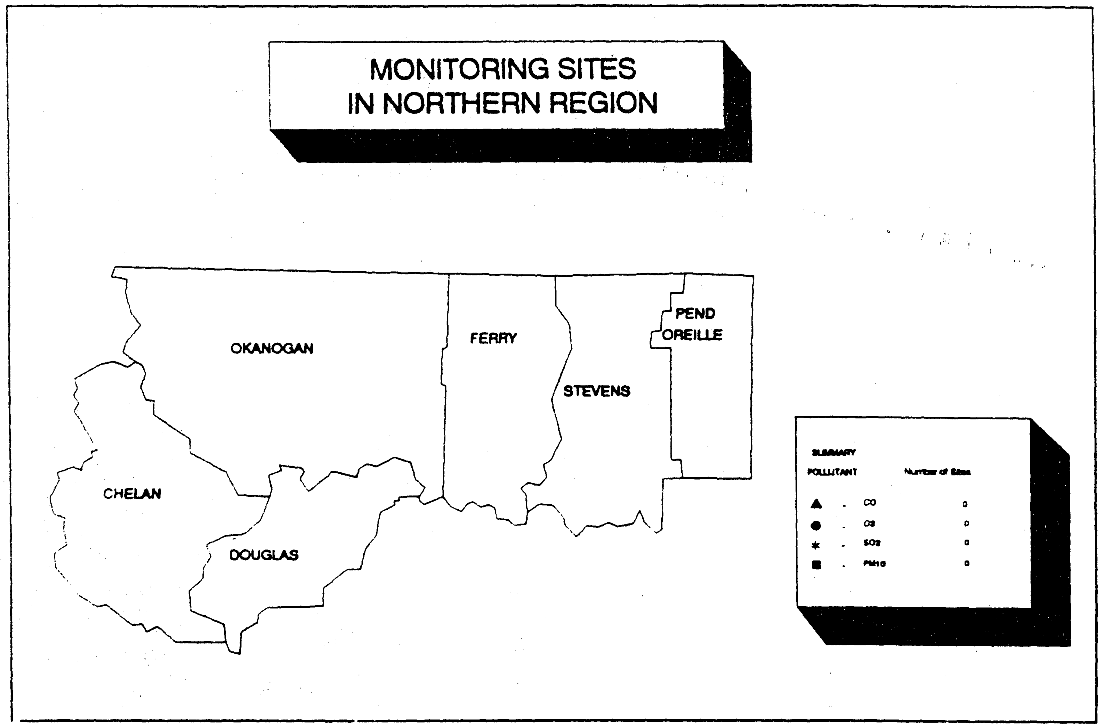
Not all pollutants are monitored continuously at all stations, and monitors are not located in all counties, primarily because of the high cost of installation and operation. In fact, in the Northern Washington Intrastate region, there are currently no state supported air monitors.

Areas within the state where monitored values have exceeded the federal National Ambient Air Quality Standard (often several exceedances over a period of years) are designated as non-attainment and are subject to strict limitations on future industrial growth. Failure to develop a plan which shows attainment of the standards within a reasonable period of time could result in the federal government withholding funds targeted for sewage treatment and highways.

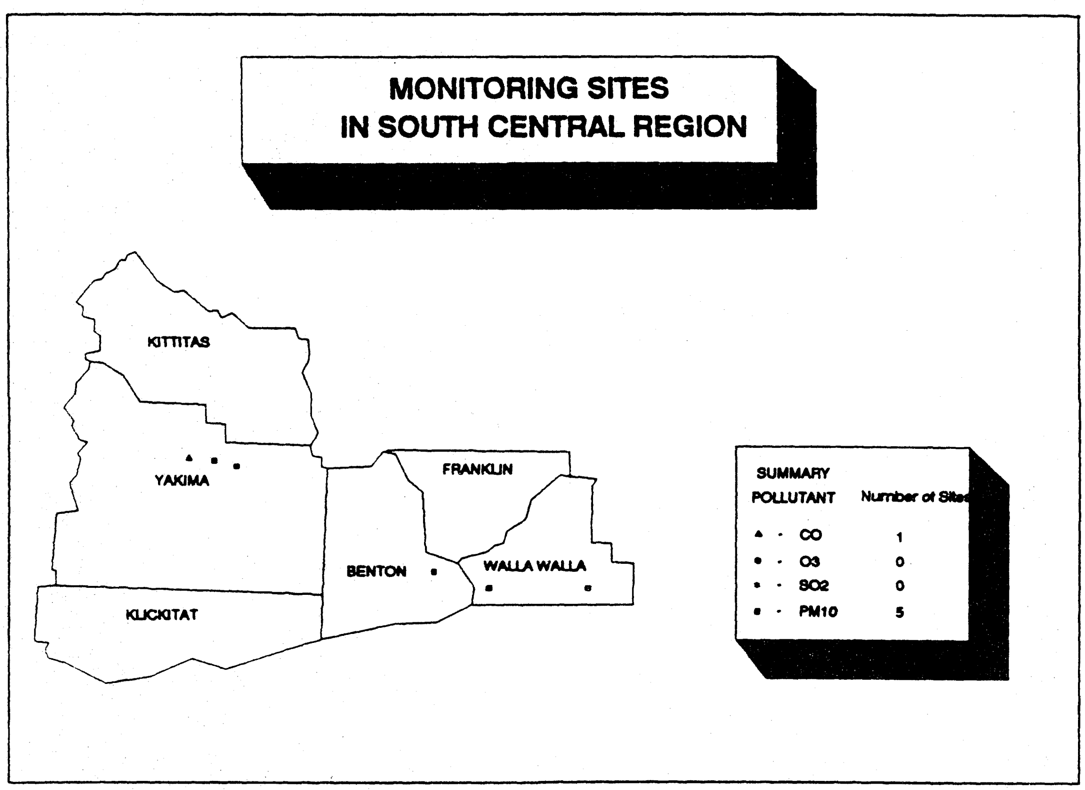
Figures 5 through 10 show monitoring locations within each region.


MONITORING SITES
IN NORTHWEST REGION
SAN JUAN
WHATCOM
ISLAND
SKAGIT
CLALLAM
JEFFERSON
MASON
GRAYS HARBOR
THURSTON
PACIFIC
SUMMARY
POLLUTANT Number of Sites
▲ - CO 1
● - O3 1
* - SO2 5
■ - PM10 3


MONITORING SITES
IN SOUTHWEST REGION
LEWIS
COWLITZ
SKAMANIA
WAHKIAKUM
CLARK
SUMMARY
POLLUTANT Number of Sites
▲ - CO 1
● - O3 1
* - SO2 1
■ - PM10 1

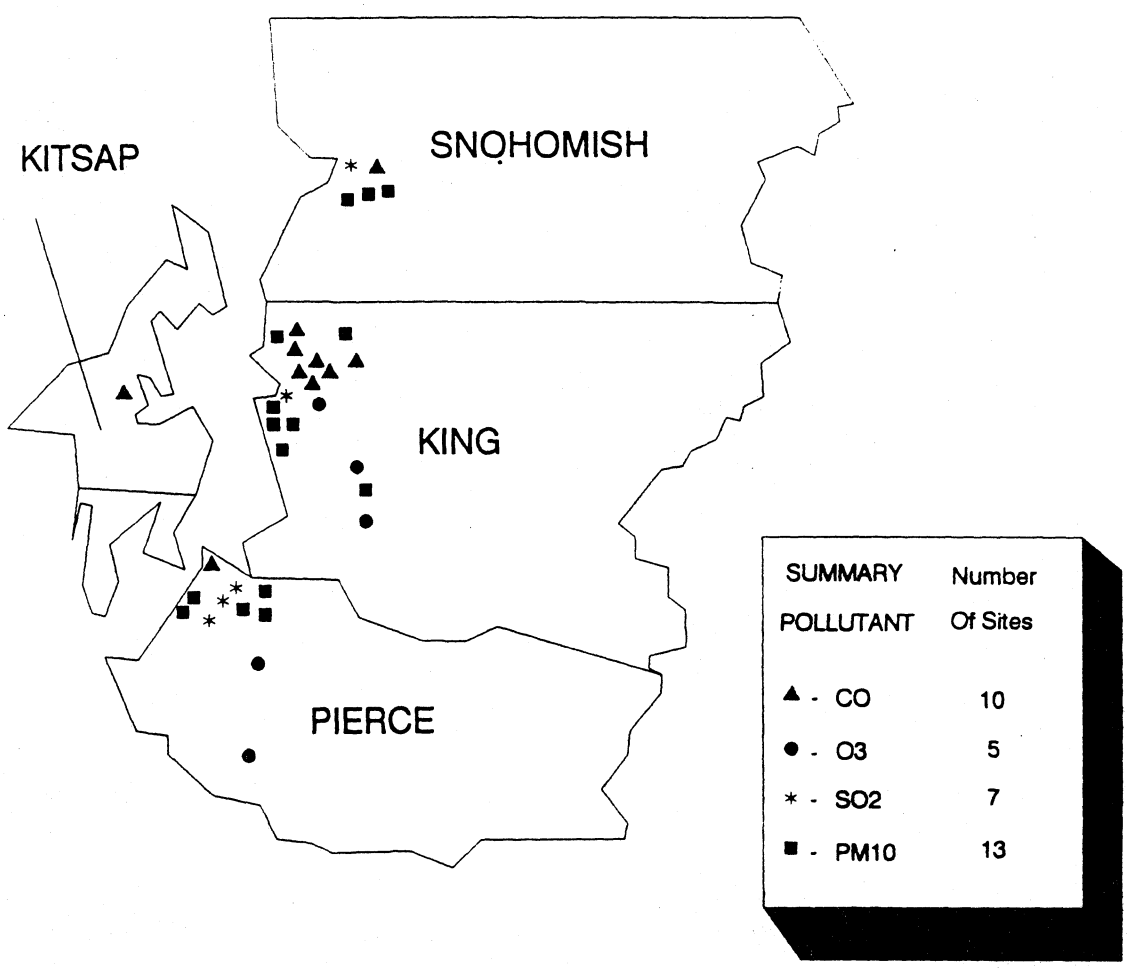


MONITORING SITES
IN NORTHERN REGION
OKANOGAN
FERRY
STEVENS
PEND
OREILLE
CHELAN
DOUGLAS
SUMMARY
POLLUTANT
Number of Sites
CO 0
O3 0
SO2 0
PM10 0

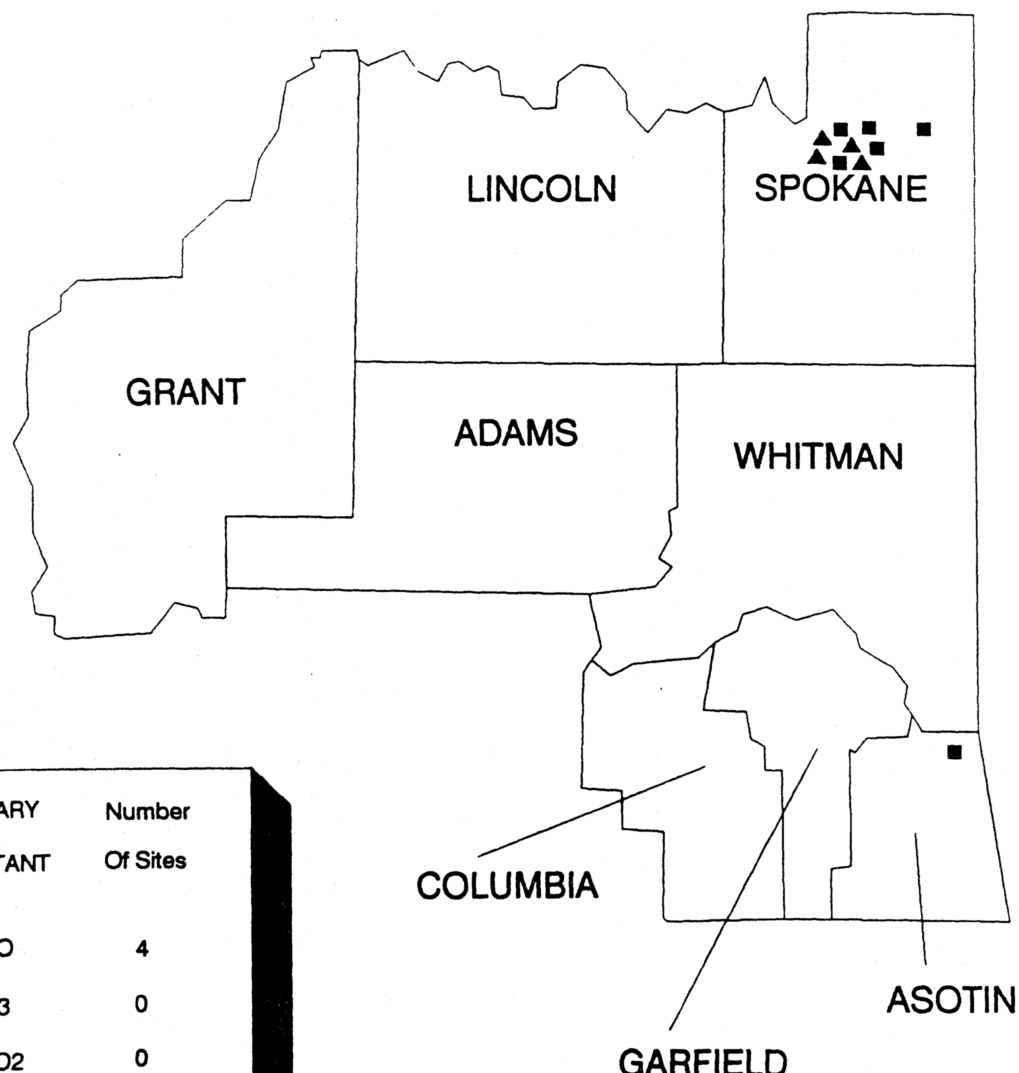


MONITORING SITES
IN SOUTH CENTRAL REGION
KITTITAS
YAKIMA
FRANKLIN
BENTON
WALLA WALLA
KLICKITAT
SUMMARY
POLLUTANT
Number of Sites
CO 1
O3 0
SO2 0
PM10 5

MONITORING SITES IN PUGET SOUND REGION



MONITORING SITES IN EASTERN REGION



SUMMARY POLLUTANT	Number Of Sites
▲ - CO	4
● - O3	0
* - SO2	0
■ - PM10	6

In addition to these criteria pollutant monitors, the state also operates a visibility monitoring network (for a description of the visibility program, see section III.A.4.). A map of the sites used in the visibility monitoring network showing the proximity of the monitoring sites to Wilderness areas is included on the following page, Figure 11.

Additional monitoring in the state includes a toxics air monitoring site located on the Tacoma tideflats, radiation monitoring around the Hanford Reservation conducted by the Department of Social and Health Services, and several acid precipitation sites along the crest of the Cascades.

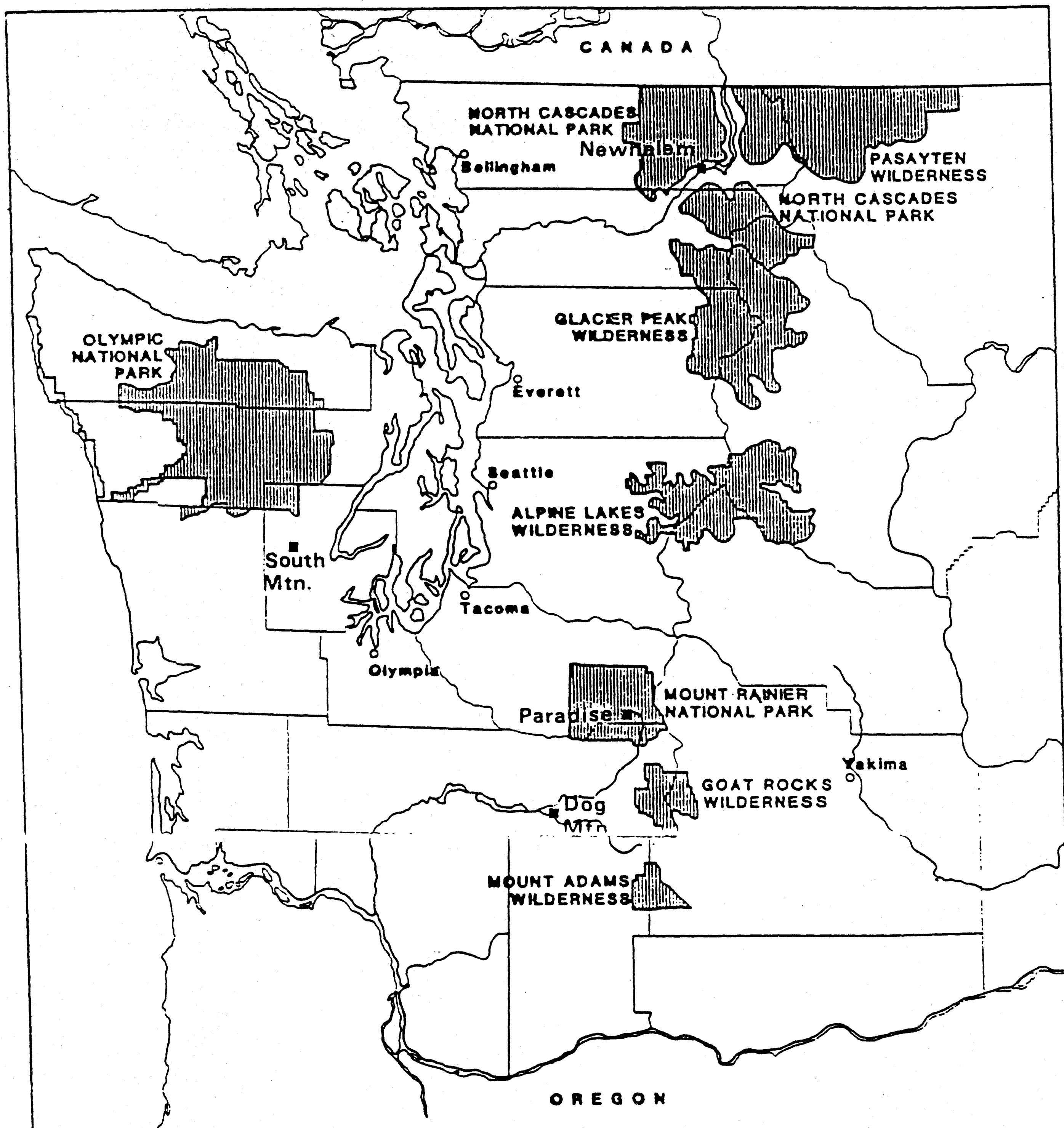


FIG. I 1986 VISIBILITY MONITORING NETWORK

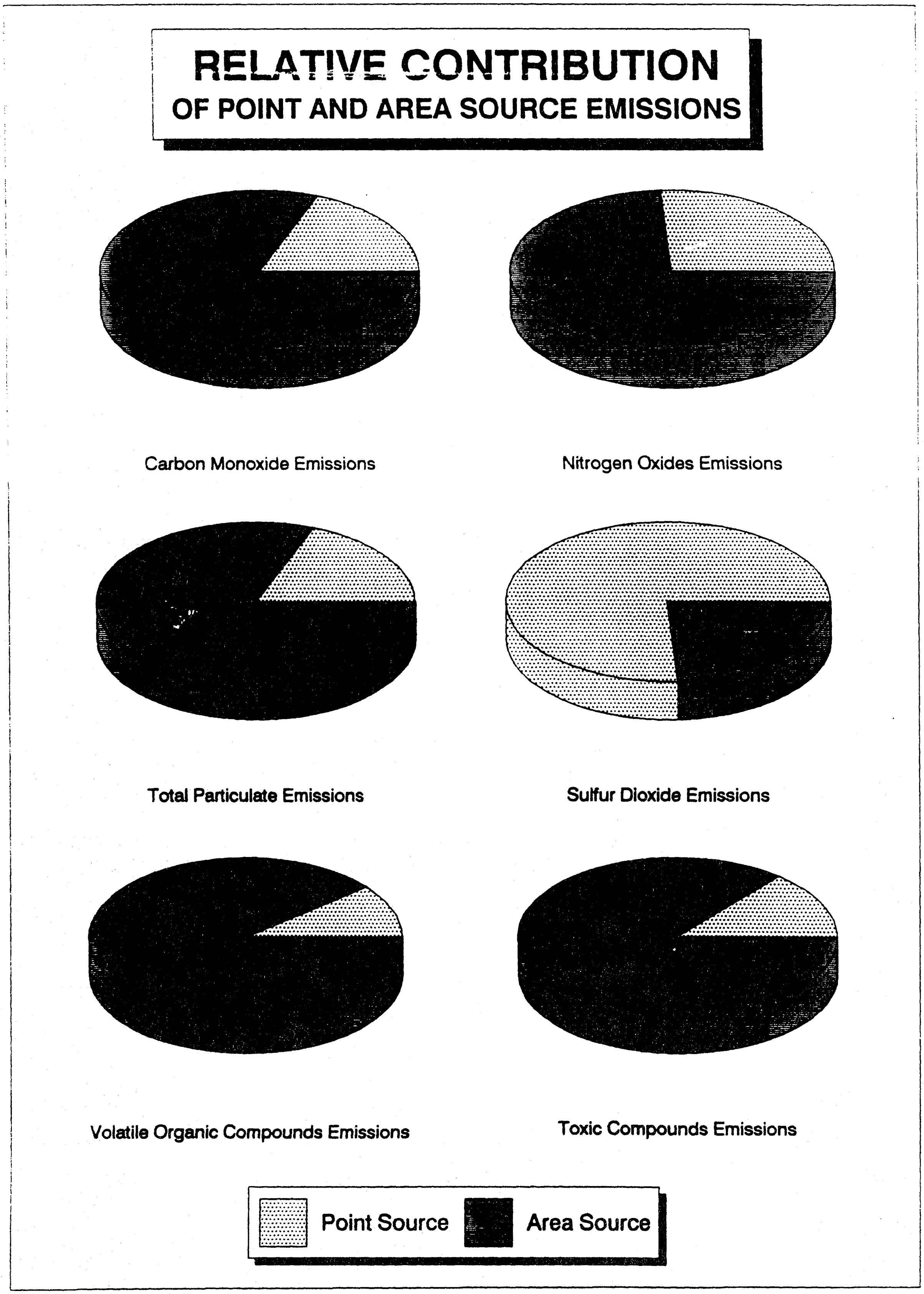
2. Air Contaminant Emissions

There are two basic measurements in air quality - ambient air concentrations and pollutant emission rates. Though the two measures are obviously related, the relationship isn't necessarily simple. The ideal situation would be to have enough ambient air monitors to be able to characterize the air at all places at all times. However, as noted in the previous section, air monitoring can be very expensive, and all we can realistically hope to do with the network is to generally characterize regional air quality. If this were our only tool for determining air quality, we would be hard pressed to estimate concentrations a half mile downwind of a major air pollution source based solely on ambient air measurements taken across town or, more typically, across the county. Source emission rates, combined with mathematical models, help us to estimate what the ambient concentration would be if we were to monitor. This method is therefore a valuable tool as an alternative to air monitoring.

The Washington Emission Data System (WEDS) is a compilation of source and emission rate information. Emissions are either estimated using standard emission factors or are determined based on tests of stack gases, known as source tests. Sources are classified as either point or area sources, the distinction being that point sources collect air contaminants to be discharged through a stack. Typical area sources include motor vehicles, slash burns and other outdoor burning, woodstoves, dry cleaners, and fugitive dust from unpaved roads and parking lots.

The following emission rate figures have been broken into two groups - criteria pollutants and non-criteria, or toxic, pollutants. Figures 12 shows the relative contributions statewide of area versus point sources of criteria pollutants. For a more comprehensive analysis of the criteria pollutant emission sources, a region by region breakdown is included in Appendix A.

Figure 12


RELATIVE CONTRIBUTION
OF POINT AND AREA SOURCE EMISSIONS
Carbon Monoxide Emissions
Nitrogen Oxides Emissions
Total Particulate Emissions
Sulfur Dioxide Emissions
Volatile Organic Compounds Emissions
Toxic Compounds Emissions
Point Source
Area Source

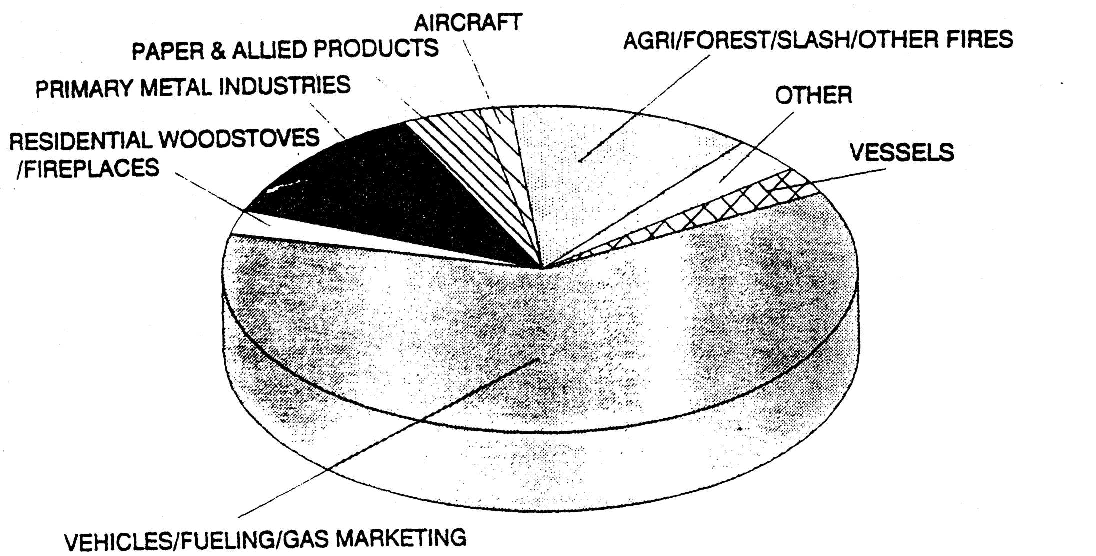
All the criteria pollutant emissions are dominated by area sources with the exception of SO2, generally associated with power plant emissions. This dominance by area sources is significant since the effectiveness of control strategies is directly related to how much of the total would be affected by the strategy. For example, strict limits on VOC emissions from chemical production facilities could reduce emissions by 300 tons or more, but in light of the estimated 2.3 million ton emitted by area sources, it is doubtful that the air quality improvement would even be measurable.

Major sources of each of the criteria pollutants include:

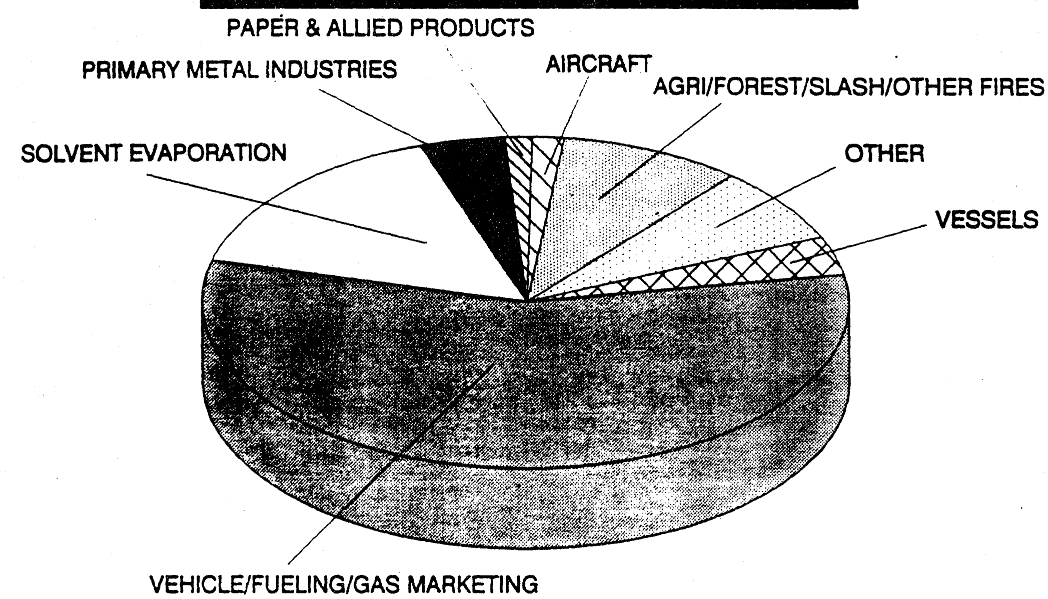
Carbon Monoxide	Transportation Aluminum production
Particulates	Transportation Woodstoves Slash burns
Sulfur Dioxide	Electric Utilities Boilers (small and industrial)
Volatile Organics	Transportation Gasoline delivery, storage
Nitrogen Dioxide	Transportation Electric utilities Industrial boilers

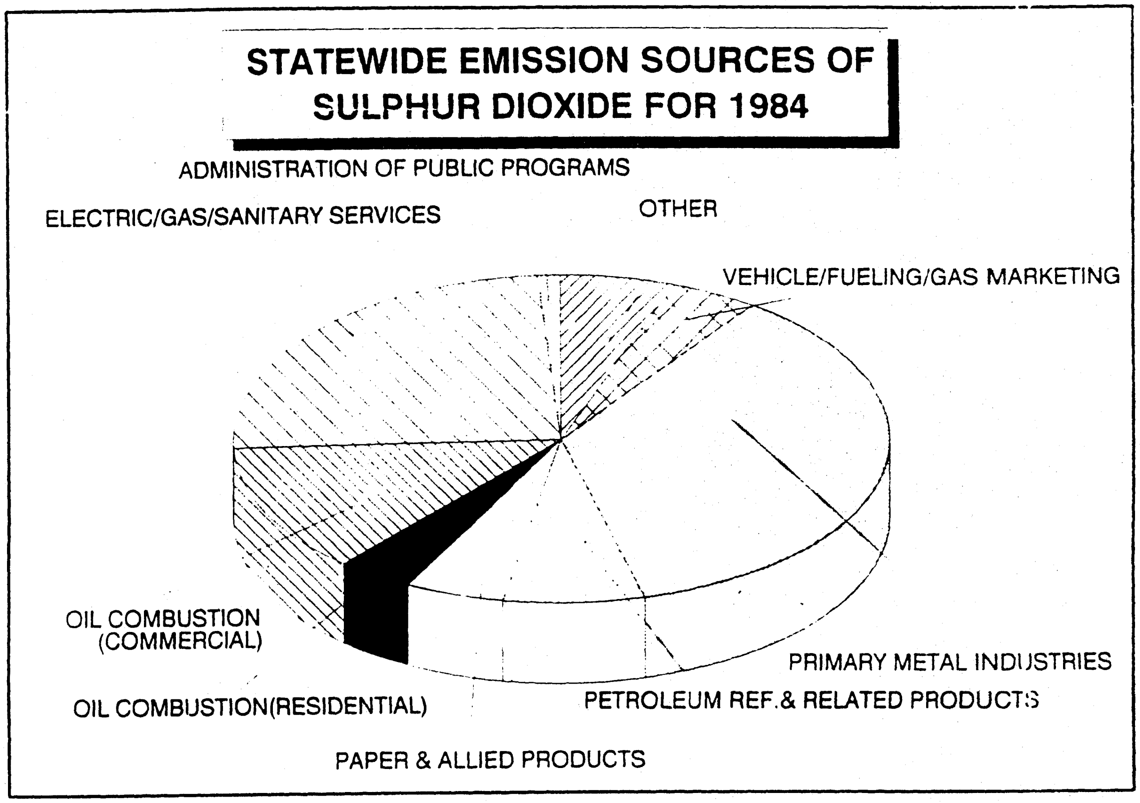
It is easy to see from the above chart that transportation is the most significant contributor to criteria air pollutants. Statewide summaries of the principle sources of each criteria pollutant, and toxic pollutants treated as a group, can be seen in figures 13 through 18. Similar charts for each air quality control region are included in Appendix A.

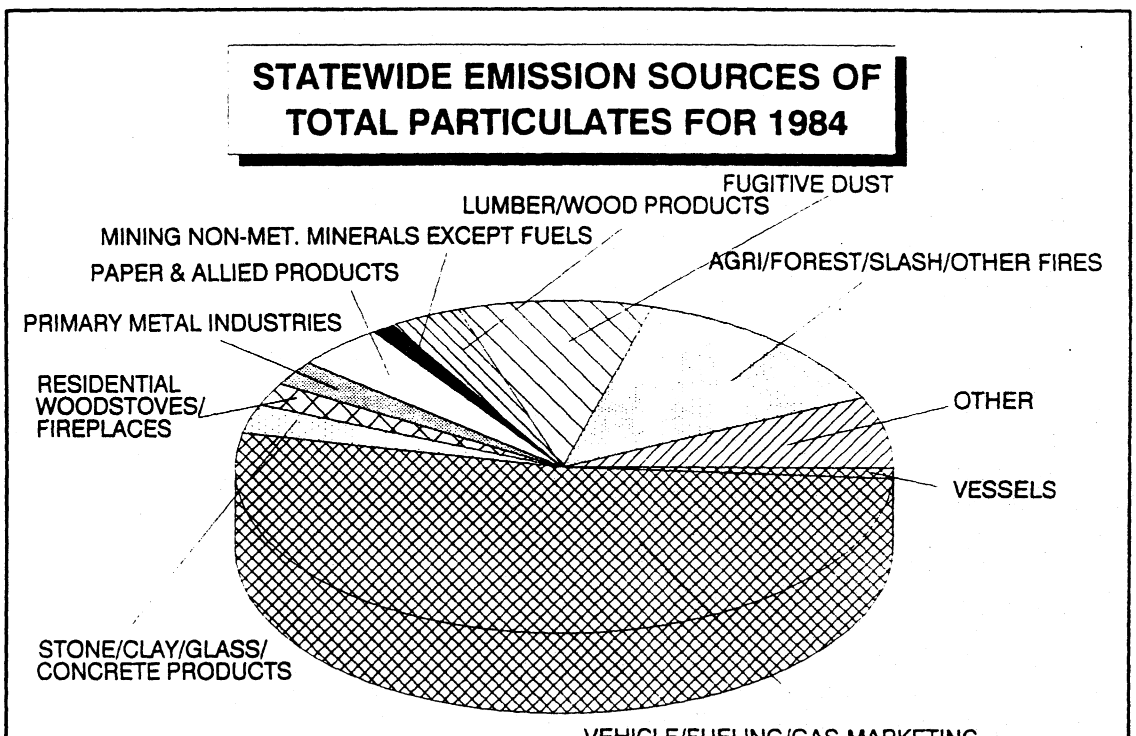
STATEWIDE EMISSION SOURCES OF CARBON MONOXIDE FOR 1984

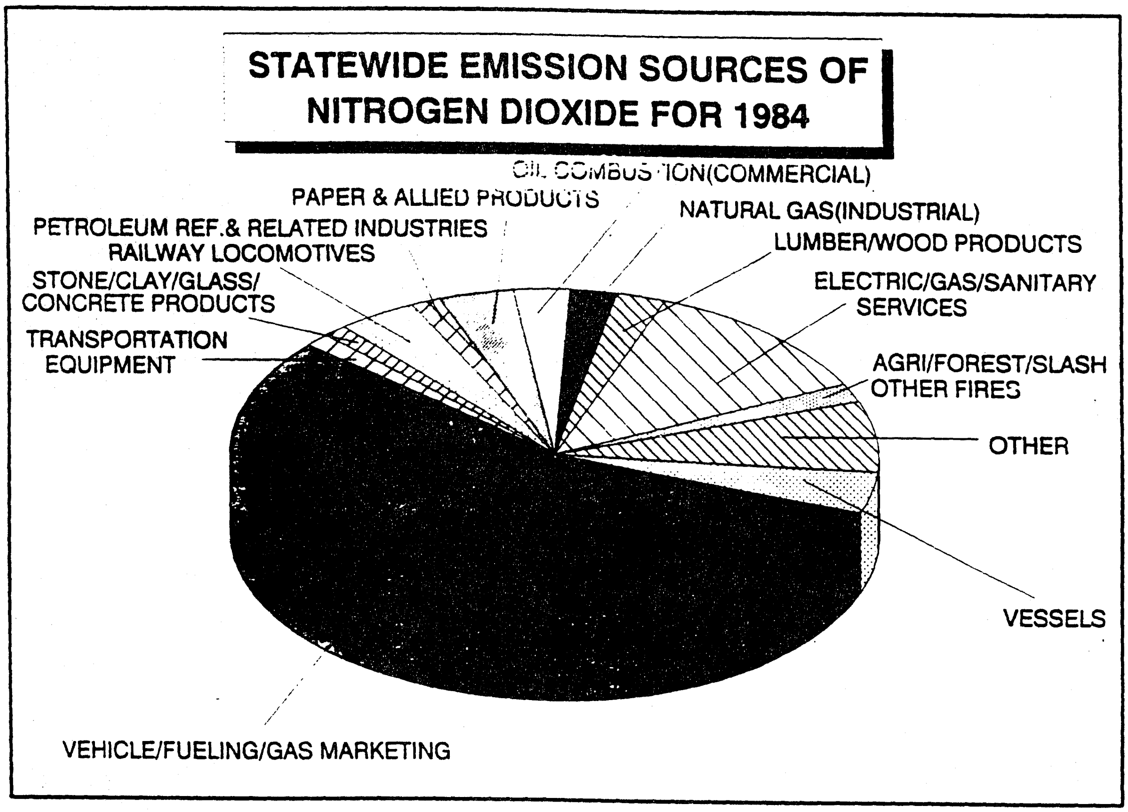


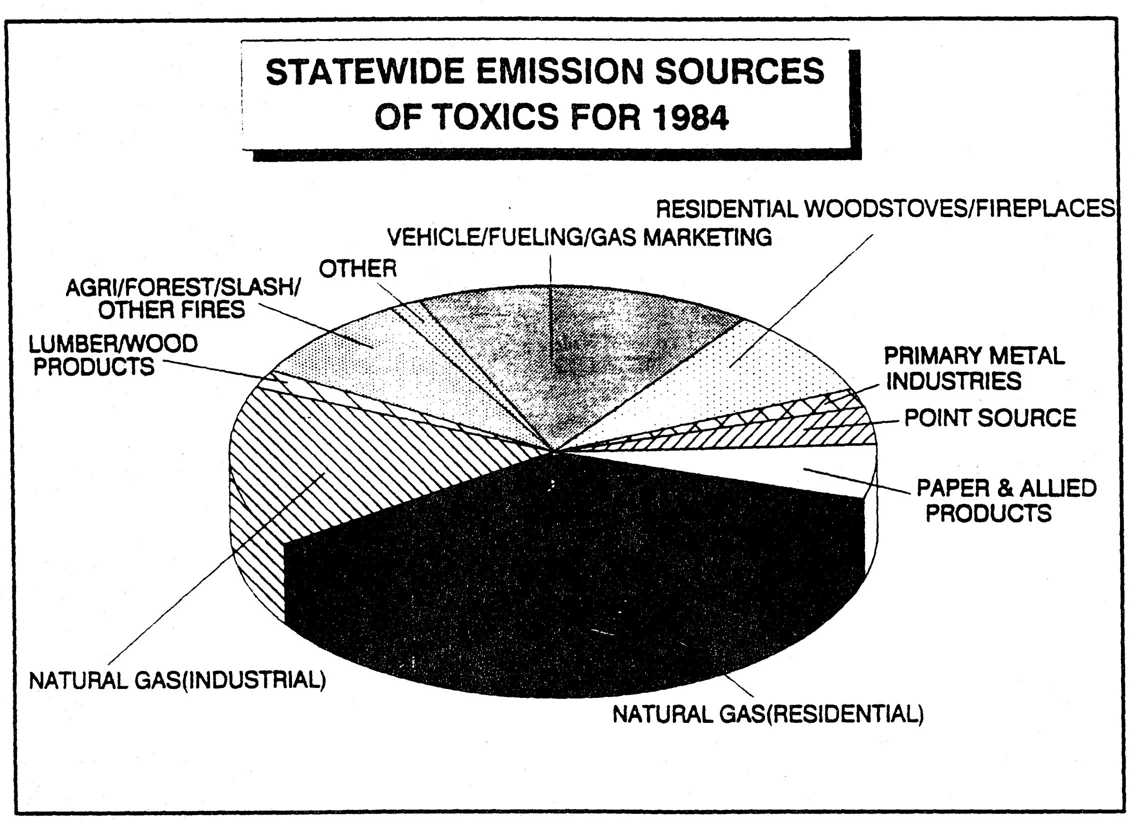
STATEWIDE EMISSION SOURCES OF VOLATILE ORGANICS FOR 1984




STATEWIDE EMISSION SOURCES OF SULPHUR DIOXIDE FOR 1984
ADMINISTRATION OF PUBLIC PROGRAMS
ELECTRIC/GAS/SANITARY SERVICES
OTHER
VEHICLE/FUELING/GAS MARKETING
OIL COMBUSTION (COMMERCIAL)
PRIMARY METAL INDUSTRIES
PETROLEUM REF.& RELATED PRODUCTS
OIL COMBUSTION(RESIDENTIAL)
PAPER & ALLIED PRODUCTS


STATEWIDE EMISSION SOURCES OF TOTAL PARTICULATES FOR 1984
FUGITIVE DUST
LUMBER/WOOD PRODUCTS
MINING NON-MET. MINERALS EXCEPT FUELS
AGRI/FOREST/SLASH/OTHER FIRES
PAPER & ALLIED PRODUCTS
PRIMARY METAL INDUSTRIES
RESIDENTIAL WOODSTOVES/ FIREPLACES
OTHER
VESSELS
STONE/CLAY/GLASS/ CONCRETE PRODUCTS
VEHICLE/FUELING/GAS MARKETING


STATEWIDE EMISSION SOURCES OF NITROGEN DIOXIDE FOR 1984
OIL COMBUSTION(COMMERCIAL)
PAPER & ALLIED PRODUCTS
NATURAL GAS(INDUSTRIAL)
PETROLEUM REF.& RELATED INDUSTRIES
RAILWAY LOCOMOTIVES
LUMBER/WOOD PRODUCTS
STONE/CLAY/GLASS/ CONCRETE PRODUCTS
ELECTRIC/GAS/SANITARY SERVICES
TRANSPORTATION EQUIPMENT
AGRI/FOREST/SLASH OTHER FIRES
OTHER
VESSELS
VEHICLE/FUELING/GAS MARKETING


STATEWIDE EMISSION SOURCES OF TOXICS FOR 1984
RESIDENTIAL WOODSTOVES/FIREPLACES
VEHICLE/FUELING/GAS MARKETING
OTHER
AGRI/FOREST/SLASH/ OTHER FIRES
LUMBER/WOOD PRODUCTS
PRIMARY METAL INDUSTRIES
POINT SOURCE
PAPER & ALLIED PRODUCTS
NATURAL GAS(INDUSTRIAL)
NATURAL GAS(RESIDENTIAL)

It is also useful to look at trends in emission rates. Criteria pollutant trend plots for are included in Appendix B point sources only. Area source emissions have not been routinely updated and are therefore meaningless to plot for the purpose of trend information.

There are about as many sources of toxic air pollutants as there are the pollutants themselves - hundreds. However, once again transportation related sources stand out as a major contributor to the total toxics "pie". Appendix C shows the breakdown, area versus point source, of the total air toxic emissions in each region. It is also important when looking at toxics not to focus only on total tonnage emitted. For a more realistic view of the toxic problem, the potency of the toxic must be considered. Figure 19 shows a traditional breakdown of toxic emissions in the state (broken down by total tons emitted). Figure 20 shows the statewide breakdown of toxics according to their relative risk, taking into account potency. A similar region by region breakdown is included in Appendix D.

Figure 19

STATEWIDE BREAKDOWN OF TOXIC EMISSIONS BASED ON TOTAL AMOUNT EMITTED

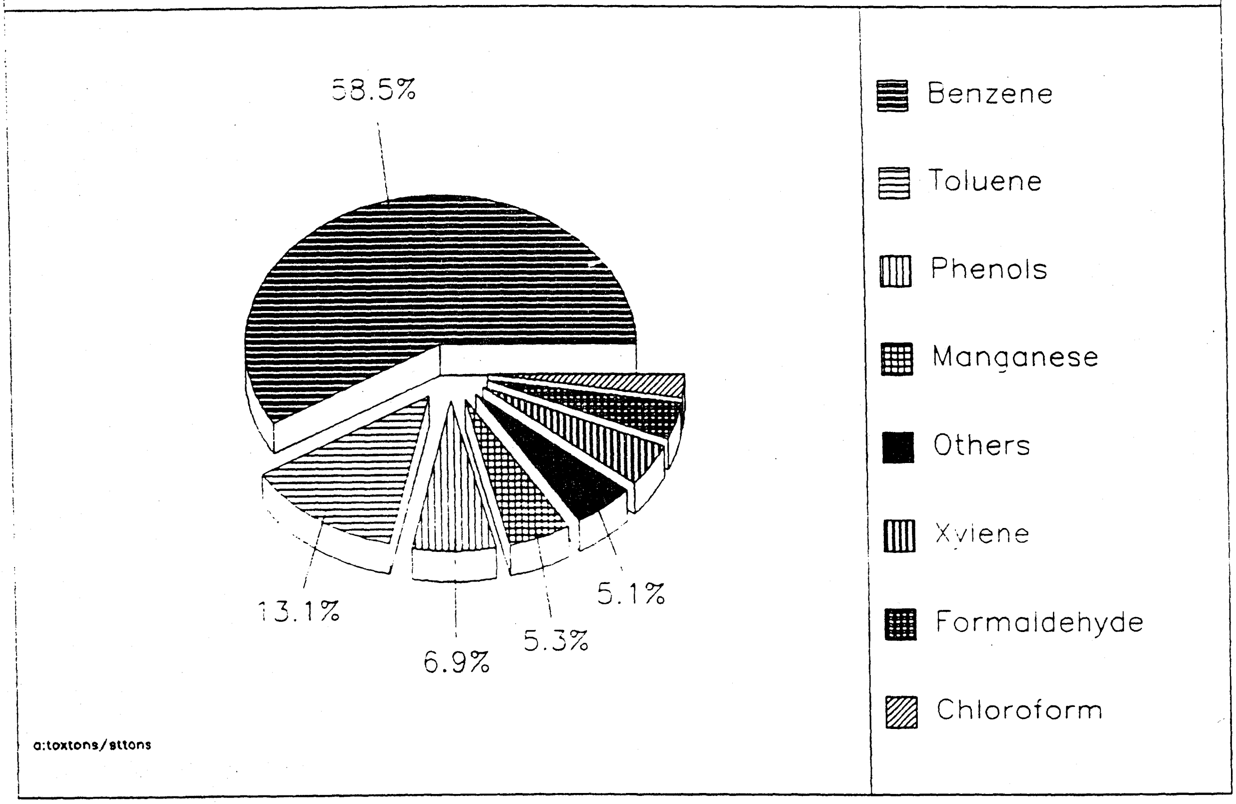
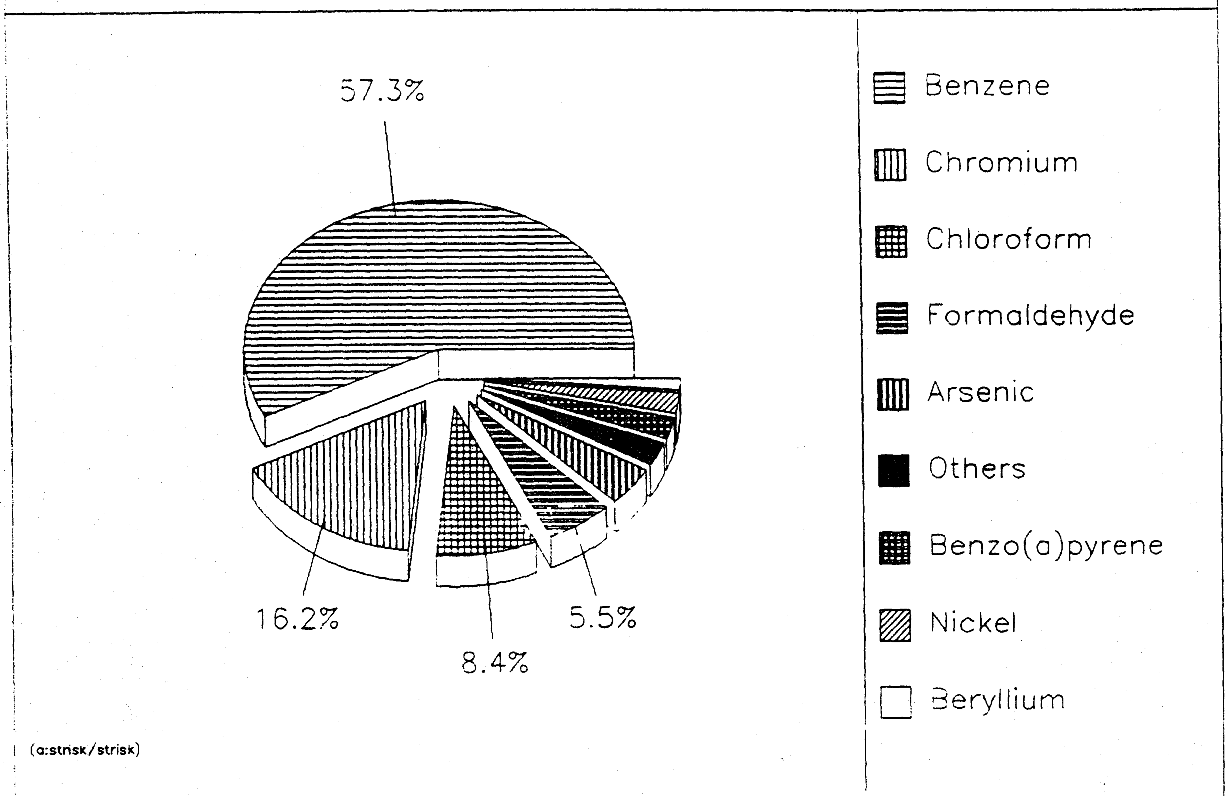


Figure 20

TOXIC EMISSIONS RANKED BY RISK (does not include Dioxin)



We have not included pesticides or asbestos in this chart because neither are in the current emission database. It should be noted that for the state as a whole and for each region, this method of comparison indicates that <u>dioxin is the most risky</u> by such a large amount that if we had included it as part of the pie, the remaining risks would show up as mere splinters. Either dioxin is a risk we should pay particular attention to, or our emissions and/or potency numbers are out of line

3. Monitored Air Quality

The most useful and meaningful data in determining air quality levels is actual monitored data. The State of Washington has been monitoring criteria air pollutants since the 1960's. For this resource characterization, we generally looked the last 10 years of monitored data.

Unlike the situation for criteria pollutants, we have very little monitored toxic data. Toxics monitoring is a very new field, with its share of problems (i.e., detection limits are often very low). Few states operate toxic air monitoring network without a great deal of support from EPA, not only in terms of manpower and equipment, but also in terms of technical support. The EPA does operate a toxics air monitoring site in the Tacoma tideflats area, which provides some limited data.

Since the federal Clean Air Act established ambient air quality standards, the state's primary focus has been to assess air quality relative to these standards. The basic question has been, "Do we meet the standard?" It is no surprise that historical air monitoring summaries are tabulated on the basis of these standards. For example, an area would be in violation of the national standard for ozone if a site recorded four or more exceedances of the one hour, 0.12 ppm standard within a three year timeframe. It is complicated, but the point here is that historical records tabulate the number of exceedances of this standard. We felt that to ascertain data trends, other measures were needed.

Going back to the raw data for each of the criteria pollutants, there is an enormous amount of data, more than could be analyzed for the purpose of this project. We decided to limit the dataset we would review to data comprised of the highest 50 values for each pollutant for each year. Bearing in mind that this is not an exercise in determining the status of compliance with respect to ambient air quality standards, we felt that we could get a good sense of the overall trend of the monitored data within a given region by tracking three values from this relatively small dataset:

Max This is the maximum value recorded at any monitoring location within the region for a given pollutant.

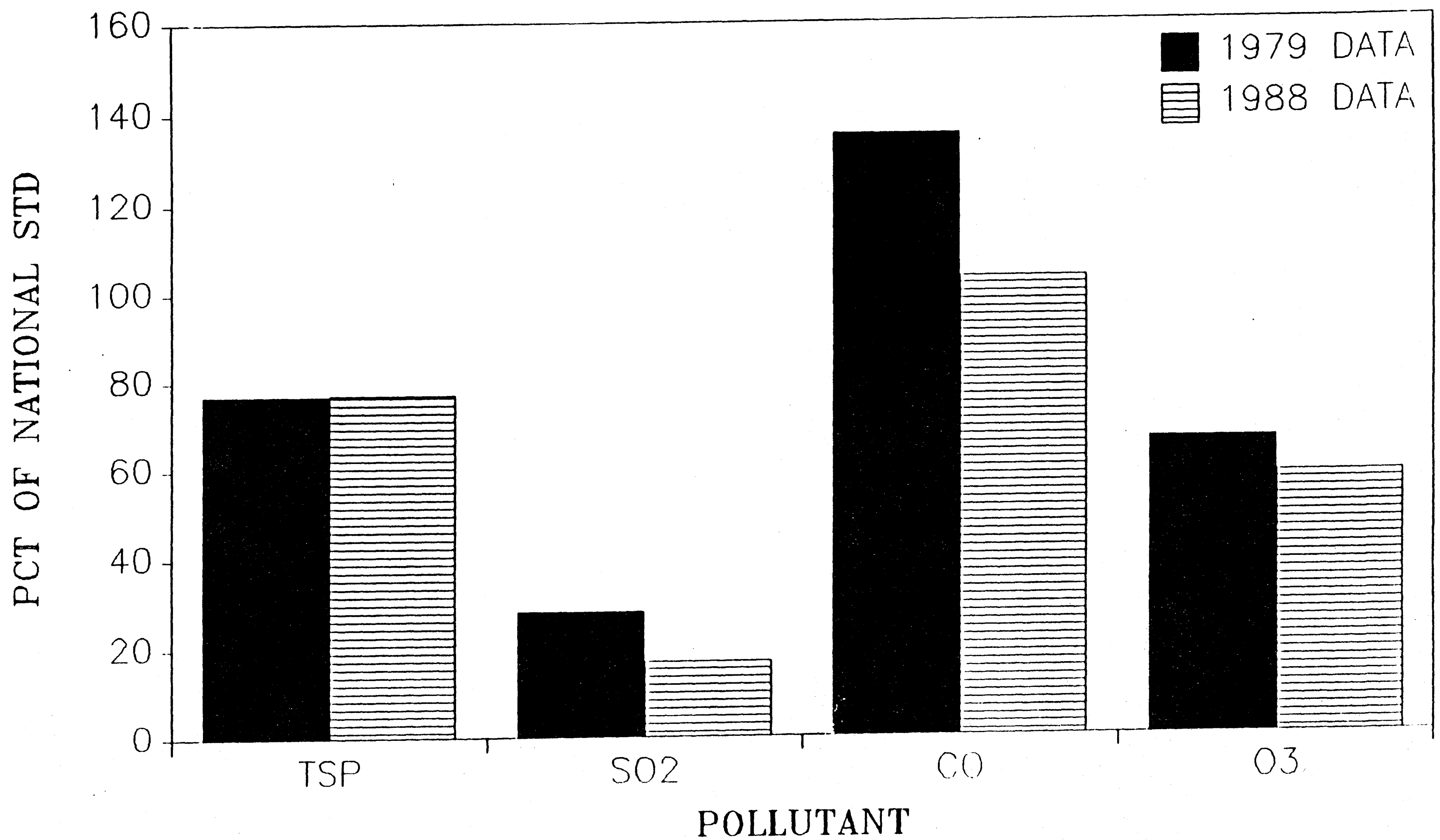
25th This is the midpoint of our yearly grouping of the 50 highest values.

50th The lowest value in the 50 per year per region dataset.

A review of the timeplots generated for each region and pollutant shows some interesting trends. We found that the 25th value was a good indicator of overall trends, being high enough values to insure we are not simply in the area of background or noise, yet producing a well behaved trendline unlike the peak values, which tend to go through large swings from year to year.

Reducing all this information down to generalizations about statewide trends has proven to be a challenge. Some pollutants are very localized. It is not uncommon to find a monitored value on one street differing considerably from one a block or two away. Nonetheless, we refer the reader to figure 21, Washington Trends in Air Quality, to get a general sense of how the state is doing with respect to the criteria pollutants. Note in this figure that we used the Puget Sound AQCR for our example. Other regions follow similar trends, though the values are lower in most regions for most pollutants. These trends are also consistent with nationwide trends, as discussed in Section III.B.

Figure 21
WASHINGTON TRENDS IN AIR QUALITY
BASED ON 25TH VALUES - PUGET SOUND AQCR



a:aqtest/testaq2

The chart shows that things are not getting worse, and in some cases are improving (CO, SO2, and to a lesser extent ozone). This could easily be misleading. Regarding SO2, much of the improvement in what were already quite low values can be attributed to the shutting down of a large source in the mid-1980's. CO continues to be a problem, particularly in the winter months when inversions are likely to happen (see section I.B.1.). Nationwide, CO levels have been on the decline, largely due to the federal new car emission standards. Dramatic improvement in emission rates from new cars relative to older cars resulted in marked air quality improvements in most metropolitan areas. The concern is that the most significant improvements have already happened - there are fewer pre-1981 cars on the road traveling fewer miles, and new car standards have not been tightened in recent years. Working against the improvement in new cars has been a steady increase in the number of cars on the roads and the number of miles traveled.

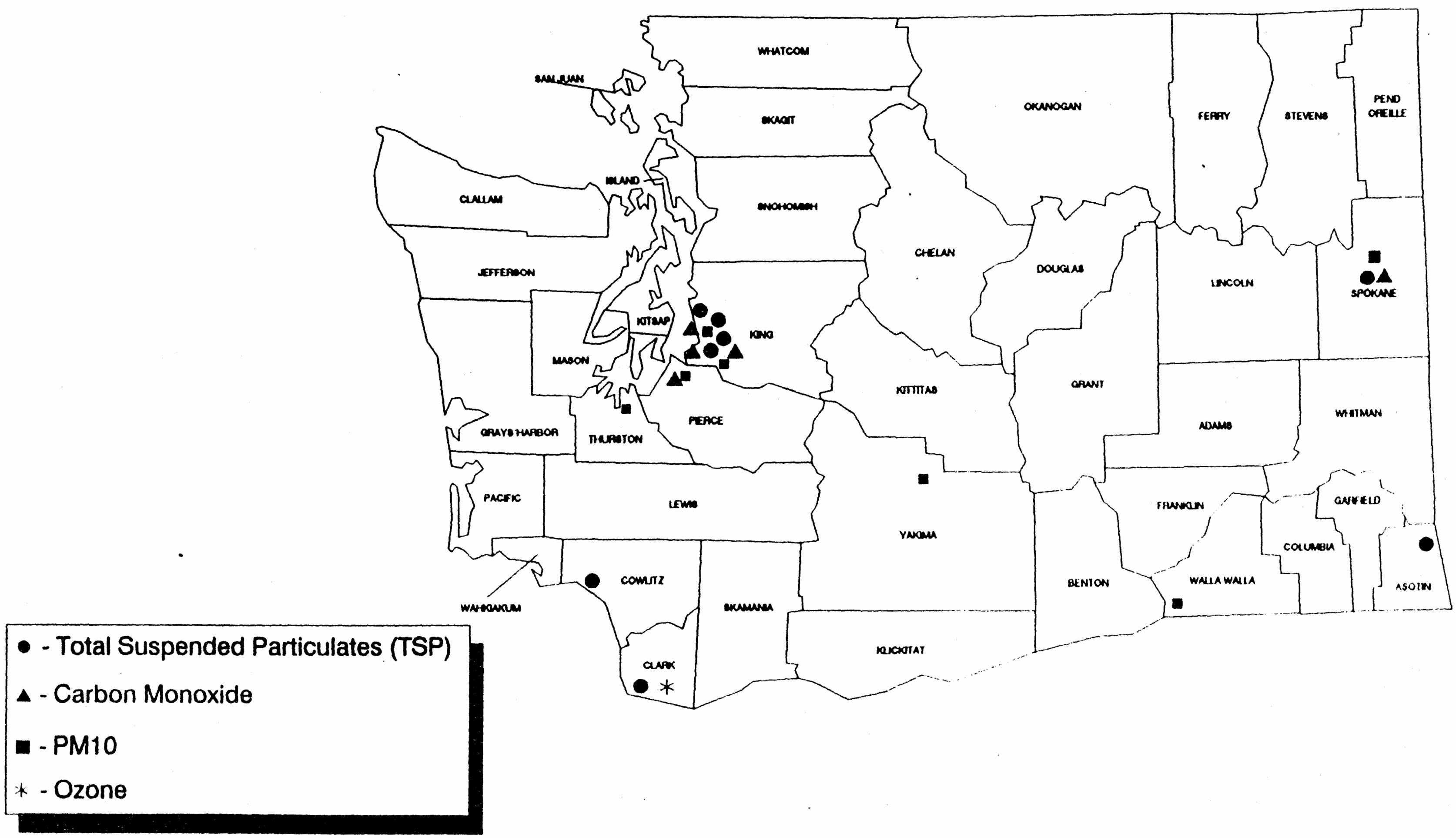
An interesting phenomenon of vehicular related pollution is that emissions do not increase in direct proportion to the population or the number of cars, it can increase at a significantly higher rate. As more cars clog the streets, the street will eventually be at capacity - any more cars and you have gridlock. At this point, even though there are only a few more cars on the road, they may take twice as long to commute a corridor, emitting CO the whole time.

The reader is referred to Appendix E for a region by region trend plot of each of the criteria pollutants.

4. Areas Violating Air Quality Standards

As noted in the previous section, much of our monitoring has been directed towards determining if areas in the state exceed the national ambient air quality standards (NAAQS). There are several areas that currently are classified as non-attainment. Figure 22 shows where these areas are in Washington State. Note that the non-attainment areas are generally grouped around major metropolitan ares such as Seattle, Spokane and Tacoma, adding credibility to the argument that air pollution is where the people are.

STATE OF WASHINGTON
NONATTAINMENT AREAS FOR 1987



B. SUMMARY OF CURRENT AIR QUALITY

Despite our image as a state with clean air, our air resource needs improvement. A number of areas are not in attainment of the national health based standards, several communities suffer from the effects of many different toxic air pollutants mixing together to form an unhealthy soup, and recent evidence indicates that if we were to monitor at sites further downwind of the Seattle-Tacoma metropolitan area, violations of the ozone standard would be likely.

Washington has 7 fine particulate non-attainment areas. Much of the problem in the winter is woodstoves. The Department of Ecology and Washington's local air pollution authorities are national leaders in the regulation of citizens' use of woodstoves. The effectiveness of this fine particulate control strategy has yet to be determined. If such a strategy fails, there is basically no other controllable source from which we can reduce emissions and show any meaningful air quality improvements.

Population is growing and to many commuters our highways are fast becoming pseudo-parking lots during rush hour. Will mass transit ease the burden, or will more roads be built so that more cars can commute to and from crowded cities? Clearly, something needs to be done to improve the air quality in those seven communities which already exceed the CO standard.

The reader is referred once again to figure 21, Washington Trends in Air Quality, in section A.4. above. A similar chart of trends nationwide shows a more striking improvement for the period 1975 to 1983 (see Figure 28 in Section III.B.). Again, this would be expected as we move from control of the obvious, big polluter to much tougher much tougher control strategies such as convincing commuters to use mass transportation in lieu of personal cars and homeowners to utilize heat sources that are less polluting than wood.

In summary, it would appear that we are holding the line for the time being. But we appear to be on the edge, and the slightest of nudges will push us over. Further, it does not appear that there is an underlying policy to prevent exceedances of health based standards - that the infrastructure is geared towards reacting to problems after they are discovered. It is quite likely that with such an approach, we will soon have a number of opportunities to react to problems.

C. POSITIVE ASPECTS OF CLEAN AIR

In addition to being vital to our health and well-being, clean air can be beneficial in two important ways: by providing an attractive environment for future residents and by attracting tourists and visitors to our state.

A recent proclamation by Governor Gardner sums up how Washington's environmental quality attracts visitors. "Whereas, the state of Washington is widely acclaimed as one of the world's most magnificent scenic areas; and whereas, the people of the state of Washington have always considered the purity of the environment as a top priority; and whereas, the natural and unspoiled beauty of Washington is a chief source of pride to the state's citizens and a prime reason for others to visit..." To many people today, quality of life depends to a large degree on quality of environment. It is common to hear of families moving away from polluted areas. Large companies are locating in areas which are likely to attract prospective employees, not scare them away. The migration of people to the Northwest should be no surprise given Washington's environmental reputation.

Tourism has become an important industry in Washington state. Few states can boost of natural resources and scenic vistas even approaching those of Washington. Tourism added $3.7 billion to the state's economy in 1987[7]. We can only speculate on the degree to which Washington's tourism industry might be impacted if Washington suffered from the same levels of pollution as are found in New York or Houston or Denver, or if acid precipitation were to leave many of our alpine lakes devoid of fish and our forests stunted and dying. As it stands, our air quality is perceived by most as being pristine, contribution to a very positive reputation for a tourism point of view. Ironically, considering the impact from tourists joining commuters on many of the state's overcrowded freeways, it could be argued that the more tourists attracted by our clean air (or at least the reputation of clean air), the more the clean air gets polluted.

III. Air Pollution Control Activities

A. REGULATING AIR POLLUTION IN WASHINGTON

1. The Federal Initiative

The first federal environmental law was the first version of the federal Clean Air Act signed into law in 1963. Since then several major amendments have been made including the 1970 Act and the 1977 Amendments. A major reason the federal government initiated air pollution control was to provide some consistency nationwide and prevent States from competing for industry by offering lenient control standards.

In contrast to other major federal environmental legislation, the Clean Air Act does not provide direct funding to solve pollution problems. The Act does provide money to State governments to implement a control program but does not fund control directly. Cleaning up the air was thought to be primarily the job of industry (smokestack industry and automobile manufactures) and that industry should be required to pay for the clean up. As air pollution control is maturing it is becoming apparent that targeting industry alone is not sufficient.

The Act mandates federal regulations to be promulgated to implement portions of the law. The majority of the promulgated regulations specify how the State governments are to implement the law. In 1987 there were over three thousand pages in the certified federal register of regulations pertaining specifically to implementing the federal Clean Air Act (CFR 40 Parts 1-99).

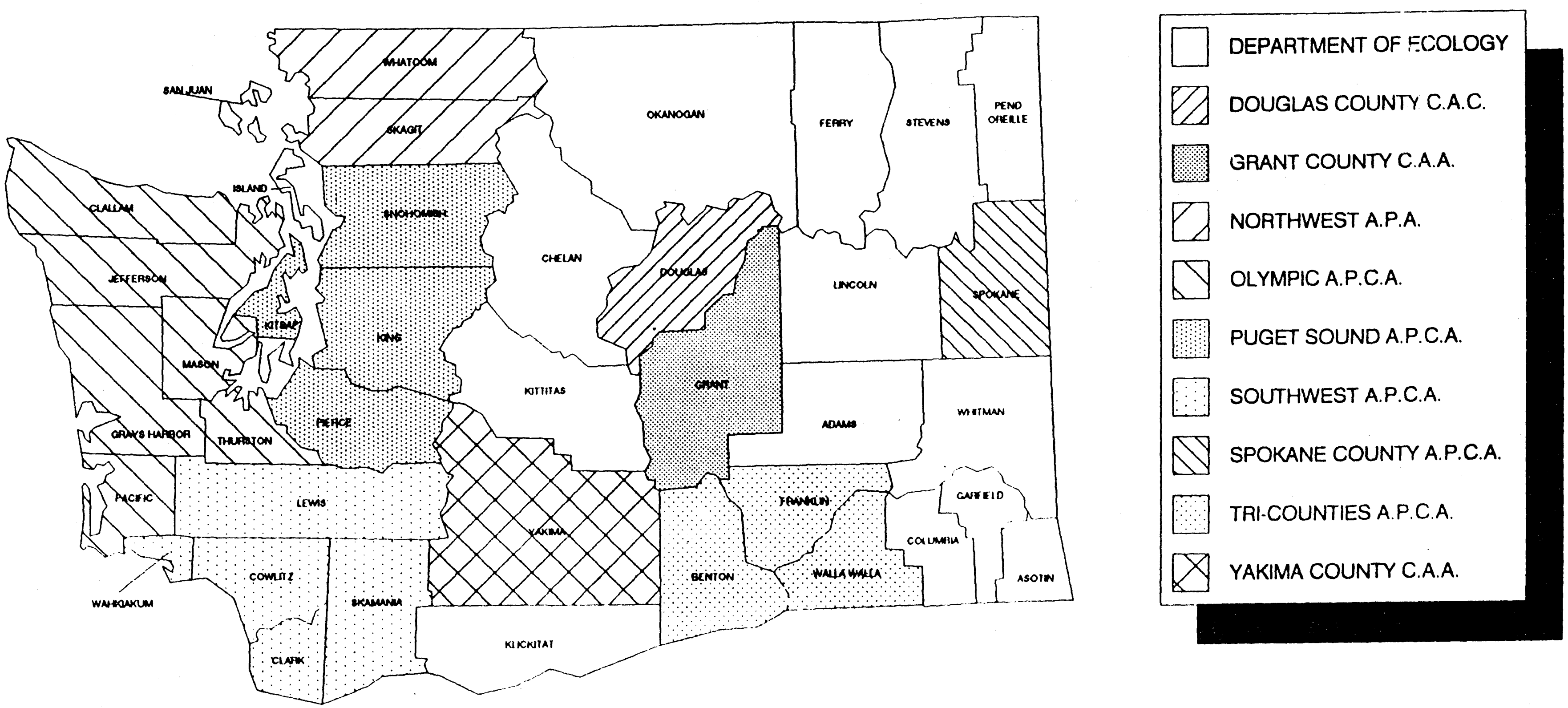
The Act has not substantially changed in almost 12 years even though repeated efforts have been made by Congress. The political volatility of the Act is best demonstrated by the fact that whole sections of the 1977 amendments have expired including the requirement for all national ambient air quality health standards to have been met, nationwide, by December 31, 1987.

2. Washington's Response to Federal Requirements

Air pollution control in Washington is based on a rather complex set of local, state and federal laws and regulations. There are three levels of government involved, each having certain, generally well defined, responsibilities. The federal government, through the Environmental Protection Agency, sets air pollution standards which apply nationally. The State government, the Department of Ecology, is required to implement those standards. In Washington a third level of government, nine local air pollution control agencies, also have broad responsibilities for implementing air pollution control activities within their single or multi-county jurisdictions. Figure 23 shows the jurisdictional boundaries of Washington's air pollution control authorities.

STATE OF WASHINGTON

LOCAL AIR POLLUTION CONTROL AUTHORITIES



All federal legislation and regulations apply, and are therefore legally enforceable, from the federal level to the State and local levels. All State legislation and regulations apply to the State and local level. And finally regulations adopted at the local level are enforceable by the local government except where specific local regulations are adopted by the State and/or federal government. The vast majority of the regulations are essentially the same at the federal, state and local levels and are therefore enforceable by all three levels of government.

A total of 22 regulations form the basis of the Washington program and are implemented and enforced by the Department of Ecology. The nine local air pollution control agencies also implement and enforce most of the State regulations. Some of the agencies have additional regulations that are more restrictive than those of the Department of Ecology.

Ecology has developed over the past twenty years a comprehensive set of air pollution control regulations. The major regulations set up a new air pollution source review system with emission standards, specifies the details of an inspection and maintenance program for motor vehicles, adopts a set of ambient standards some of which are more restrictive than the federal requirements, and establishes specific requirements for certain air pollution sources.

Washington's regulations, in general, meet the requirement that they provide, at a minimum, and equivalent level of control as federal requirements. However as the federal requirements change and become more complex it becomes more and more difficult to amend and correct the regulations. One major federal requirement which is not being met in Washington is the establishment and implementation of a renewable, fee-based permitting system for new and existing sources.

Hundreds of chemicals are routinely emitted into the air that may present public health risks. The Clean Air Act Amendments of 1970 required EPA, under section 112, to set national emission standards for hazardous air pollutants. EPA has moved slowly in implementing Section 112 of the Act issuing only seven standards in seventeen years. Delays have been attributed to shifts in EPA policy, uncertainty about the type and amount of scientific data needed to support regulatory action and time consuming development of technical and cost information.

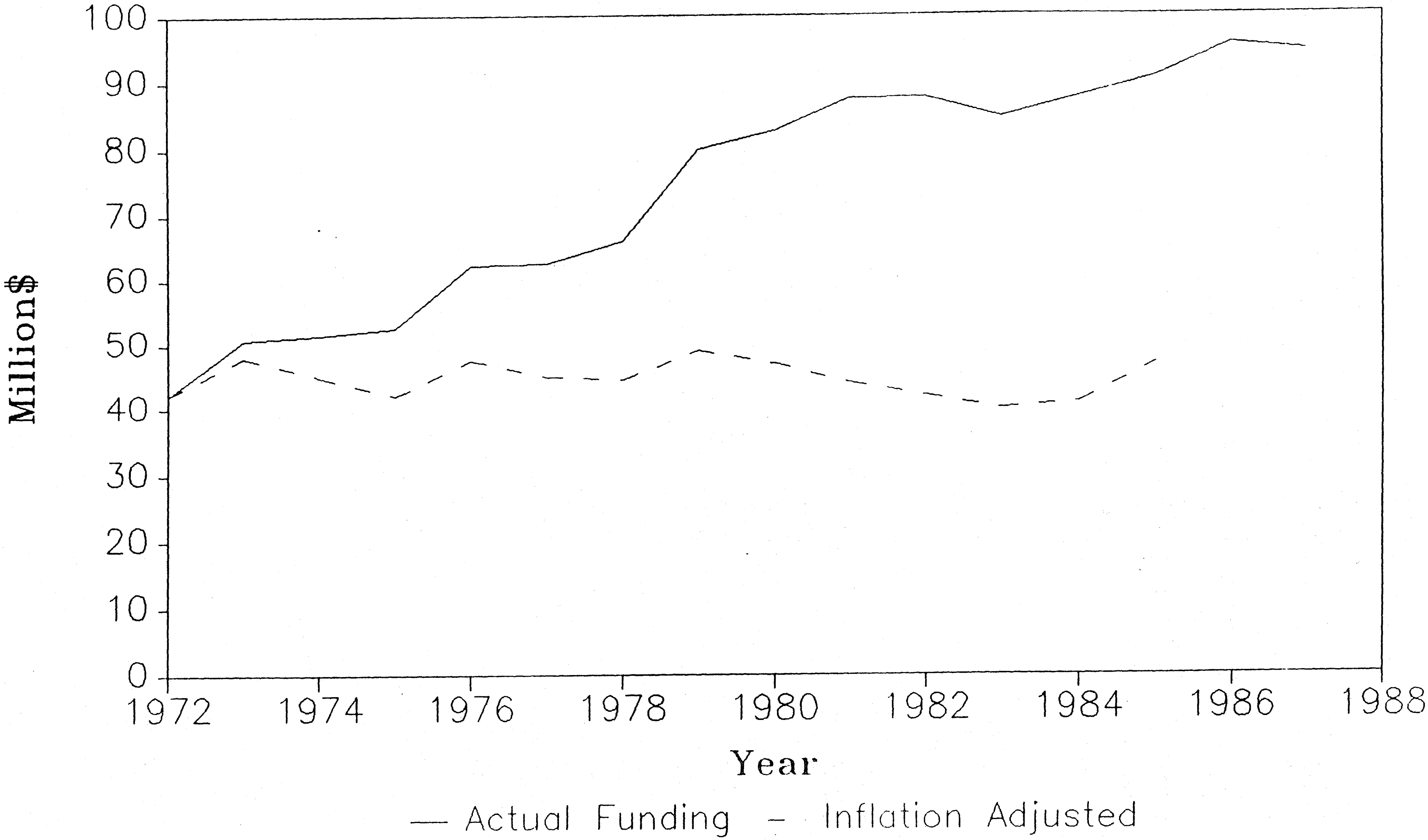
After 1983 congressional hearings concerning the delays, EPA conducted a broad study of the air toxics problem. EPA concluded that public exposure to air toxics presented risks to human health that required an aggressive response. A new strategy was developed which depends on the states to regulate air toxics and sources that do not represent a national problem. Currently, there are many states with air toxics programs in place or under development. Washington is currently developing regulations for controlling new sources of air toxics.

3. The Resource Dilemma

There is little question that air pollution control has become more complex over the years. As we moved from cleaning up the obvious, often uncontrolled sources to trying to clean up that last one or two percent, we are finding that each new step is not only very costly but also technically complex. As the technology advances, state and local regulators are finding it increasingly difficult to maintain the technical competence to insure that the decisions that are made and the approvals that are given are sound and based on the most current technical basis. Maintaining an adequate staff of competent professionals has become a costly challenge to many state and local air pollution control agencies.

Meanwhile, the responsibilities of the state and local agencies has increased dramatically since the early 1970's. Air toxics, acid deposition, asbestos and the control of fine particulates are but a few of the programs that have been added to what for most agencies was an already full plate of activities. Nationwide, funding of air pollution control efforts has increased since the early 1970s. The picture, however, differs considerably when we look at the inflation-adjusted funds going into the ever-more complex air pollution control effort. The difference is shown graphically in Figure 24.

Figure 24
HISTORY OF FUNDING
FEDERAL GRANTS TO STATE PROGRAMS



Source: EPA Air Resources Study
(a:funding/funds)

The picture looks much the same in the state of Washington, with one important difference. Most states have responded to the decreasing federal contribution for air pollution funding by increasing source permit fees. In spite of the fact that the 1977 amendments to the federal Clean Air Act require all states to implement a fee based program, a handful of states, including Washington, lack such a program. Under the circumstances, it is essential that regulators make good decisions about which issues are most urgent, and thus most important from a funding standpoint.

4. Other Air Pollution Regulations

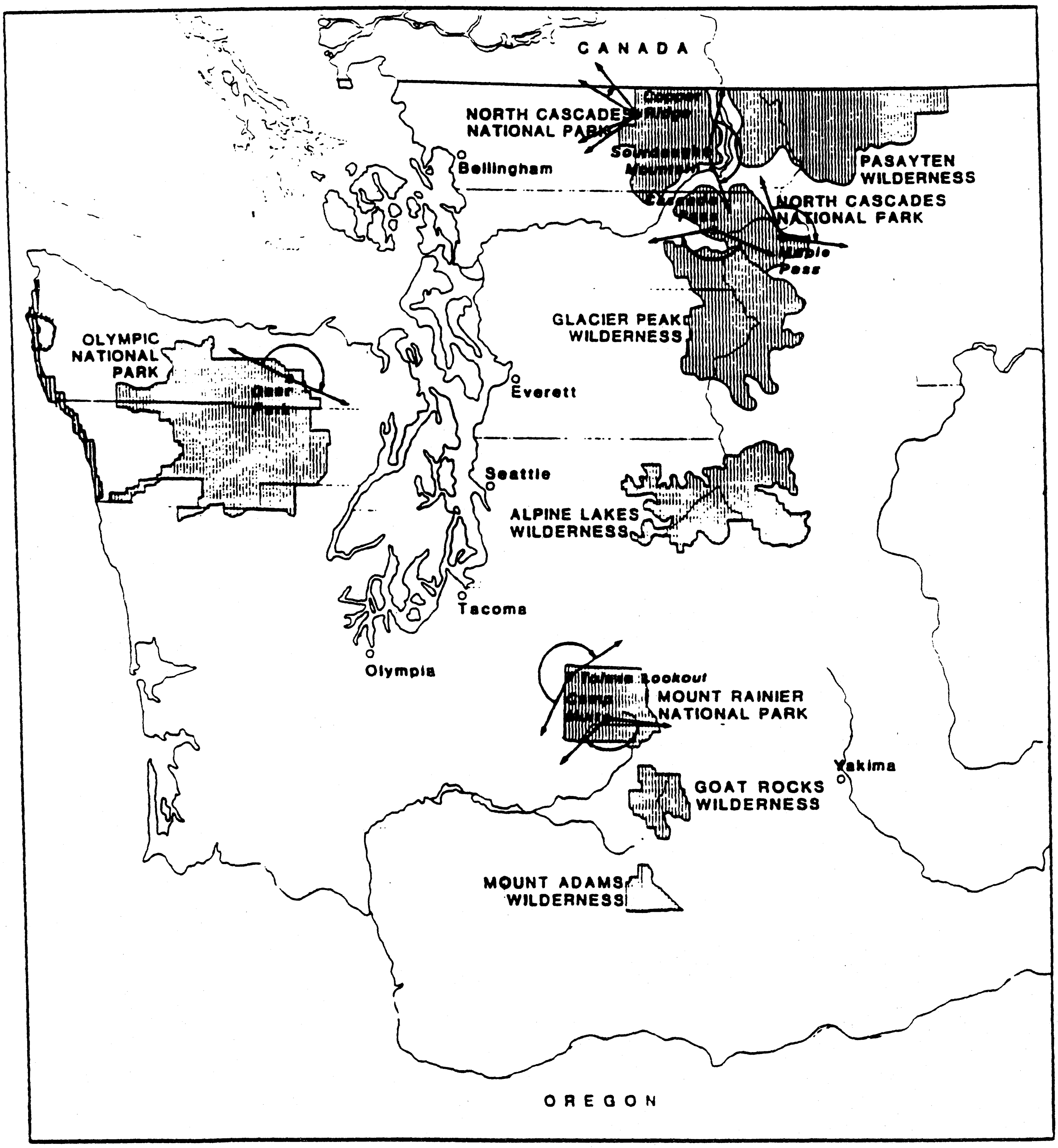
In order to provide visibility protection to the state's Class I federal visibility areas (see Figure 25), the Department of Ecology has developed revisions to the State Implementation Plan for the control of air pollution. These revisions implement new programs, procedures, and regulations that will assure visibility protection to the state's scenic parks and wilderness areas.

The key control strategies include amendments to regulations for existing and future stationary sources and the development of programs and procedures for prescribed burning.

The control strategies for prescribed burning include scheduling of burns and reduction in total emissions. Prescribed burning that could impact Class I areas will be greatly restricted during visibility important days. The forest land managers have established an objective of reducing total emissions form prescribed burning in western Washington by 35 percent by 1990. Progress evaluation will be conducted every third year to assure that reasonable progress is being achieved by these control strategies.

State of Washington

FEDERAL CLASS I AREAS WITH INTEGRAL VISTAS



Woodsmoke control. Washington's woodstove law, arguably the most comprehensive in the nation, is an example of the type of regulatory approach we can expect to see in the future. The law limits sales of woodstoves to certified clean burning stoves, restricts burning during periods of impaired air quality as determined by local air pollution officials, and requires individuals to burn only properly seasoned wood. In spite of its comprehensive nature, this law will have little impact without the willing cooperation of the individuals burning the wood. There simply are not, and probably will never be, adequate enforcement staff to ensure a high level of compliance in all communities at all times. Ultimately, the success of such a regulatory approach will depend on the extent to which the citizens understand that they are the source of the problem, and the extent to which that understanding translates into an "environmental ethic" - that is, a willingness to voluntarily comply with a curtailment request with or without the threat of civil penalties. Given the fact that woodstoves are the primary contributors of several air pollutants, we are relying on this regulatory experiment to work. If it does, it may well become a model for future regulatory actions designed to control "people sources" of pollution.

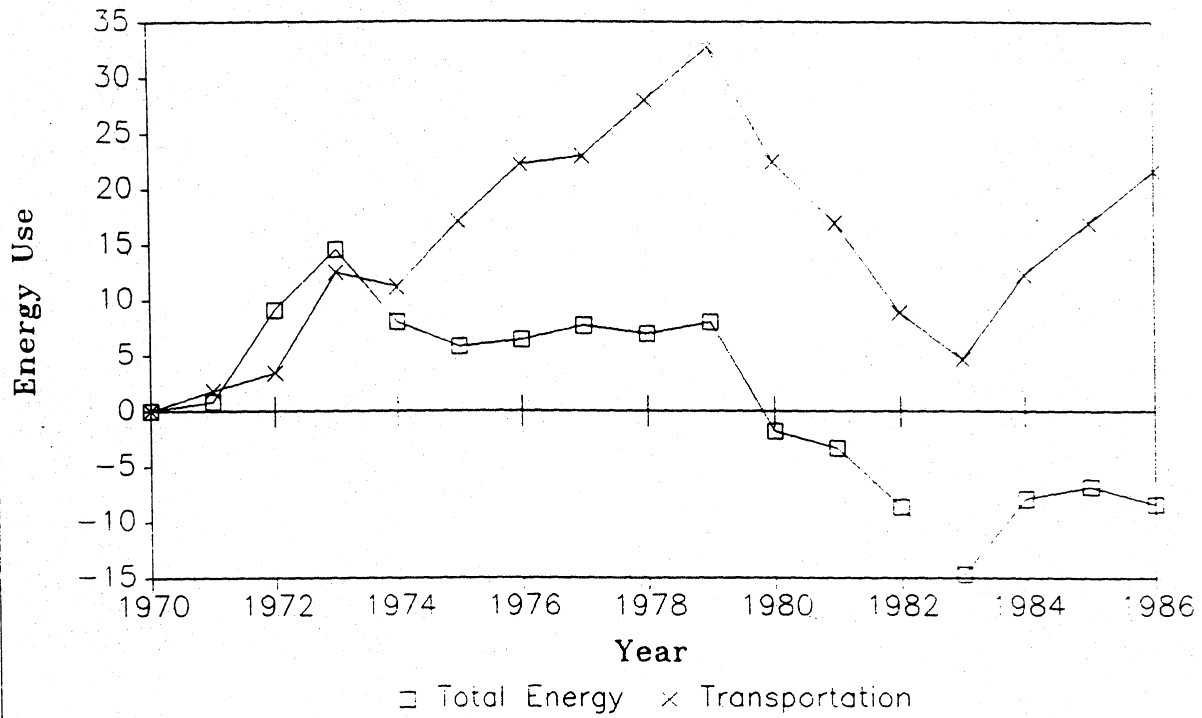
The Smoke Management Plan. In 1970, the Washington Department of Natural Resources, USDA Forest Services, Washington Forest Protection Association, Bureau of Indian Affairs, and the Washington Department of Ecology adopted a comprehensive smoke management program (the Smoke Management Plan) for managing smoke from prescribed burning on forest lands. The purpose of the program was to maintain high levels of air quality in densely populated and smoke sensitive areas throughout the burning season. In 1971 the Department of Natural Resources (DNR) was given sole authority for issuing and regulating burning permits for abating forest fire hazards and improving land for silviculture operations. DNR was further required to condition the issuance of such permits to comply with air quality standards established by the Department of Ecology. The Smoke Management Plan was amended in 1975, 1983, and 1985 to make the program more effective and to comply with federal Clean Air Act requirements for visibility protection.

It was widely predicted in 1970 that prescribed burning (i.e. slash burning) as a means of handling forest debris would end within 10 years. As of 1989, slash burning is still common practice. In 1986, the last year for which complete data is available, over 1,200 prescribed slash burns were set on over 84,000 acres. Though this represents a significant reduction in acreage relative to 1976 (approximately 20% less), prescribed burning still accounts for a significant percentage of the total emissions of some pollutants (see Section B. Threats to Air Quality). Furthermore, recent studies have shown that impacts from slash burning can cause violations of the national ambient air quality standard for fine particulates. In addition, there is evidence that summertime visibility impairment, as measured by the Department of Ecology's visibility monitoring network, is directly related to slash burning activity. All of this suggests the need to reassess the Smoke Management Plan in terms of its effectiveness as an air quality control program.

B. SUCCESSES IN THE CONTROL AND PREVENTION OF AIR POLLUTION

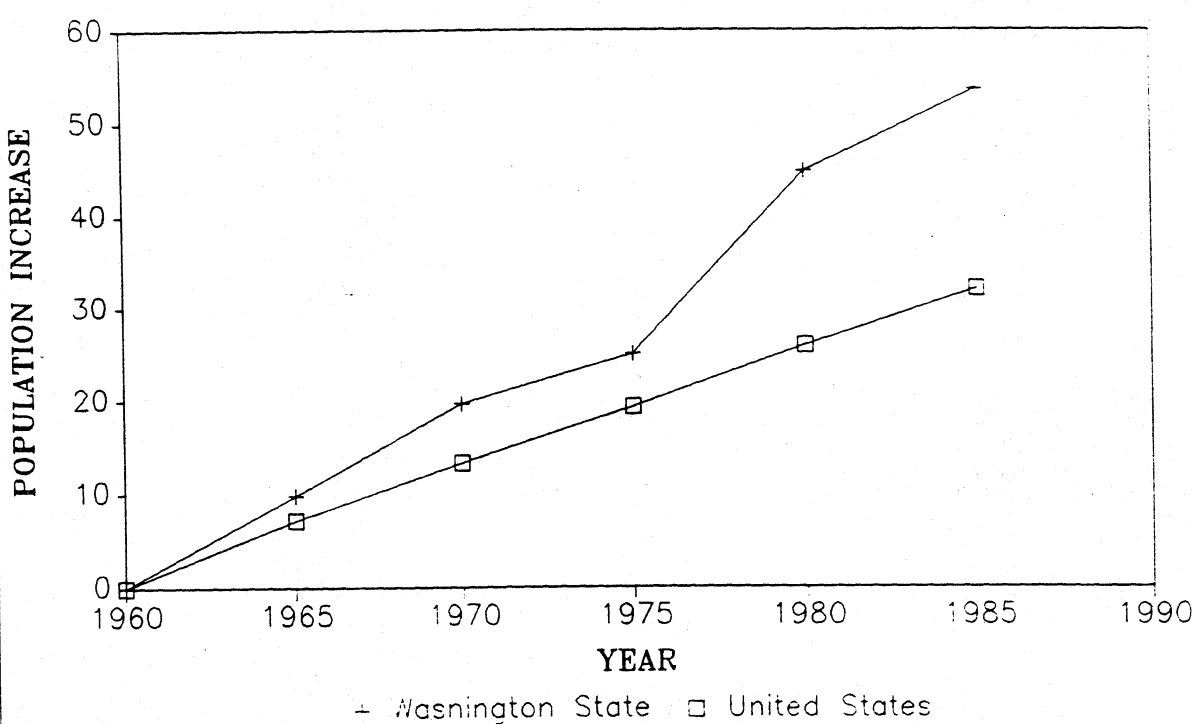
There is a clear relationship between increasing population, energy demand and air pollution. Despite a concerted effort to become more energy efficient, our per capita energy consumption has not improved (see figure 26) and Washington's population continues to grow at an even greater rate than the rest of the nation (figure 27). If Washington's vision of the future is not to be shrouded in dirty air, we will be depending more than ever on our ability to control emissions and our willingness as individuals to change our lifestyles in such a way that we have less impact on the air that we breathe.

Figure 26
YEARLY PER CAPITA ENERGY CONSUMPTION
PERCENT CHANGE RELATIVE TO 1970



Million Btu Per Capita
Source: Wash St Energy Use Profile
a:ener/energy

Figure 27
POPULATION GROWTH IN WASHINGTON STATE
PERCENT INCREASE SINCE 1960

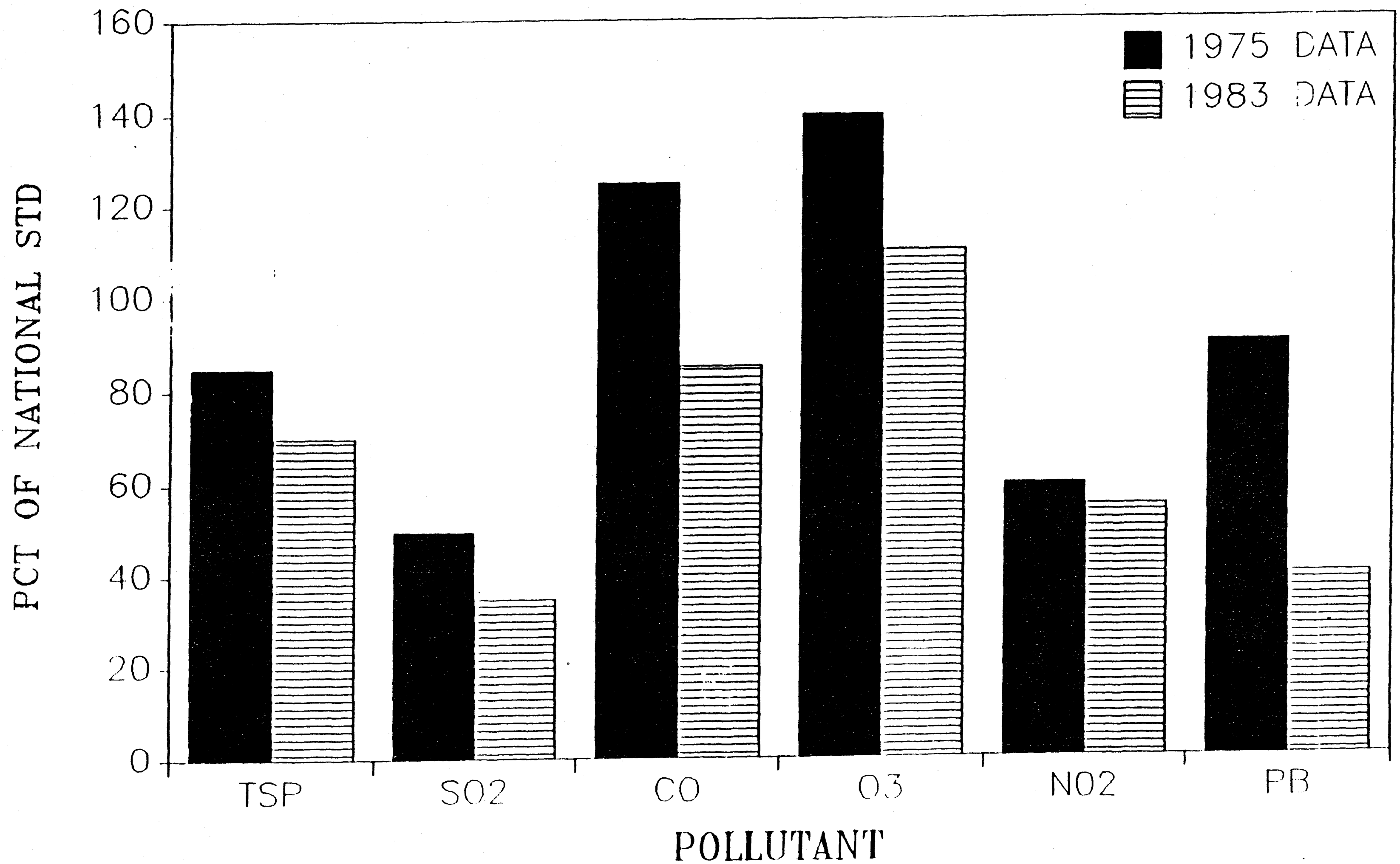


Source: Wash St Energy Use Profile
a:pop/poprate

Though future air pollution problems will be hard to solve, we can be encouraged by the fact that we have had some air pollution control successes over the past twenty years. Nationwide from 1977 to 1986, particulate levels decreased 23%, sulfur dioxide 37%, nitrogen dioxide 14%. carbon monoxide by 32%, and ozone levels decreased by 21%[8]. Ovcr the same time periods in Washington, similar progress has been made (see Figure 21 and Appendix E for details). Figure 28 graphically displays the improvement nationally in criteria pollutant air quality.

Figure 28

NATIONAL TRENDS IN AIR QUALITY



Source: USEPA
a:aqtest/testaq1

1. Getting the Lead Out - A Shared Success

Lead is a pollutant that is particularly toxic to young children. Unlike most other pollutants such as sulfur dioxide and ozone, lead has a particularly harmful effect on growing children. The EPA recognized the unique toxicity of lead when it set national ambient air quality standards for lead. The standard was set to keep the blood levels of lead in children below toxic levels. At the time the standard was set in the mid-1970's, the primary source of lead nation-wide was lead in gasoline. Many areas near heavily traveled freeways exceeded the standard of 1.5 ug/m^3. Seattle was no exception.

But lead from gasoline wasn't Seattle's only problem. A secondary lead smelter in an industrial area in Seattle also caused air quality standard violations. To correct the problem the Department of Ecology, the Puget Sound Air Pollution Control Agency, and the EPA cooperated in a plan. To reduce the emission from cars and other gasoline powered vehicles, EPA developed and implemented a program aimed at lowering the amount of lead in gasoline. This strategy reduced the concentration of lead in the air near I-5 in Seattle from over twice the standard to about one third the standard. Nationwide, between 1977 and 1986, ambient levels of lead in the air declined by 87 percent and emissions decreased by 94 percent.

The secondary lead smelter caused ambient levels as much as ten times the standard. The emissions not only came from the stacks and the process, but from the lead laden dust carried out by the trucks. Through better pollution control equipment, plant operation and maintenance, and changes in the smelting process, the area now meets the lead ambient air quality standard.

This example demonstrates that several levels of government can work together to achieve reductions in emissions from a variety of source types - in this case, cars and point sources. It also showed that we can accurately predict the impacts of reducing emissions from these sources This is important when one considers that, if we are inaccurate in our predictions we either fail to bring the air quality to acceptable levels or, conversely, overregulate, which can prove to be very expensive.

2. CO - A Tale of Two Cities

Carbon monoxide is a colorless and odorless gas that affects nervous and respiratory systems. Transportation sources (basically the cars that we drive) are the primary sources of carbon monoxide. Because of traffic and congestion, most urban areas in the country have high ambient levels of carbon monoxide. The greater Seattle area is no exception.

Since Ecology first started measuring CO levels in Seattle violations of the national ambient air quality standard have been measured. In both 1976 and 1977 there were more than 150 days above the standard. In those years the highest levels were more than twice the standard.

To correct this problem, in the mid 1970's Ecology, in cooperation with local government, developed a plan for lowering the CO levels in the Seattle area. Major parts of the plan included an automobile inspection and maintenance (I/M) program targeting most of western King County and transportation control measures such as increased use of mass transit and carpools.

The progress in lowering CO concentrations in Seattle has been significant. From 157 days above the standard in 1977, there was only one or two in 1986 and 1987 while the highest concentrations are today only about half of the 1977 levels.

Other parts of greater Seattle have not done as well. Even with the reduction in emissions from the I/M and federal new car standards, areas like Bellevue have not shown such a significant improvement in air quality. Though transportation control measures were included for this area, such measures were significantly more effective in Seattle where parking costs were high and transit service reasonably good. Bellevue CO levels remained constant or slightly increased since we first started measuring CO in 1978. The days per year with violations ranged from two to eight with no clear trend. Because most of the cars in Bellevue are under the same I/M program as the cars in Seattle it is likely that the transportation control measures in Seattle are the biggest difference between the two cities. One could only speculate what the air quality in Bellevue would be if Bellevue adopted similar transportation control measures.

The reader is referred to sections I. and II., Background and Current Status and Trends, for a more complete discussion of CO concentrations, emissions and trends.

3. The "Smell" of Success at Pulp Mills

The most significant sources of odor is Washington have for years been the state's kraft pulp mills. The kraft pulping process produces a very odorous class of chemicals called reduced sulfur chemicals. These gases have a "rotten egg" smell and can be smelled at very low concentrations, less than one part in a billion. Before the state set the first odor control regulations in about 1970, it was common to smell the kraft pulp mills ten to twenty miles away.

Both Washington and Oregon saw a need to control the emissions from kraft mills. We also saw advantages in developing standards jointly. As a result of a joint effort of the two states and the industry emission standards were developed for recovery furnaces. These standards required reduction of emissions by about 95% from the recovery furnaces and allowed the industry time to develop, design, and install new equipment. To comply with the new standards many of the pulp mills installed new recovery furnaces which cost as much as $100,000,000 in today's dollars. The regulation also required the mills to study other emissions sources and report back to the Department of Ecology. These studies showed that after reducing the emissions of reduced sulfur compounds from recovery furnaces by a factor of twenty or more, other sources such as lime kilns and digestors became major sources. By the mid- 1970s Ecology reviewed the information and set new emissions limits including much lower levels from lime kilns and requirements to treat the gases from the digestors. In the late 1970's EPA proposed and Washington adopted even more stringent standards for both new and existing kraft mills. These current standards limit the emissions of reduced sulfur compounds to five parts per million (5 ppm) or about one hundredth the amount that an average recovery furnace emitted before controls were first required.

Kraft pulp mills in Washington still have the distinctive odor of rotten eggs, even though the emissions have been reduced by as much as a factor of one hundred. Maybe we will never be able to eliminate the odor, but we have significantly reduced the amount of odor and made the surrounding areas more livable.

4. Controlling Fluoride - A Washington Success

Fluoride is a toxic pollutant which, at very high levels, can affect cattle and crops. For this reason we classify it as a welfare related pollutant. Health related pollutants directly affect human health. In Washington, the major source of fluoride emissions are our state's seven primary aluminum smelters. The aluminum smelters in Washington produce about thirty percent of all the aluminum refined in the country.

At one time fluoride emissions from the aluminum plants caused crop damage and cattle illness. On their own the aluminum plants reduced their emissions as the body of evidence became clear. In the late 1960's, Washington state saw a need to reduce the emission further. The Department of Ecology worked with the aluminum industry and citizen's groups to develop new emission standards for the industry in Washington. Standards were set for both ambient air quality and the amount of fluoride in forage. These standards were among the first in the country. Although they have not significantly changed in almost twenty years, the standards are still among the most stringent in the country. Prior to setting standards for new aluminium plants, EPA came to Washington to look at our existing plants for examples of the best control technology available. The industry developed new technologies for controlling both fluoride and particulate emissions while at the same time reusing both. For most plants the savings gained from controlling fluoride and particulate emissions offset a substantial portion of the annual operation costs of controls.

Ambient levels of fluoride have been reduced considerably and, unlike the situation that existed before the implementation of these standards, there are no longer lawsuits against the aluminum plants claiming damage to crops or cattle.

5. Motor Vehicles - Improving but More Work Remains

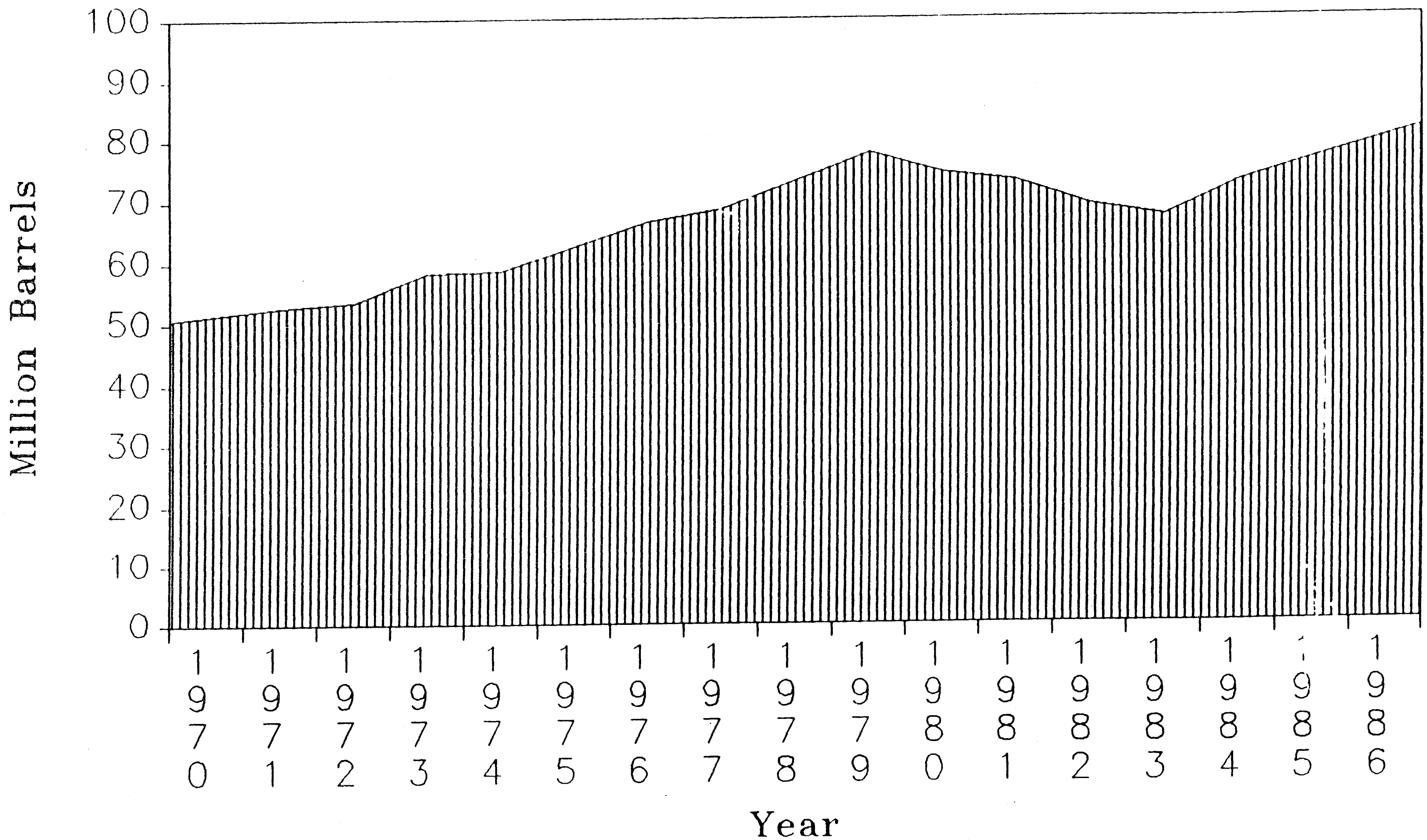
In the Environment 2010 Comparative Risk Project - Ambient Air Pollution, it was estimated that over 1,700,000 people live in areas that exceed the federal standard for carbon monoxide (most of which comes from motor vehicle tailpipes), and that over 3 million people are exposed to elevated levels of ozone during the warm summer months. Ozone is formed in the atmosphere when sunlight triggers chemical reactions between naturally occurring atmospheric gases and pollutants such as volatile organic compounds (VOCs) and nitrogen oxides. VOCs are released into the air through the combustion, handling, and processing of petroleum products. Nitrogen oxides are also produced by combustion sources, including motor vehicles.

One simple way to reduce both CO and ozone levels would be to reduce driving, thus reducing both tailpipe emissions (CO and NOx) and VOC emissions by reducing the amount of fuel that needs to be refined, stored, delivered and pumped into cars. The driving public has been reluctant to reduce, and in fact have increased their driving in recent years, as is evident from the steady increase in consumption of motor fuels (figure 29)[8]. Nationwide, Americans increased their driving by almost two billion vehicle miles between 1980 and 1984, and in Washington, motor fuel consumption increased by nearly 30% between 1970 and 1986, despite a dramatic improvement in fuel efficiency over that period of time[9].

Figure 29

TRANSPORTATION RELATED FUEL CONSUMPTION

IN WASHINGTON STATE



Source: Wash St Energy Use Profile
a:gasdata/gasplot

As can be seen by the ozone and CO trend plots in Appendix E, ambient levels of both these pollutants have been declining. This is due in large measure to the Federal Motor Vehicle Control Program, working in concert with Washington's motor vehicle inspection and maintenance (I/M) program. Since federal emission standards were first set for 1968 model passenger cars, both CO and hydrocarbons (VOCs) have been reduced by 96 percent from the uncontrolled cars of the sixties. The I/M program contributes an additional 24 to 28 percent reduction in CO and VOC emissions from the tested vehicles each year[10].

Despite the success of both the federal new car program and the state I/M program, in the absence of either significant reductions in vehicle miles or more stringent new car standards, increases in both ambient CO and ozone are likely in many areas of the state.

C. OPPORTUNITIES ARISING FROM SUCCESSFUL AIR POLLUTION CONTROL EFFORTS

Until recently, the quality of life in America was measured by the extent to which our economy grew and our businesses prospered. The business of America meant large factories - the so-called smokestack industries. And until recently, one could almost measure how prosperous a community was by the degree to which the air was filled with soot. The attitude was, "Business is business, and business must grow, regardless of how dirty the air gets, you know", to paraphrase a well known children's author.

The economy has changed in recent years. More and more of the nation's gross national product goes to "clean" services, and the competition between communities to attract such industries is keen. While product based industries were often limited in their choices of where they could locate based on the availability of natural resources (i.e., cheap hydropower for aluminum smelting and wood supplies for paper pulping), service based industries generally aren't so limited. Their choice will often come down to which area offers the best "quality of life" for the firm's current and prospective employees.

When it comes to quality of life, Americans are now far more concerned about environmental issues, and perhaps foremost among those is air quality. What opportunities does clean air provide? How important is a view of Mt. Rainier or Glacier Peak from the deck of a ferry on Puget Sound? What is the difference between flying into the Seattle or Spokane airport on a clear summer day compared to descending into a smog shrouded Denver or Houston? All else being equal, air quality just may be the deciding factor in the choice of which state will become the home of the next Microsoft.

In 1987, an economic consultant studied Pierce County's economy. The Department of Trade and Economic Development wanted to know how the county's economy could be stimulated. Among the findings was a conclusion by the consultant that Pierce County, and in particular, Tacoma would be hard pressed competing with other communities as long as their air quality was poor, or perceived to be poor, by potential businesses. Much of that perception is based on the so-called "odor of Tacoma" from the town's pulp mill. What opportunities are created from clean air? A task force with representatives from county and city government, business and the public in the Tacoma area have worked for over a year to hammer out a series of recommendations which they hope will improve the air quality, and ultimately the quality of life in their community. Clearly, in their view, their efforts to improve air quality will provide substantial economic opportunities for the community.

IV. Future Impacts on Air Quality

A. POPULATION GROWTH AND SHIFTS IN THE LABOR MARKET

Washington's population has grown at a more rapid rate than the nation's as a whole (see Figure 27, Section III.B.). This is particularly significant as it relates to air quality because so much of the pollutant emission budget is directly related to "people pollution" - motor vehicle emissions and wood burning pollution are two prime examples. Equally important from an air quality standpoint are the emissions resulting from our demand as consumers for more products and services. More people mean more homes, aluminum cans, lumber, paper, dry cleaning, and all the other assorted goods and services which result in incremental contributions to air pollution emissions. Generally, we have assumed that as the population increases, air emissions will increase proportionately. The notable exception to this is transportation related emissions, where both vehicle fueling and miles traveled are likely to increase at twice the rate of population growth (see Section V.A. for further discussion).

With regard to shifts in the labor market, few such shifts would result in significant impacts to the air resource, though on a localized basis pollution levels can be profoundly effected by even small businesses. On a regional basis, however, monitored air quality would not be expected to change significantly strictly due to changes in the labor market.

For a complete discussion of our projection of population increases in each of the air quality control regions, and the resulting projected increase in air emissions, the reader is referred to Appendix E (population) and Appendix G (emissions). Key data from these tables are summarized below:

Projected Population and Emission Changes
from 1988 to 2010

Region	Projected Population Change (%)	Projected Emission Change (%)*
Olympic - NW	25.12	45.8
Southwest	14.64	31.0
South Central	2.60	36.0
Northern	11.80	19.1
Puget Sound	29.92	53.7
Eastern	8.72	15.7

* - Total of all pollutants

B. CHANGES IN TRANSPORTATION PLANS

1. Motor Vehicles as Sources of Air Pollution

The use of motor vehicles is either the largest or one of the major sources of air pollution in most urban areas in Washington. The carbon monoxide health standard is being violated in at least seven urban areas in Washington and motor vehicle exhaust accounts for almost all of the pollution.

Even just the movement of vehicles can cause air pollution problems. For instance the use of motor vehicles contributes to the particulate (PM-10) pollution problems in some urban areas by causing dirt on roadways to be thrown into the air.

In addition to exhaust emissions and emissions from movement on roadways, motor vehicles cause emissions of significant amounts of volatile organic compounds, which react with other chemicals to form ozone. The fueling of vehicles and leakage of vapors from hoses and carburetors on the vehicle cause harmful emissions.

The federal new car emission standards are the same today as they were in 1981. Therefore any additional reduction of emissions from tailpipes must come from post 1981 cars replacing the higher emitting pre-1981 cars. In areas where population is increasing it is easy to understand how more vehicle use may quickly offset any decreases from newer cars replacing older cars.

In an attempt to maximize the effectiveness of the federal new car standards Washington has been implementing a vehicle inspection and maintenance (I/M) program. It is well known that the efficiency of federally required vehicle emission controls deteriorate with age and use. To minimize this deterioration motor vehicles in two urban areas (Seattle and Spokane) are required to have the emissions checked and adjustments to the vehicle made if necessary. This State program is helping ensure that the emission controls from the federal program will continue to operate through the life of the automobile.

2. Mitigating the Impacts of Growth

While the federal new car standards, with I/M assisting in their implementation, are effective in reducing emissions, they cannot necessarily be expected to be adequate in areas of growth. Without offsetting emission reductions, growth will inevitably result in ever increasing air pollution.

Several areas in Washington have been experiencing significant growth. In the Seattle-Tacoma-Everett metropolitan area, between the years 1980 and 1988 the use of motor vehicles increased by 77%, while population only increased by 14% during that time. Even with this tremendous increase in traffic, the number of days of violation of the carbon monoxide health standard at several monitoring sites did not clearly demonstrate any significant trend either increase or decrease. In the years up to 1982 however there was a clear indication of a decrease at the Seattle site (112 violation days in 1972 and 2 days in 1982). Also of interest is the lack of an increase or decrease trend at the Bellevue monitoring site, where there have been between 2 and 8 violation days per year since 1978 (3 in 1978 and 4 in 1987).

While it is difficult to draw any quantitative conclusions from this information it is logical to say that in the face of high traffic (and therefore potential automobile pollution) increases at several carbon monoxide monitoring sites held relatively constant. Some combination of offsetting reductions must have been implemented successfully for this lack of increased air pollution.

The Seattle area has been particularly aggressive in implementing transportation projects which help alleviate traffic congestion and therefore decrease air pollution from motor vehicles. Carpool/vanpool programs, exclusive bus and carpool lanes, improving the mass transit system all are really air pollution control measures. Because analysis of air pollution is an inexact science it is difficult to quantify reductions from any one control measure. However it is possible from an intuitive standpoint to say that air pollution would be much worse had the measures not been implemented.

Prompted by new state legislation allowing for the continuation of motor vehicle emission inspection and maintenance (I/M), an analysis will be performed in the next several months which will better indicate the impact growth, I/M and other control measures on carbon monoxide levels in several urban areas in Washington.

V. Air Quality in the Year 2010

The Environment 2010 Committee estimates that population will increase 32% statewide between now and the year 2010. In the following sections we will project the impact this increase in population will have on future air quality. An analysis of impacts projected to the year 2010 for each of the air quality control regions is included in Appendix G.

A. Assumptions

There are several factors which will significantly influence air pollution emission rates - changes in motor vehicle usage and fuel consumption, economic activity (especially in industries that are significant sources of air emissions), changes in how residents heat their homes, mass transit ridership, effectiveness and durability of control devices, to name a few.

Though we could project how each of these factors might change over the next 20 years, and from those projections estimate the net increase or decrease in pollutant emission rates, there are inherent uncertainties with each of these projections. We feel that we can be at least as accurate by making a few simplifying assumptions.

<u>Transportation Related Emission Sources.</u> In spite of an impressive improvement in motor vehicle fuel efficiency, fuel consumption has increase significantly in recent years (see figure 29). Fortunately, vehicle emission rates improved over the same period, resulting in a general improvement in carbon monoxide and, to a much lesser extent ozone monitored levels (refer to figure 21). Future improvements in emission rates from new vehicles are not anticipated in this study, however, and we are forecasting vehicle miles traveled (VMT) to increase faster than population. Over the last 17 years, VMT nationwide increased 65% while population increased 20%. Based on this 3 to 1 ratio and the projected 32% population increase, we would forecast an increase of 104% in VMT between now and the year 2010. Offsetting at least a part of this increase would be the limitations in carrying capacity of our highways. For the purpose of this study, we estimate VMT growth, and therefore transportation related emissions growth, at twice the rate of population growth - 64% statewide between now and the year 2010.

<u>Non Transportation Related Sources.</u> In the absence of additional pollution control efforts, as the population increases, so too does the pollution. As we build more homes, we install more fireplaces and demand more from the factories and businesses that supply the products we need. We assume for the purpose of this study that non-transportation related emissions will increase at the same rate as population.

Current Trends. Our projection of future air quality begins with an analysis of current trends. Population and transportation related trends will be adjusted by the extent to which current monitored values are trending upwards or downwards. This analysis used the ten years of ambient data taken in the Puget Sound AQCR as described in Section II.A.3. Although the use of the 25th highest measured concentration reduced the scatter in the data, additional analysis was required to determine trends. For such a limited amount of data, the exploratory analysis technique of using running medians is especially useful. The resulting trends for carbon monoxide, particulate matter, and sulfur dioxide are clearly seen in Figures 30, 32, and 33. The ambient concentrations of ozone are highly dependent on the highest temperatures recorded during the year and, as Figure 31 clearly shows, the trend in ozone concentration is uncertain.

Natural Sources. Not all air pollution sources are manmade. Any analysis of pollutant sources should include and accounting of natural sources - volcanos, forest fires, biological processes, etc. With these estimates, we can predict the impact on air quality that an increase in emissions from one source type would have. This study assumes the following percentages of natural source emissions to the total.[11]

CO: 10% from forest fires, oceans, terpene reactions, etc.

VOC: 50% from biological processes

TSP: no estimate; negligible in urban areas, significant in rural environments

SO2: negligible; principle source volcanos.

Toxic Pollutant Emissions. We will assume for the sake of this study that trends in toxic air pollutant emissions can be predicted using criteria pollutant trends as a surrogate. Motor vehicle tailpipe emissions are the primary source of carbon monoxide (see figure 13). A number of other pollutants come from internal combustion engines - nitrogen dioxide, lead, toluene, benzene, xylene, and formaldehyde. Ozone trends might be followed by any volatile organic, many of which are toxic, while SO2 trends might be representative of emissions from smokestack industries. Given the lack of historical toxic emission data, our projections of future air quality will be based of our projections of criteria pollutant air quality.

B. AIR QUALITY IN THE YEAR 2010

In this section, we will project the status of the air resource in the year 2010 using the Puget Sound AQCR as our example, a region in which over half the state's population resides, in which a majority of the air pollutants are emitted and an area that has been extensively monitored over the years.

In addition to the significance of the Puget Sound Region in terms of population and industrial activity, our most accurate emission estimates are generally from this area, where a number of emission samples have been taken (typically a far more accurate emission estimation method than the ordinary factoring approach). Each air quality control region differs to some extent - emission sources vary, populations are projected to change at different rates, etc. Projected air quality for each of the six regions was derived from data in Appendix F and G, and are summarized below.

The basic formula used to project 2010 air quality levels is as follows:

$$\text{2010 Estimate} = C * (1+ F*P) \qquad (1)$$

where:

C = Current monitored value ("25th" value)
F = Fraction of total emissions manmade (not natural)
P = Projected fractional increase in emissions, as determined in equation (2) below.

and:

$$P = Pop * (1 + F_t) \qquad (2)$$

where:

Pop = fractional increase in regional population
F_t = fraction of total emissions from transportation related sources.

Note that Appendix G lists, by source type (transportation or non transportation related), emission sources within each region. From this compilation, F_t, the transportation related fraction, can be determined.

As noted above, this equation was adjusted in our analysis to account for current trends. To do this, we estimated the slope of the current trendline (the rate of decline or increase) and "overlayed" the estimated growth-related estimates. For example, if the current trend of a given pollutant were declining at the rate of 1 ppm every 4 years, and our growth related increase were 1.5 ppm every 4 years, the net projected increase would be 0.5 ppm every 4 years, or 2.75 ppm between 1988 and the year 2010.

1. Carbon Monoxide.

Referring to Appendix E, the Puget Sound AQCR average CO concentrations as represented by the 25th highest values have generally declined since 1979, but have shown a tendency in the last three years to level out and begin to increase. Currently, concentrations are neither trending up nor down.

The following values are used in equations (1) and (2) to estimate Puget Sound AQCR concentrations in the year 2010:

C = 9.0 ppm
F = 0.90
Pop = 0.35
F_t = 0.62
P = 0.57

2010 Estimate = 9.3 * (1+ 0.90 * 0.57) = <u>13.7 ppm</u>
= 51% increase over current levels

2. Ozone.

Referring to Appendix E, the Puget Sound AQCR average O3 concentrations as represented by the 25th highest values have generally increased since 1981 following a period of decline. Over the past four years, values have been within 0.01 of 0.07 ppm, showing no apparent tendency to increase or decrease. We will assume the current trend is flat.

The following values are used in equations (1) and (2) to estimate Puget Sound AQCR concentrations in the year 2010:

C = 0.07 ppm
F = 0.50
Pop = 0.35
F_t = 0.70
P = 0.60

2010 Estimate = 0.07 * (1+ 0.50 * 0.60) = <u>0.09 ppm</u>
= 30% increase over current levels

3. Sulfur Dioxide.

Referring to Appendix E, the Puget Sound AQCR average SO2 concentrations as represented by the 25th highest values have consistently declined over the past ten years. The rate of decline over the past four years has been 0.0005 ppm each year. Projecting this decline to the year 2010, we would estimate a 0.01 ppm decrease in current levels without accounting for population impacts.

The following values are used in equations (1) and (2) to estimate Puget Sound AQCR concentrations in the year 2010:

C = 0.022 ppm
F = 1.00
Pop = 0.35
F_t = 0.09
P = 0.38

2010 Estimate = 0.022 * (1+ 1.00 * 0.38) = 0.03 ppm
2010 Estimate (adjusted) = 0.03 - 0.01 = 0.02 ppm
= no change over current level

Note that this adjusted estimate which takes into account the current tendency for monitored values to decline may be optimistic since much of the decline in monitored values, and therefore the basis for the negative trend, can be attributed to the closure in the early 1980's of the Asarco smelter in Tacoma.

4. Particulate Matter.

Referring to Appendix E, the Puget Sound AQCR average Particulate Matter (TSP) concentrations as represented by the 25th highest values have shown a tendency to increase slightly in the last ten years. Over the past four years, values have not differed by more than a few percent, showing no apparent tendency to increase or decrease. We will assume the current trend is flat.

The following values are used in equations (1) and (2) to estimate Puget Sound AQCR concentrations in the year 2010:

C = 181 ug/m3
F = 0.90 assumed
Pop = 0.35
F_t = 0.72
P = 0.60

2010 Estimate = 180 * (1+ 0.90 * 0.60) = 282 ug/m3
= 54% increase over current levels

5. Toxics.

Lacking both trend information and monitored data, we will "assign" each of the targeted toxic air pollutants to one of the criteria pollutants above based on the rationale given in the beginning of this section. Again, the only purpose in doing this is to overcome a lack of data, not to suggest that we can predict what ambient concentrations of toxic pollutants might be found in the year 2010. Further analysis of this issue would be appropriate once an adequate database has been established.

Surrogate: Carbon Monoxide
Principle Source(s): Vehicle tailpipe emissions
Estimated increase, 1988-2010: 51%
Toxics in this category include: Toluene
Benzene
Xylene
Formaldehyde

Surrogate: Ozone
Principle Source(s) (precursors): Natural biological action
Vehicle refueling
Estimated increase, 1988-2010: 30%
Toxics in this category include: Dichloromethane
Ethylene dichloride
Ethylene dibromide
Perchloroethylene
Trichloroethylene

Surrogate: Sulfur Dioxide
Principle Source(s): Electric utilities
Boilers
Estimated Increase, 1988-2010: no change
Toxics in this category include: Arsenic
Beryllium
cadmium
Chloroform
Chromium
Fluoride
Mercury
Nickel
POM's

Surrogate: Particulate Matter
Principle Source(s): Motor vehicles
Woodstoves
Estimated Increase, 1988-2010: 54%
Toxics in this category include: Acetaldehyde
Dioxins
Phenols
Formaldehyde

It would be far too speculative to use these projected increases in emission rates to estimate the increase in risk associated with the toxic pollutants. However, it should be noted that, with few exceptions, these toxics are currently not regulated, nor are emissions of these substances measured or concentrations sampled in the ambient air.

C. SUMMARY OF PROJECTED AIR QUALITY IN THE YEAR 2010

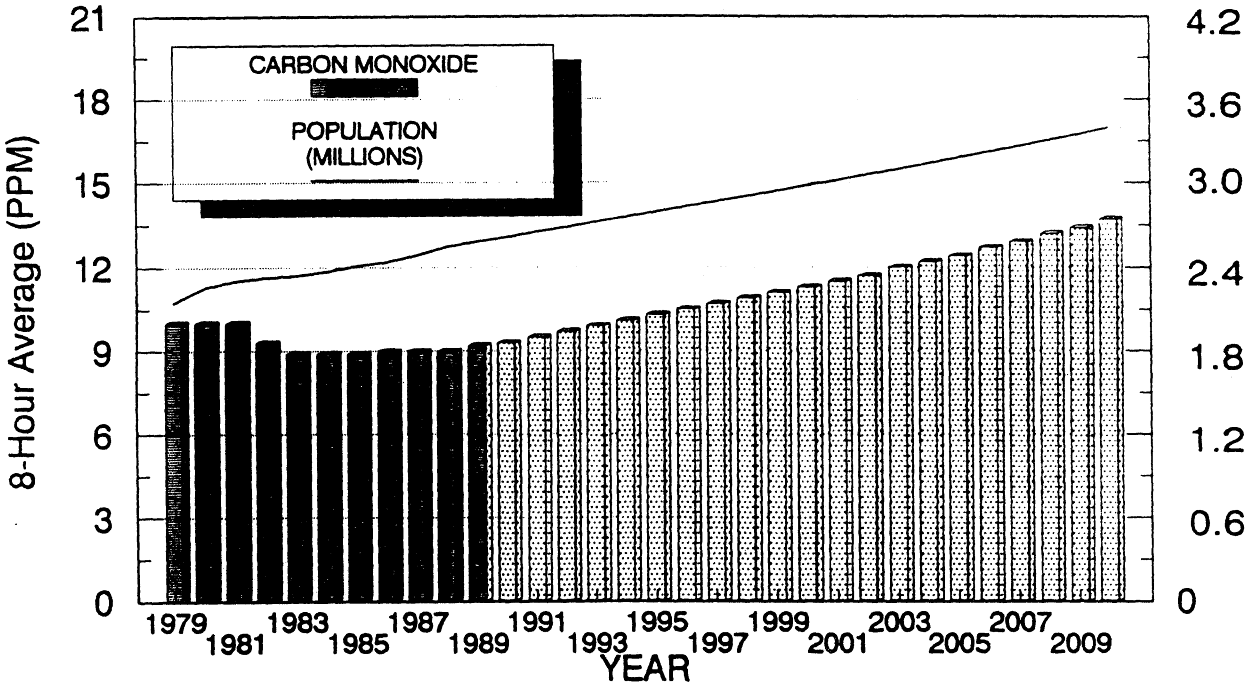
Generally, outside of the Puget Sound AQCR, monitoring data is very limited. Thus it is difficult, at best, to determine historical trends. In order to estimate increases in air pollution concentrations over current values, we will use the simplfying assumption that current trends are flat. Using data from Appendix F and G, estimated increases in ambient air pollution levels for each air quality control region are as follow:

Percent Increase Relative to 1988 Levels

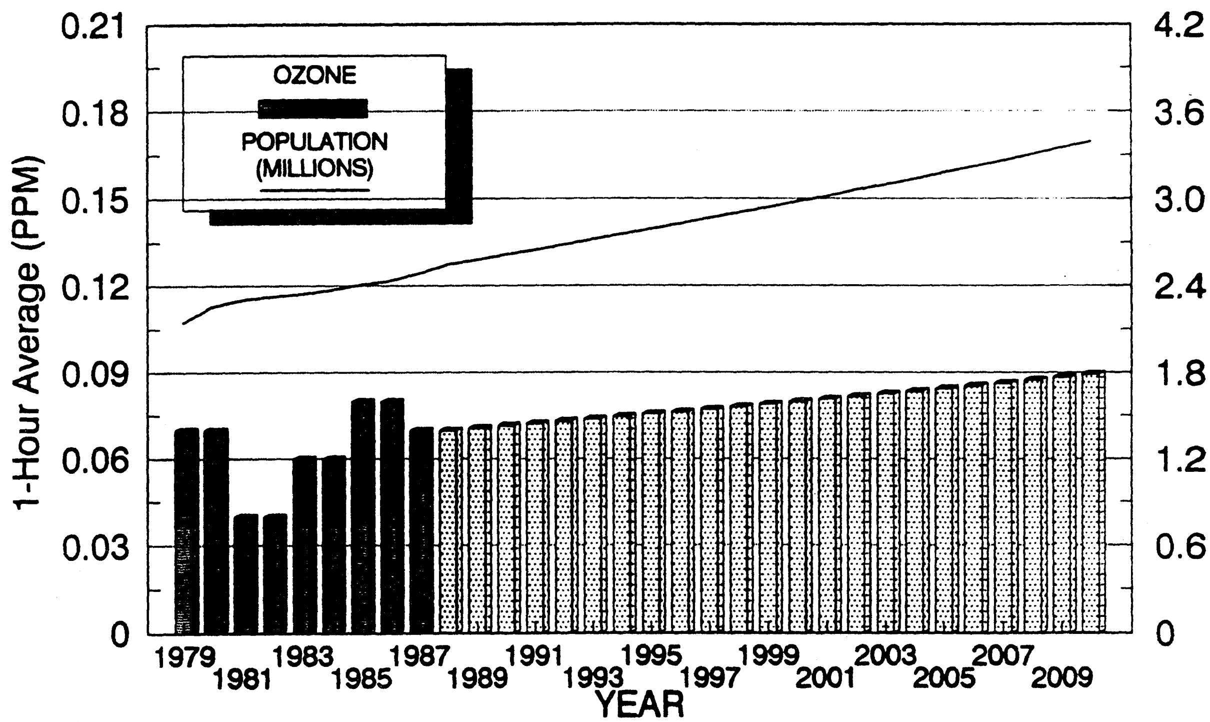
	CO	O3	SO2	PM
Puget Sound	51%	30%	n/c	54%
Olympic - Northwest	44%	21%	31%	37%
Southwest	32%	15%	22%	27%
Northern	18%	9%	16%	8%
South Central	33%	19%	28%	17%
Eastern	13%	8%	27%	8%

Figures 30 - 33 graphically show our projections of future air quality, based on 25th values, in the Puget Sound Region.

PROJECTIONS OF CO CONCENTRATION (BASED ON PUGET SOUND AQCR)

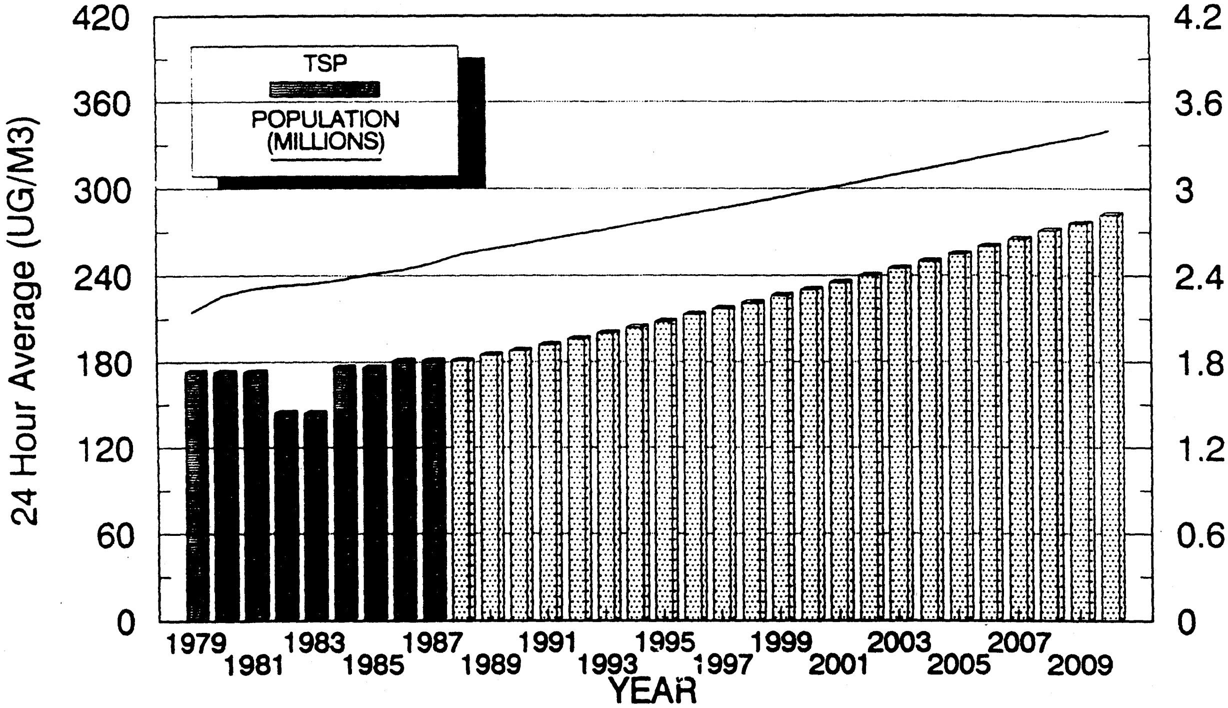


PROJECTIONS OF OZONE CONCENTRATION (BASED ON PUGET SOUND AQCR)



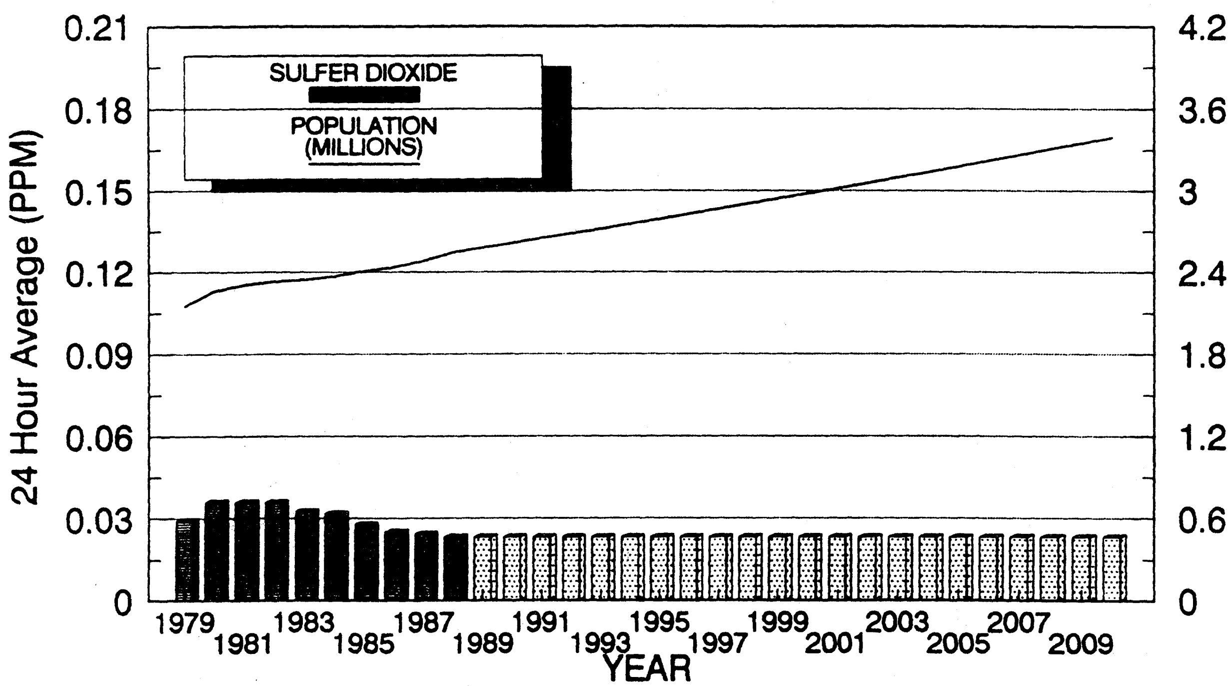
PROJECTIONS OF TSP CONCENTRATION

(BASED ON PUGET SOUND AQCR)



PROJECTIONS OF SO2 CONCENTRATION

(BASED ON PUGET SOUND AQCR)



Our conclusions regarding what we see from these plots ares as follows:

- o CO The average CO concentrations as represented by the 25th highest values have generally declined since 1979, but have shown a tendency in the last three years to level out and begin to increase. Being primarily a transportation related pollutant, we expect significant increases between now and the year 2010.

- o O3 After several years with relatively low values, ozone has begun to climb. Since 1981, the 25th high has almost doubled from .04 to .07, though the rate of increase in recent years has been quite slow. Again, we would project that this upward trend will continue in the absence of additional control measures.

- o SO2 Our plot shows a steady decline in 25th high SO2 values throughout the most recent 10 year period. Continuation of this trend, or perhaps leveling out at the currently low levels, is what we would project.

- o PM Our plot shows that we have been holding the line against increases in particulate matter (PM) concentrations. Significant increases in PM emissions are anticipated, however, resulting in high values throughout the state.

Given the status quo scenario followed in this study, we would expect new areas to exceed the CO and PM standards, while areas that already violate standards will continue to do so. Interestingly, once violations are recorded, the Department of Ecology, EPA and local authorities would probably respond in earnest to the problem, but such response is often too little too late. It is not uncommon to find that effective control programs are not implemented until three or four years after air pollution standards are exceeded. Some delays are unavoidable, others institutional - in any case, the process can be expected to be slow. Some key steps in the process include:

- o Submit air monitoring data to EPA, after QA by state
- o Data analysis (monitoring/modeling/emissions inventory)
- o Attainment demonstration
- o Compliance schedules
- o Implementation

This example serves to illustrate a point. Often there is a substantial, yet legitimate lag between when an air quality problem is "officially" discovered and actual air quality control strategies are implemented. Without taking steps to avoid nonattainment, it is our judgement that given a 30 percent growth rate, nonattainment of one or more pollutant will be inevitable in urbanized areas that are not currently so designated.

Our conclusion is that, given the no additional control scenario, the outlook for the air resource is bleak. Two fundamental changes relative to current practice will be needed to stave off significant problems between now and the year 2010:

- o The public needs to understand there role in cleaning up the air - that they are a major part of the problem and that the solution will depend on their changing lifelong habits, the most important of which being the single passenger car mode of transportation.

- o Air pollution control must shift from being reactive to preventive - a "prevention, not just attainment" philosophy.

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2. ibid

3. ibid

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5. 1988 population estimates from "1987 Washington State Yearbook"

6. Personal conversation with Lisa Carloye, Department of Ecology

7. Personal conversation with David Tanner, Washington State Department of Trade and Economic Development

8. Air Resources Study, EPA. January, 1989

9. "Washington State Energy Use Profile, 1960-1986" Washington State Energy Office, January 1988

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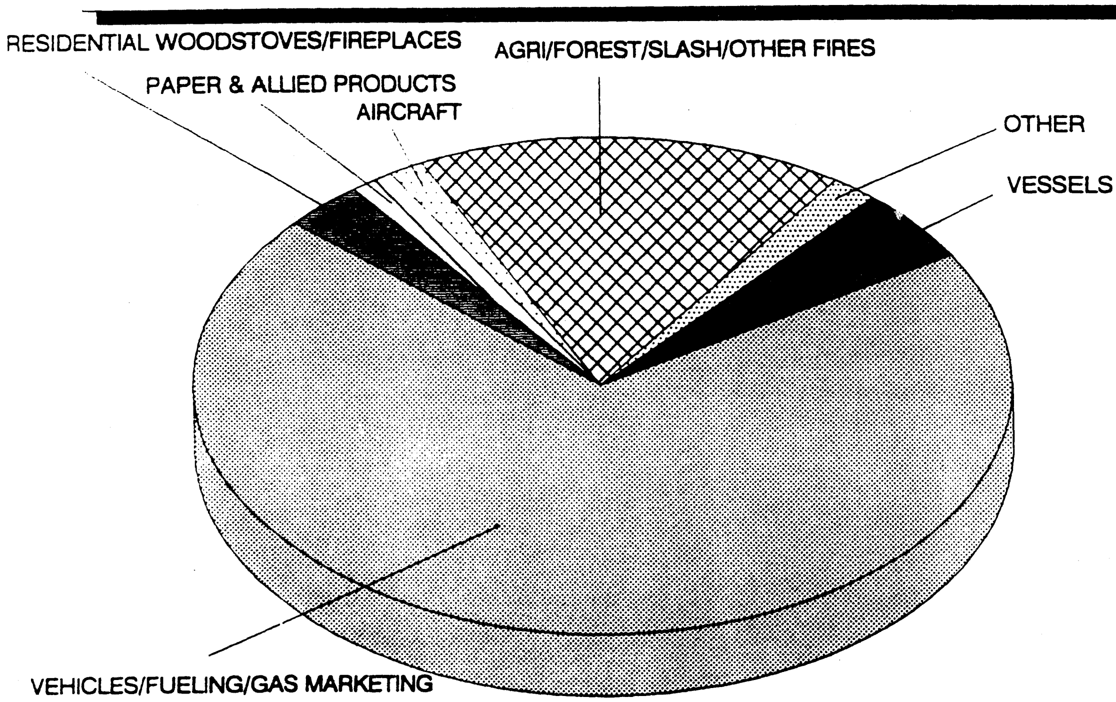
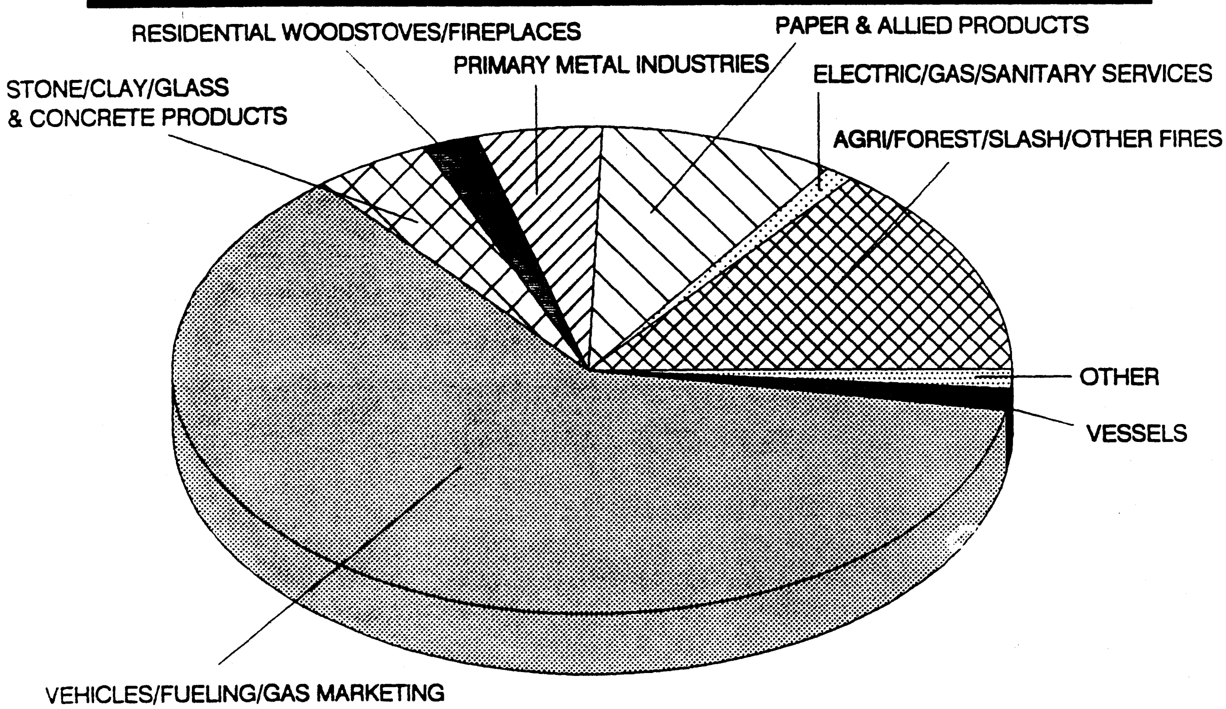
11. Stern, Arthur C. "Air Pollution". Third Edition. 1976.

APPENDIX A

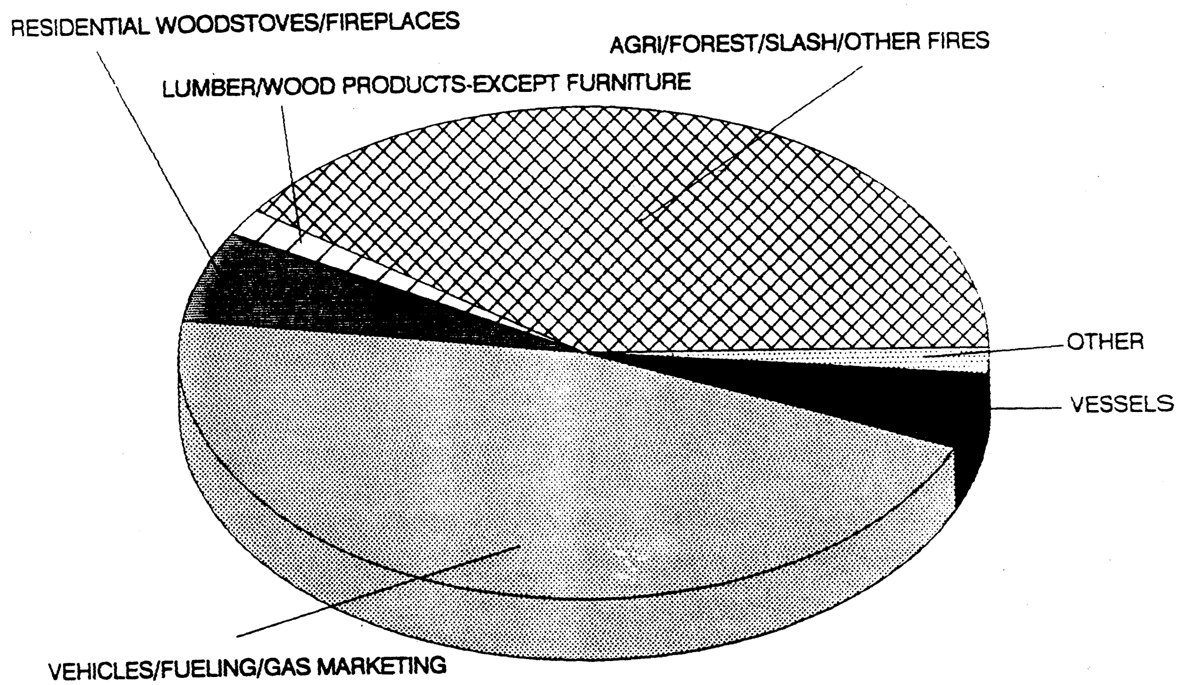
CARBON MONOXIDE EMISSIONS IN THE NORTHWEST REGION FOR 1984



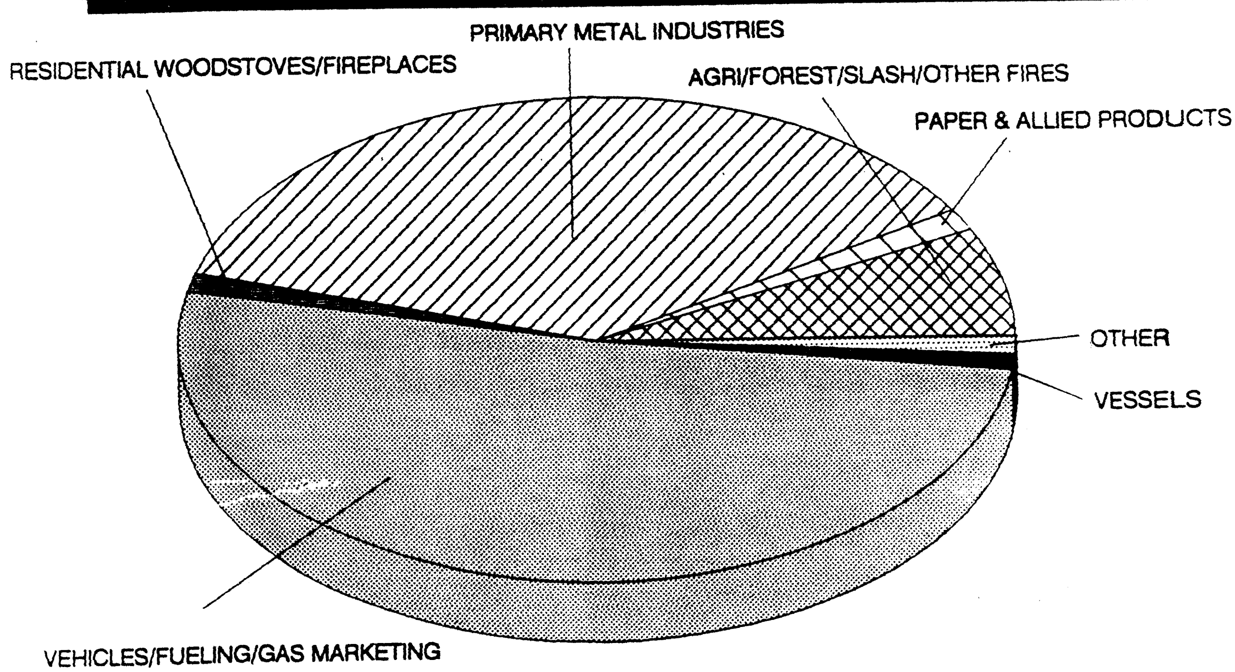
CARBON MONOXIDE EMISSIONS IN THE SOUTHWEST REGION FOR 1984



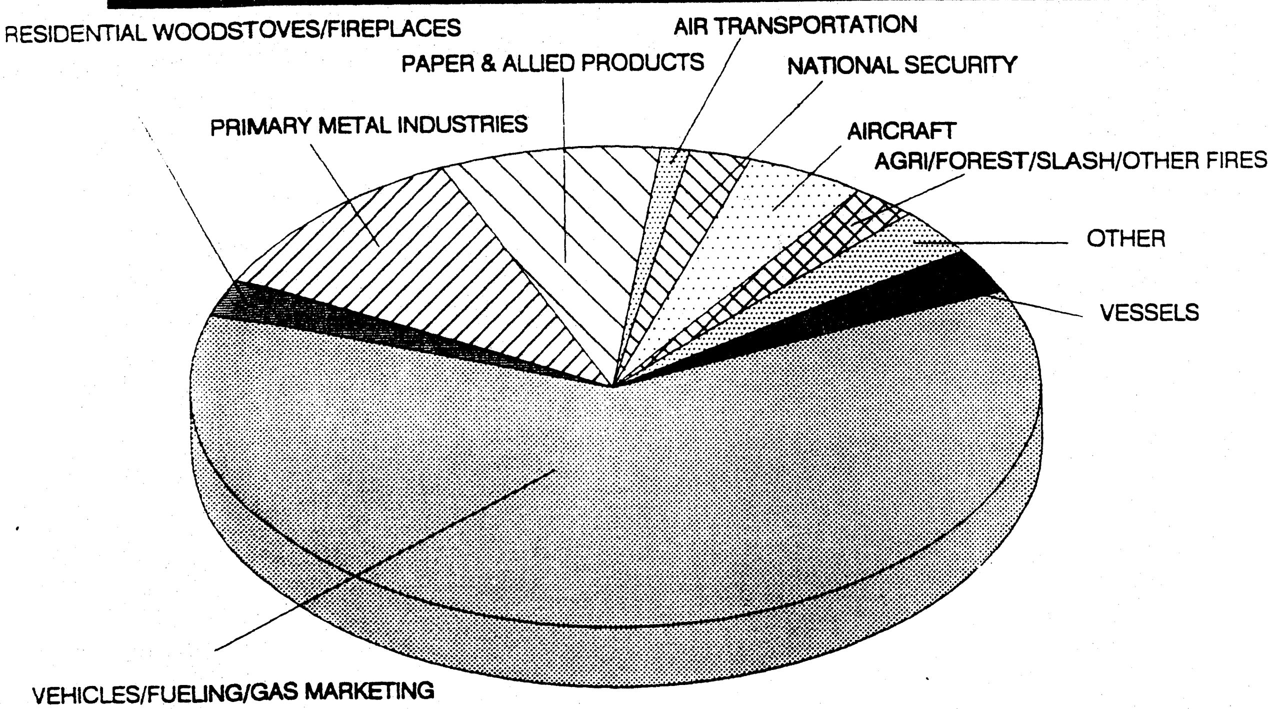
CARBON MONOXIDE EMISSIONS IN THE NORTHERN REGION FOR 1984



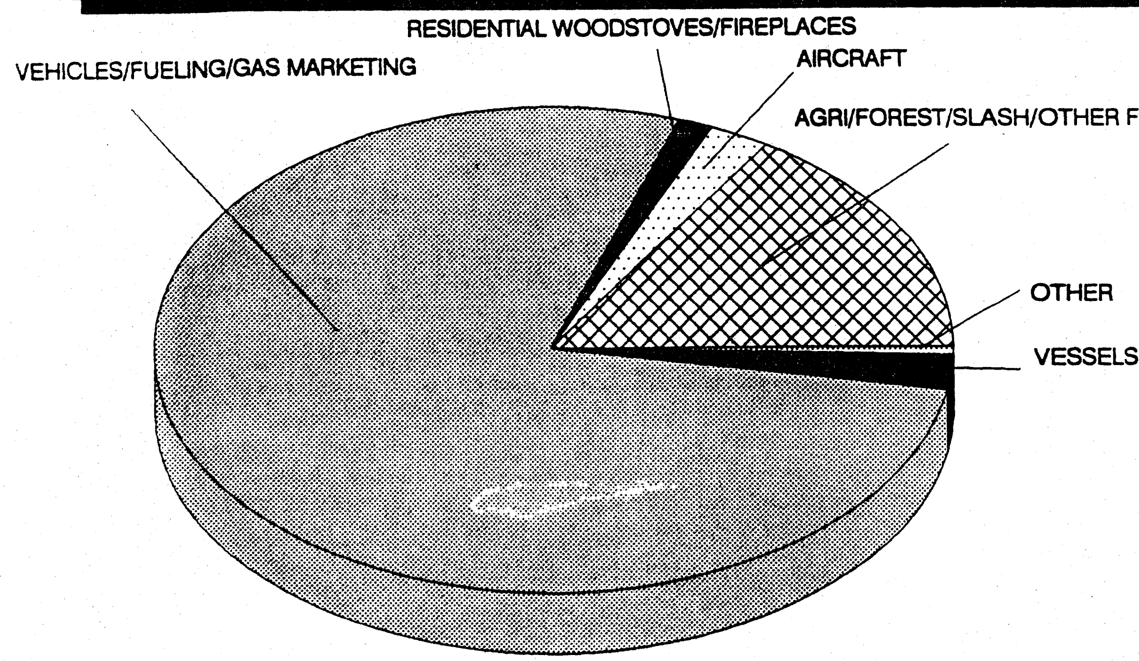
CARBON MONOXIDE EMISSIONS IN THE SOUTH CENTRAL REGION FOR 1984



CARBON MONOXIDE EMISSIONS IN THE PUGET SOUND REGION FOR 1984



CARBON MONOXIDE EMISSIONS IN THE EASTERN REGION FOR 1984



VOLATILE ORGANIC EMISSIONS IN
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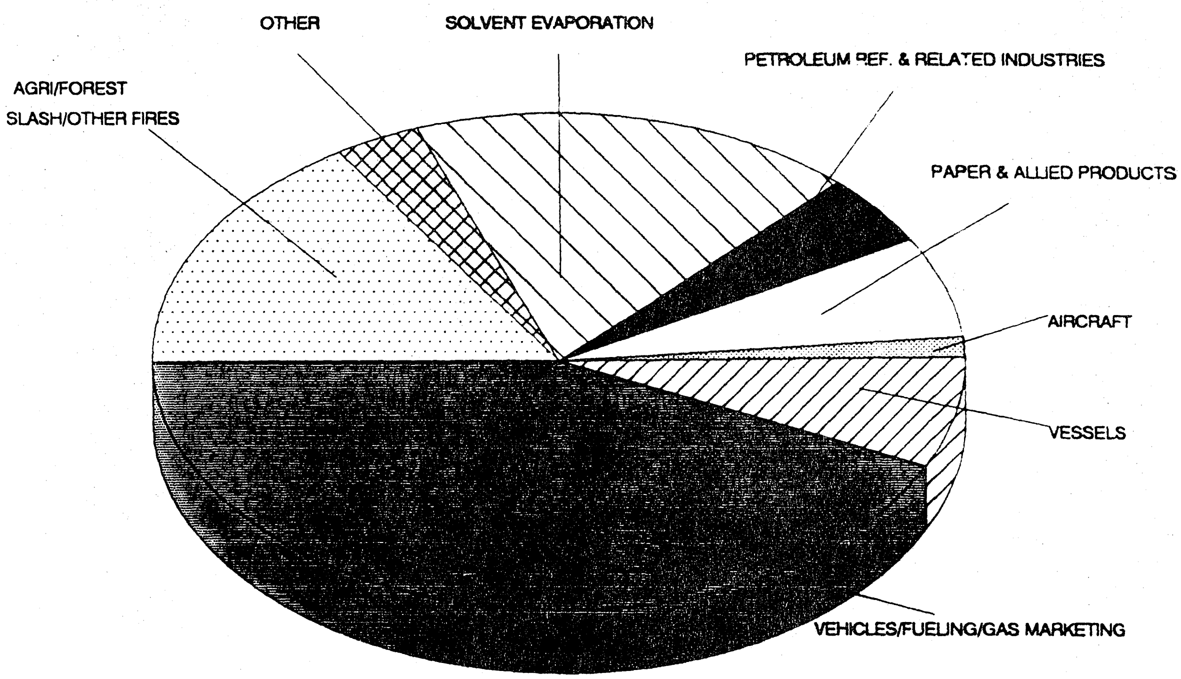

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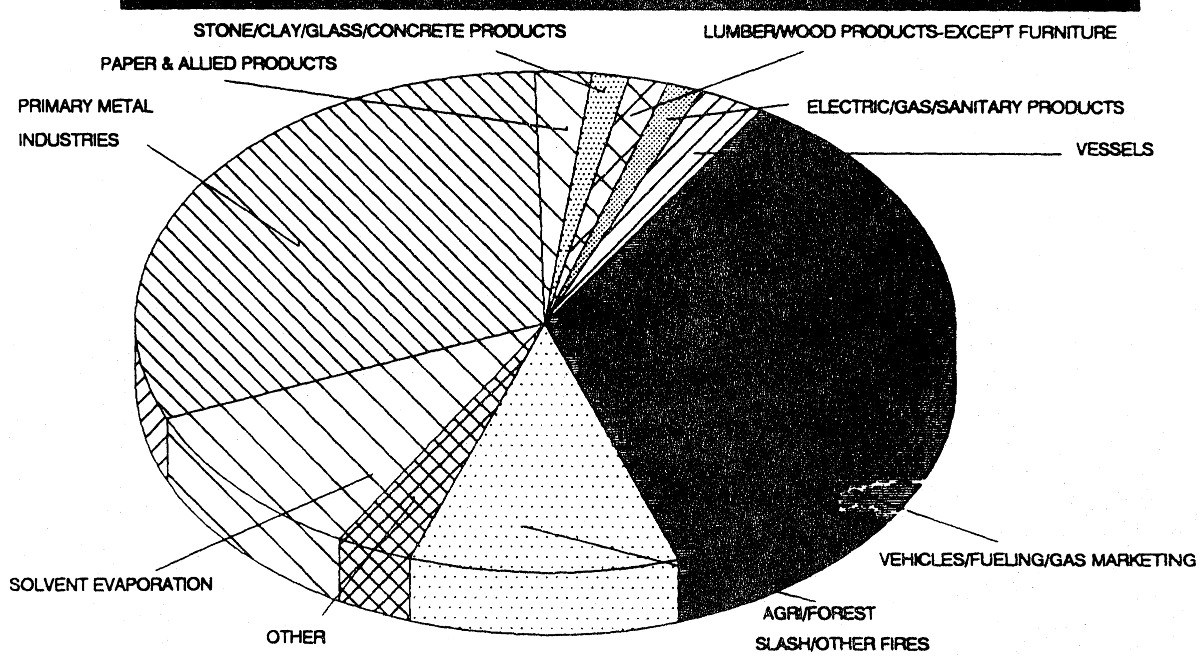

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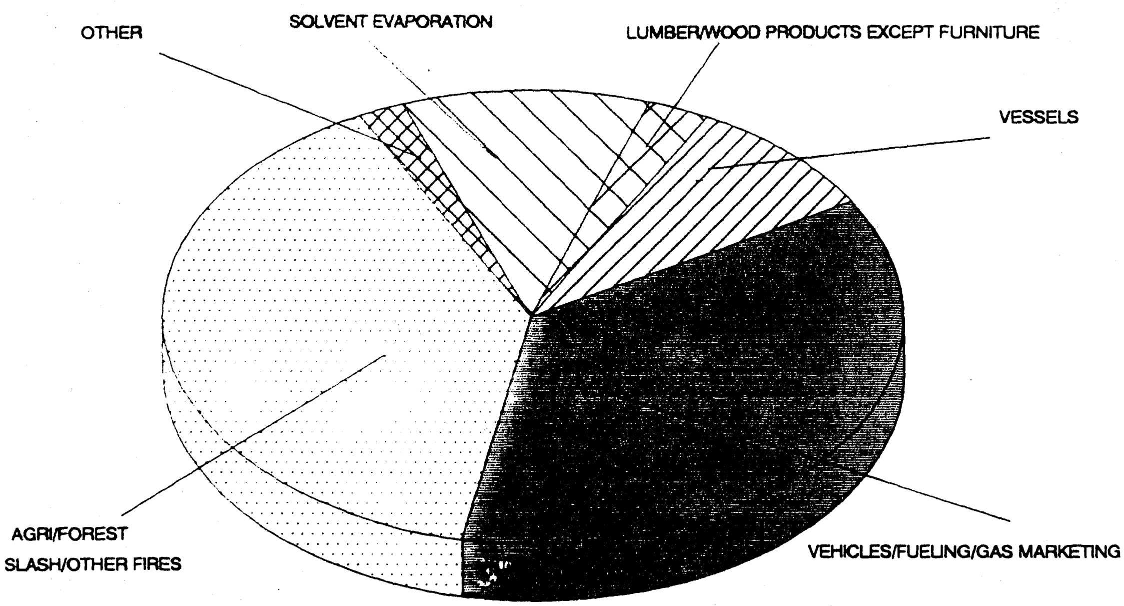

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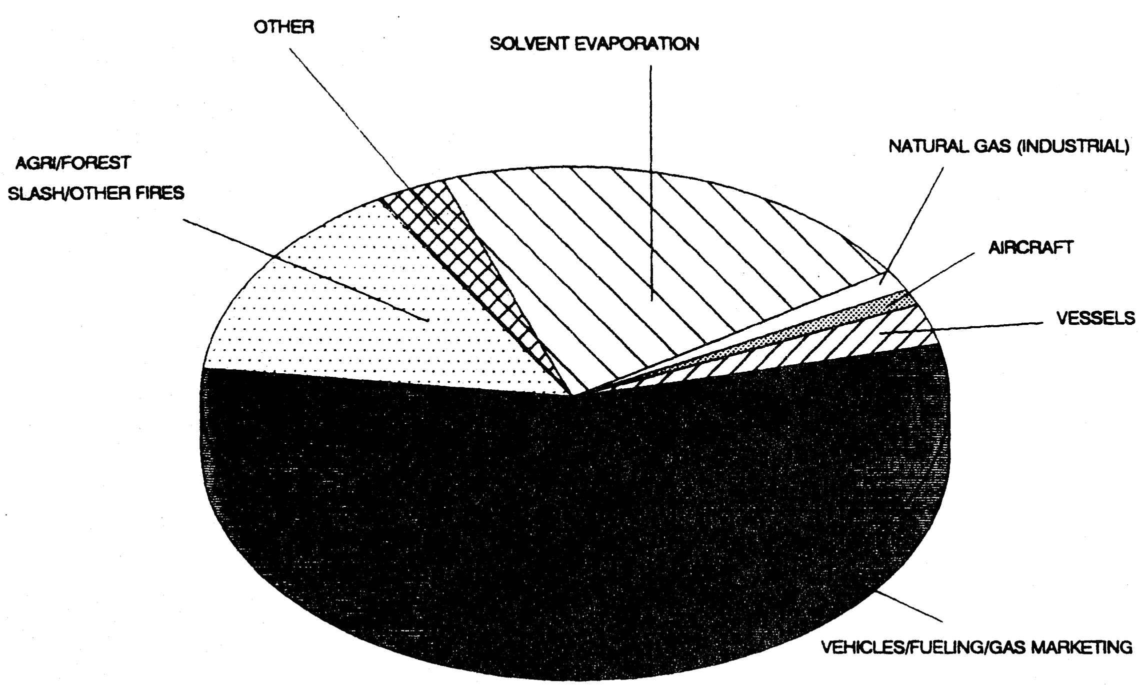

SULFUR DIOXIDE EMISSIONS IN
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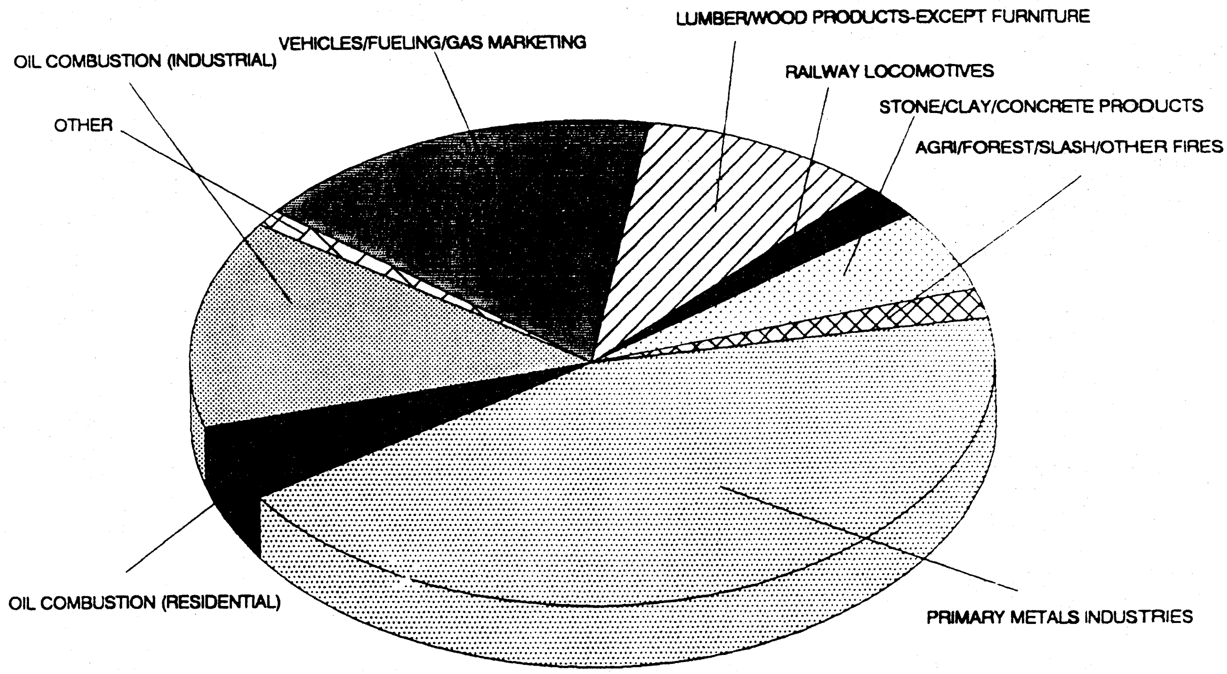

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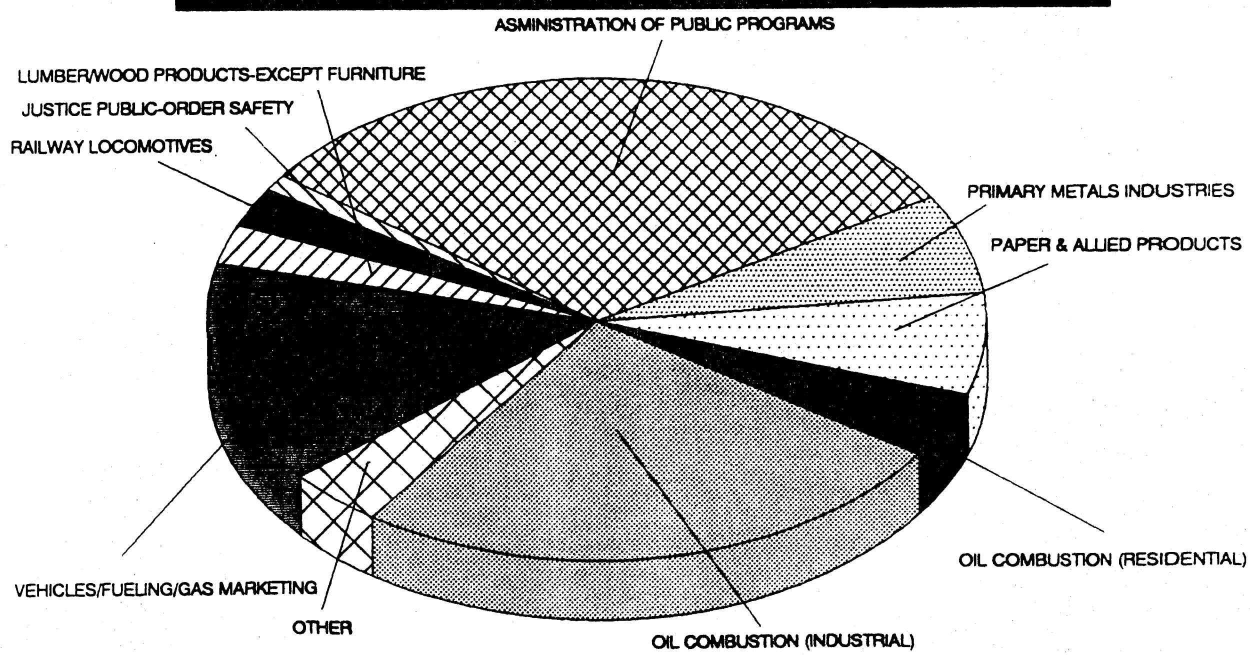
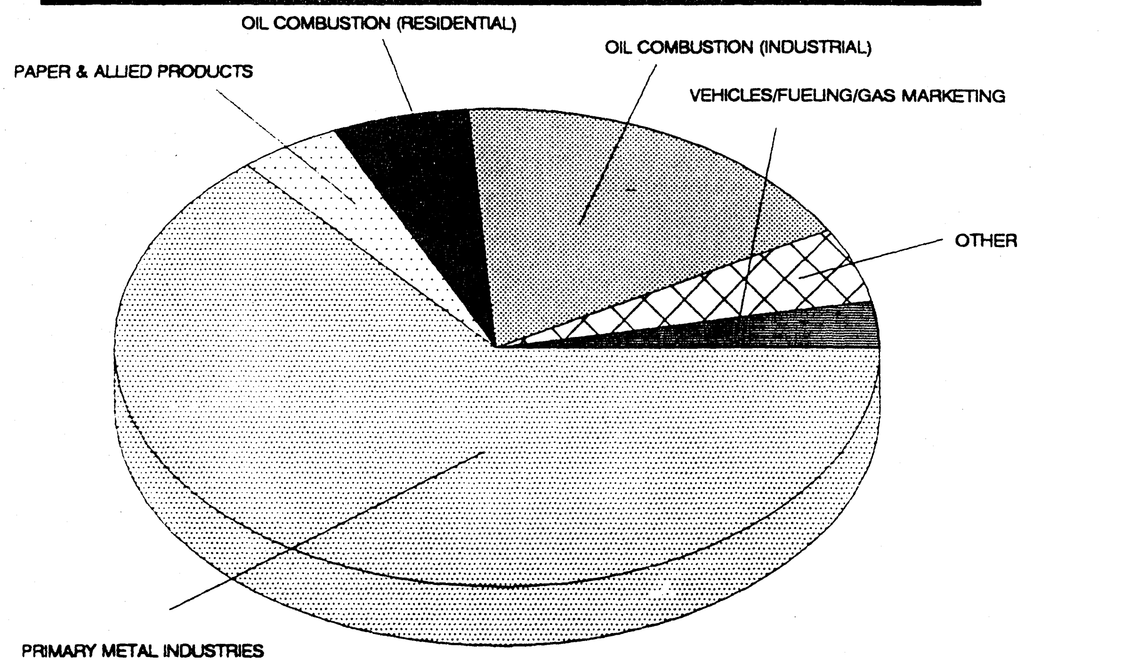
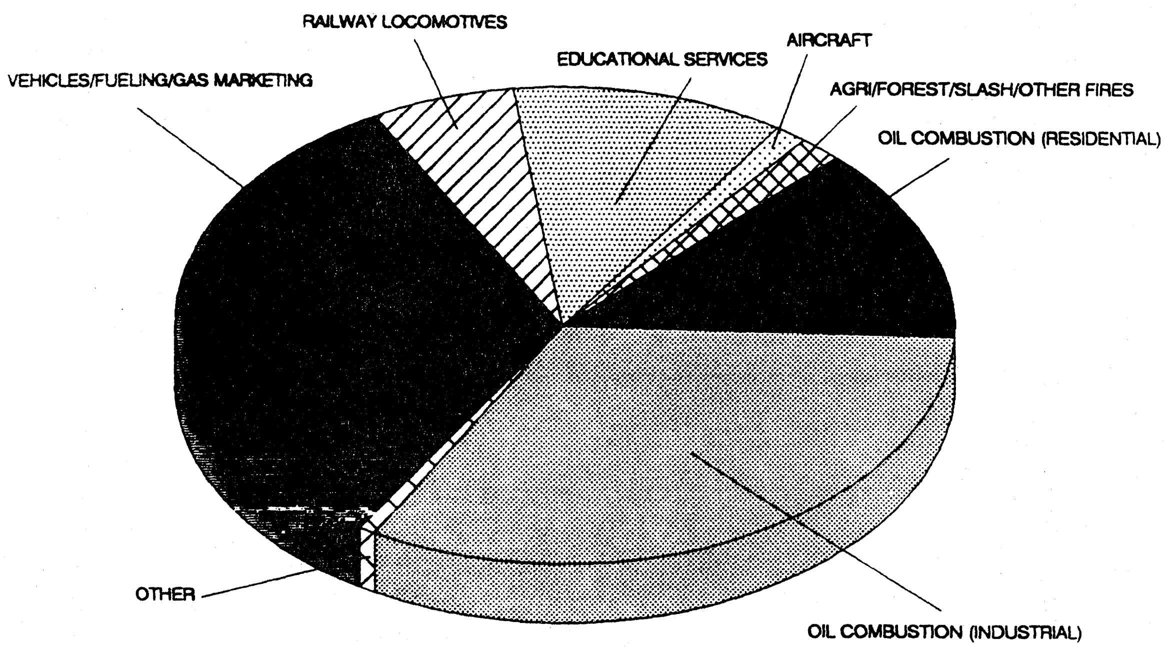


SULFUR DIOXIDE EMISSIONS IN THE PUGET SOUND REGION FOR 1984



SULFUR DIOXIDE EMISSIONS IN THE EASTERN REGION FOR 1984



PARTICULATE MATTER EMISSIONS IN
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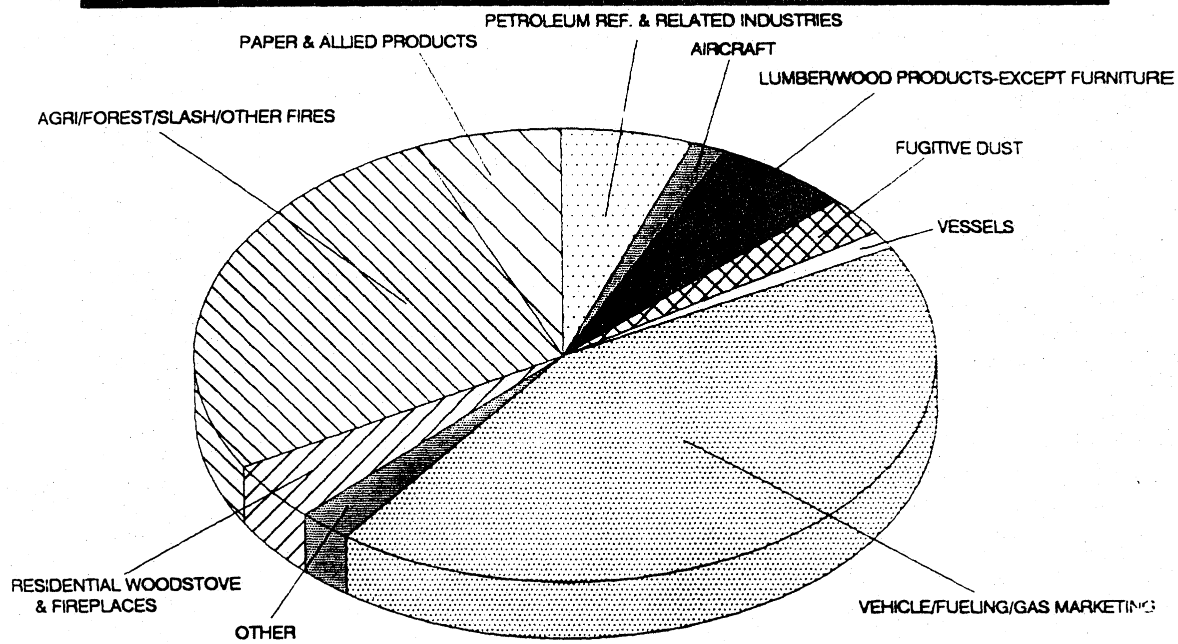

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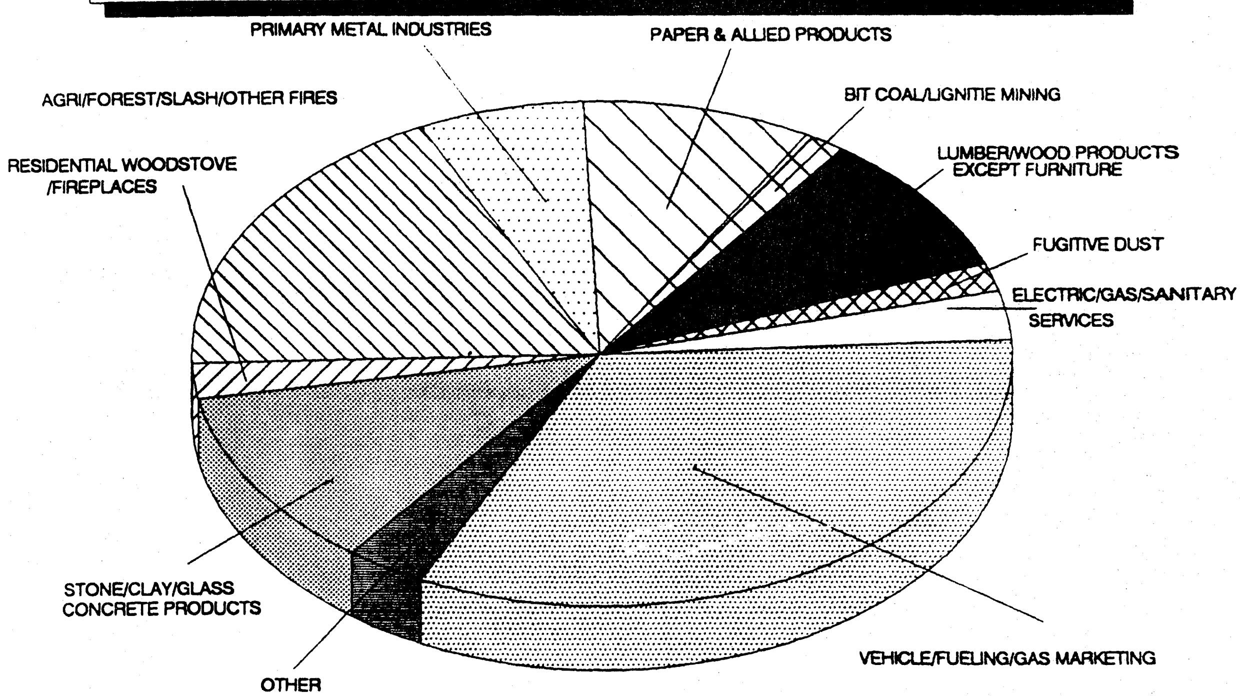

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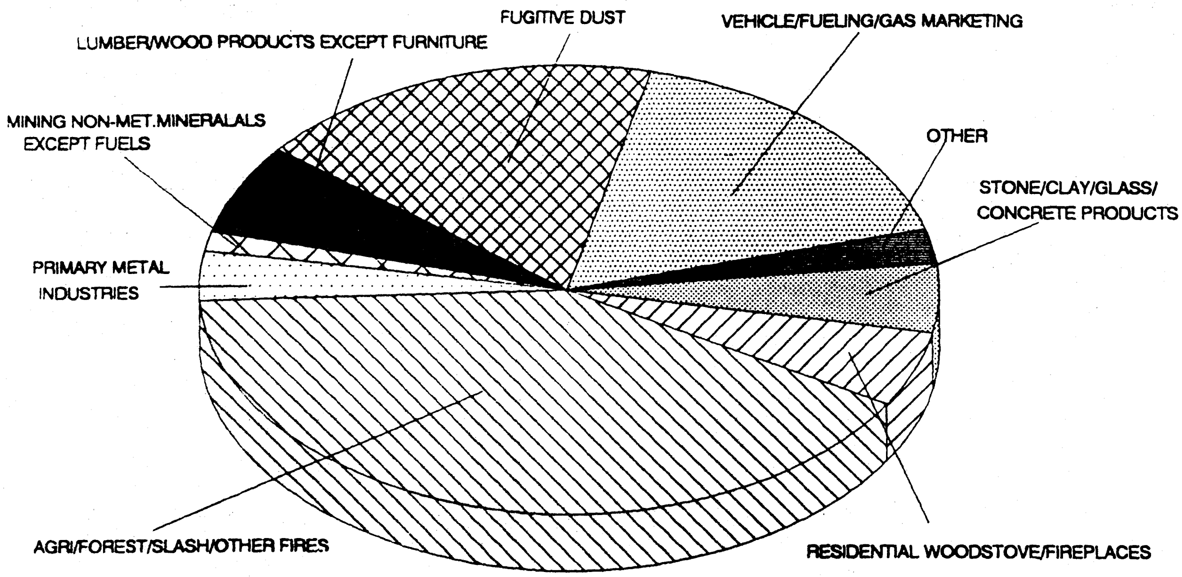

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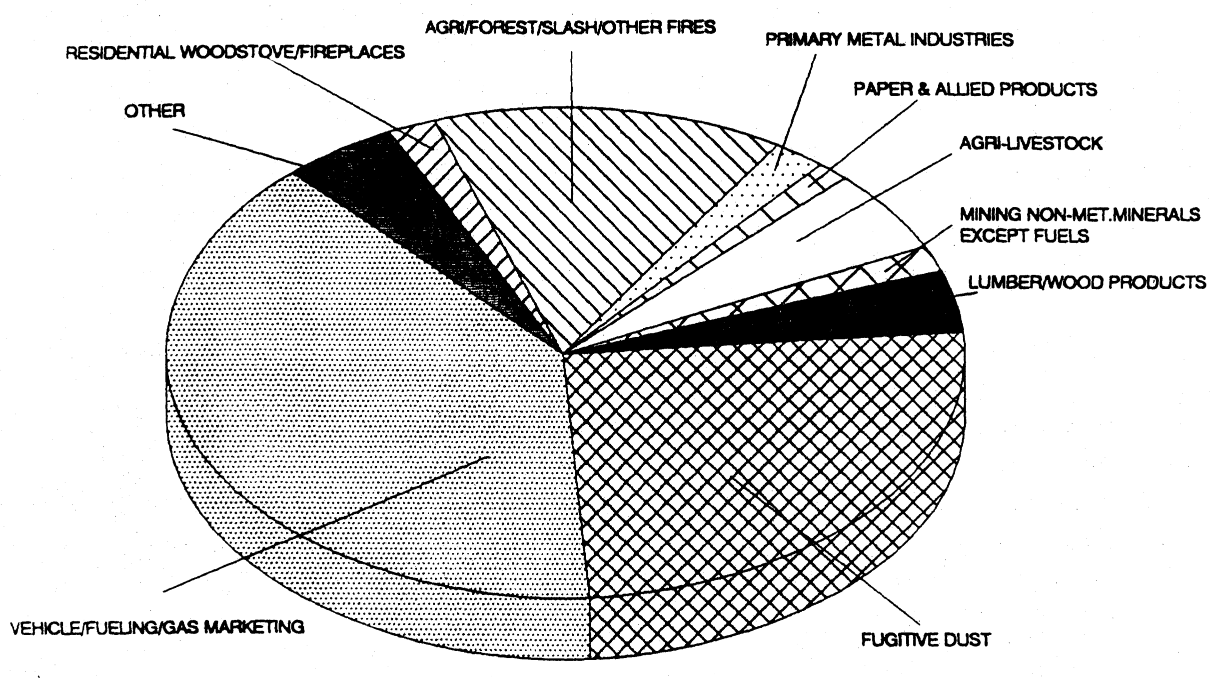

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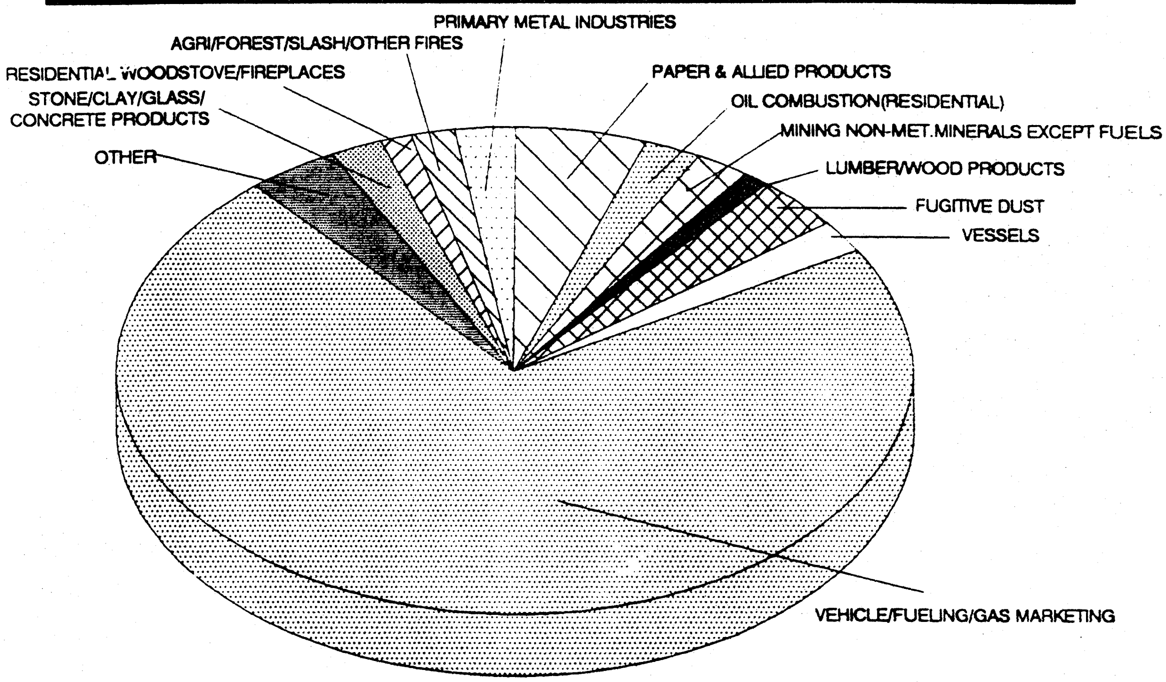

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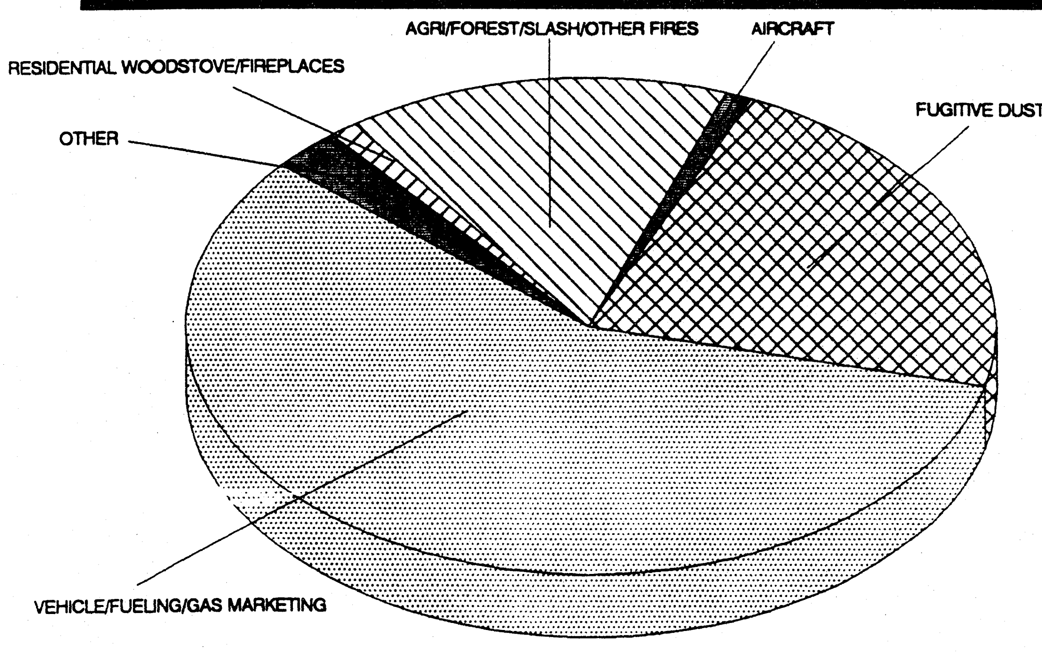

NITROGEN DIOXIDE EMISSIONS IN
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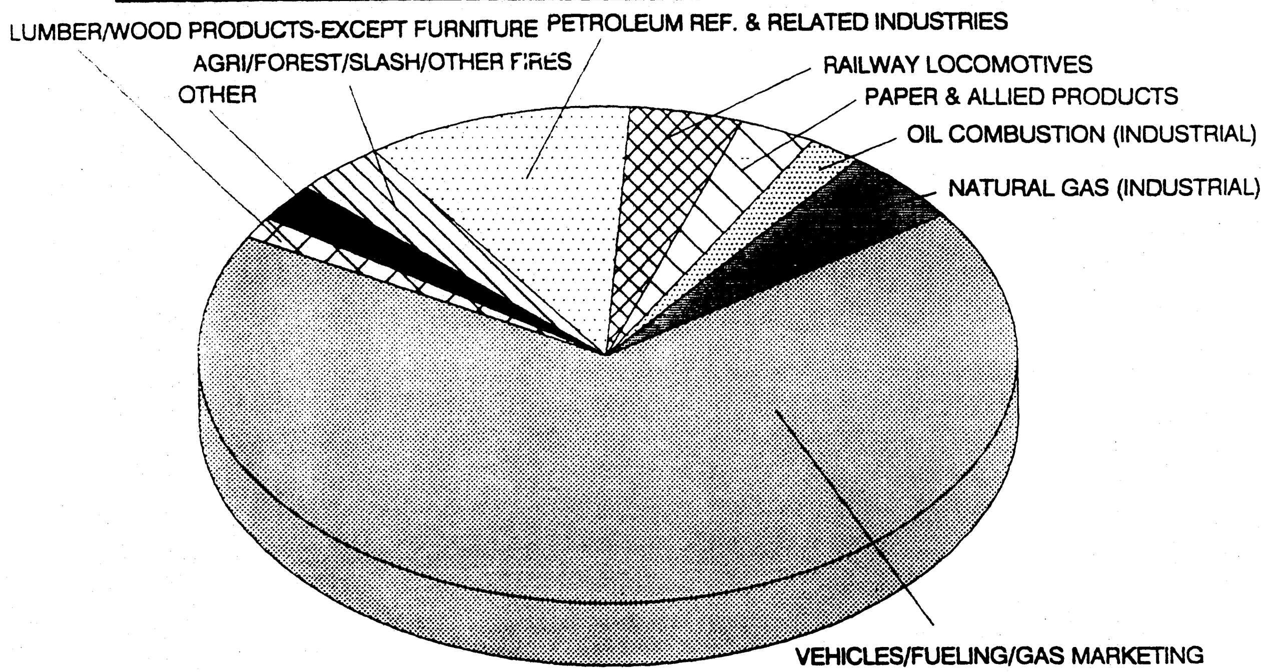

NITROGEN DIOXIDE EMISSIONS IN
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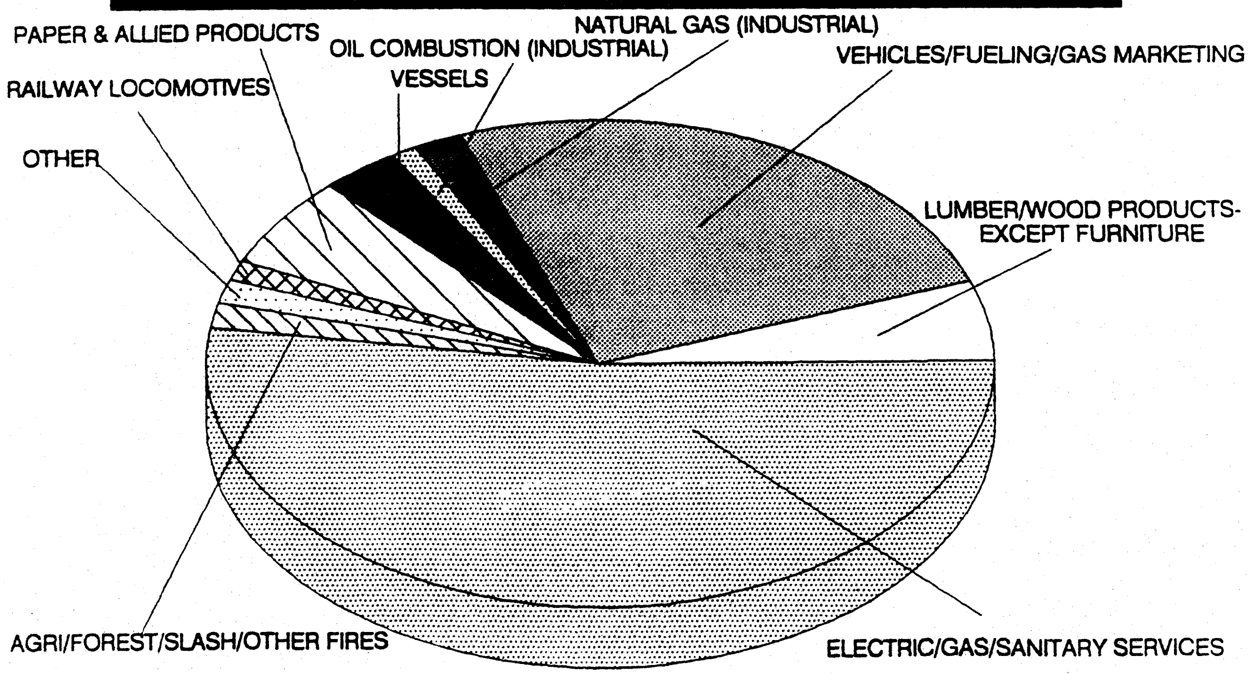

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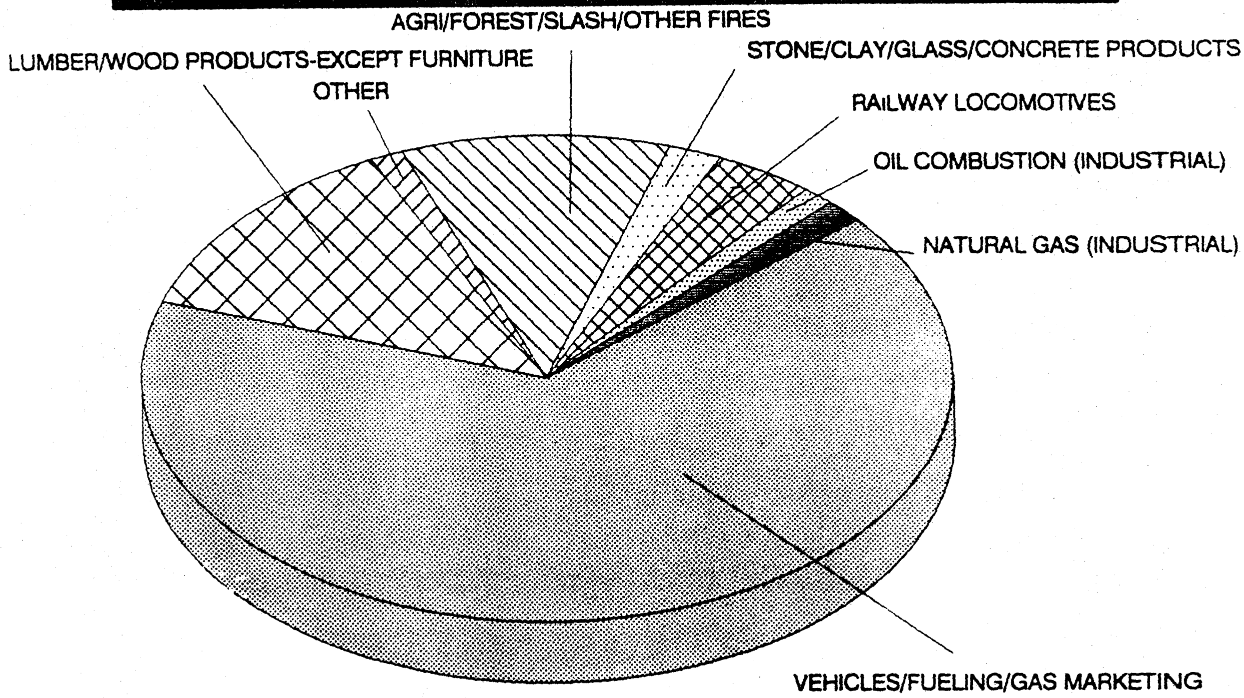

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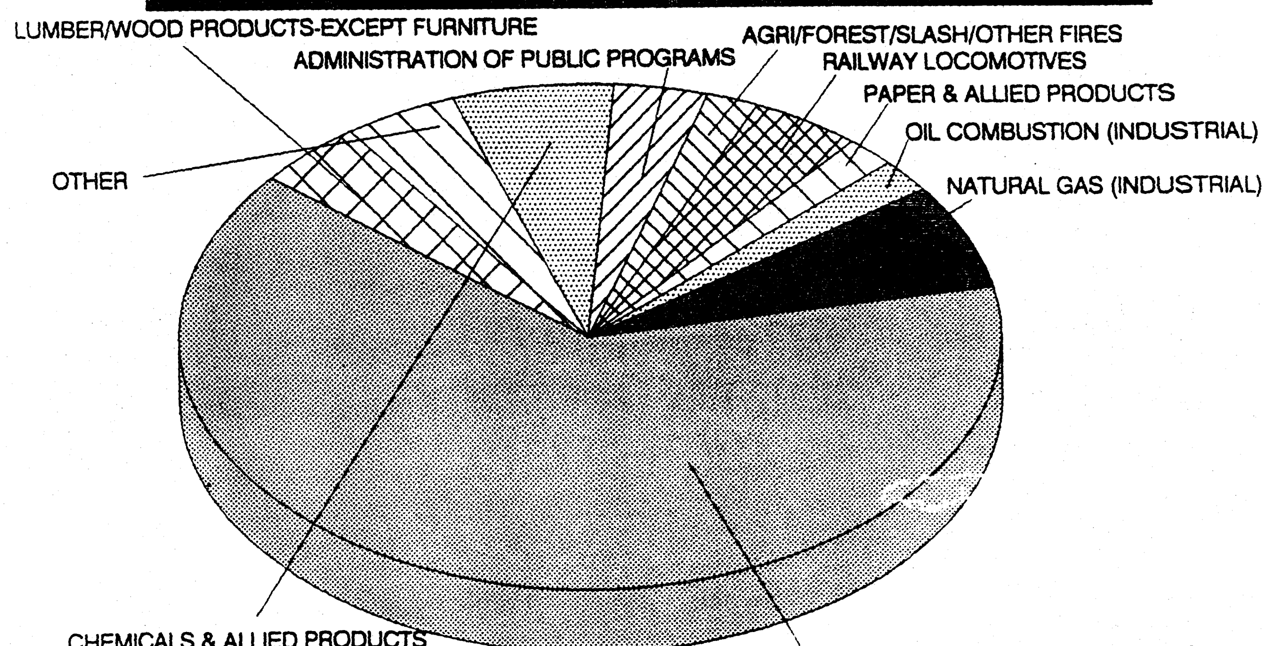

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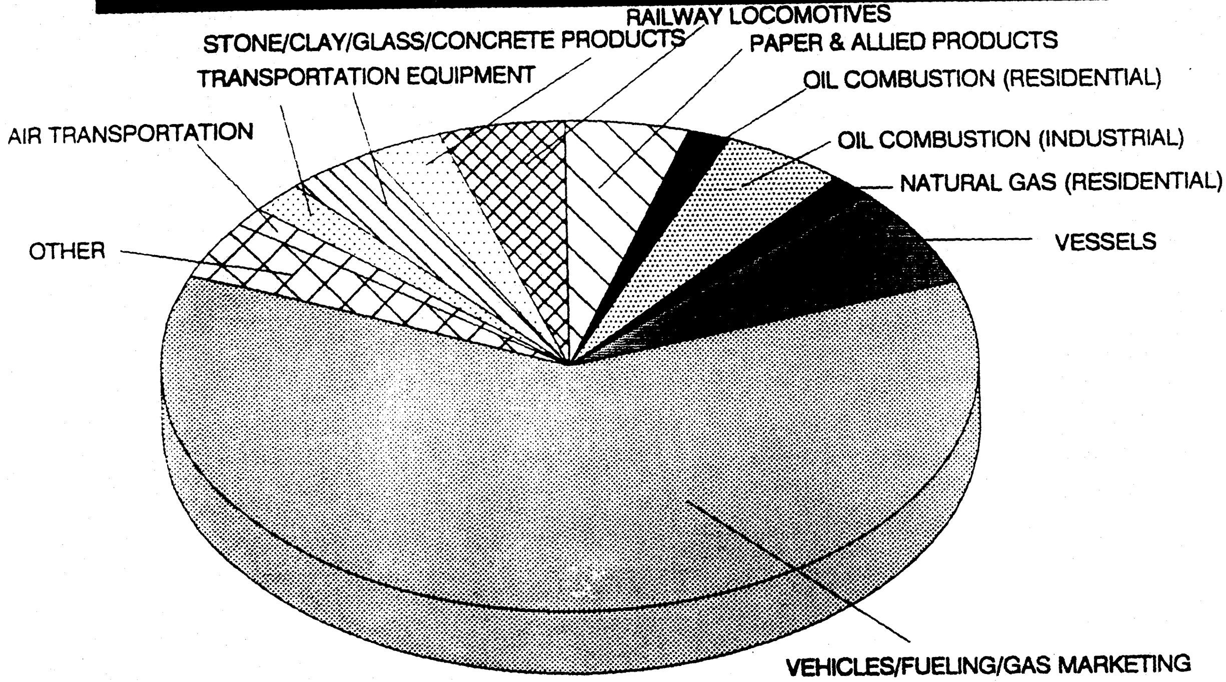

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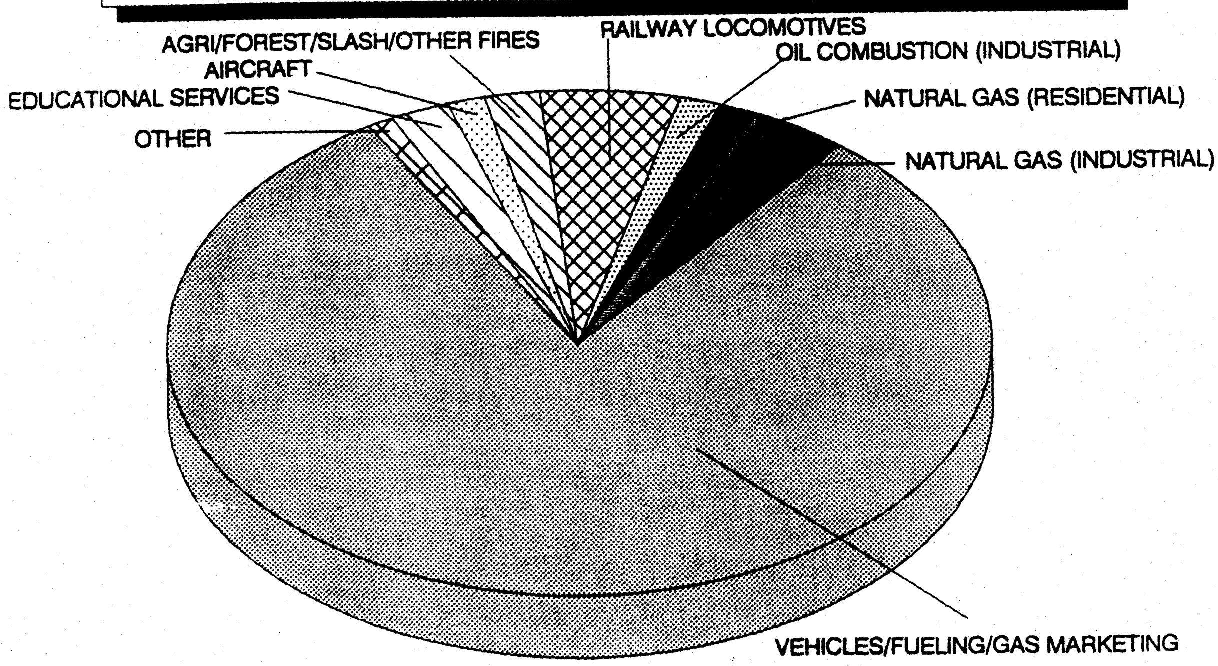
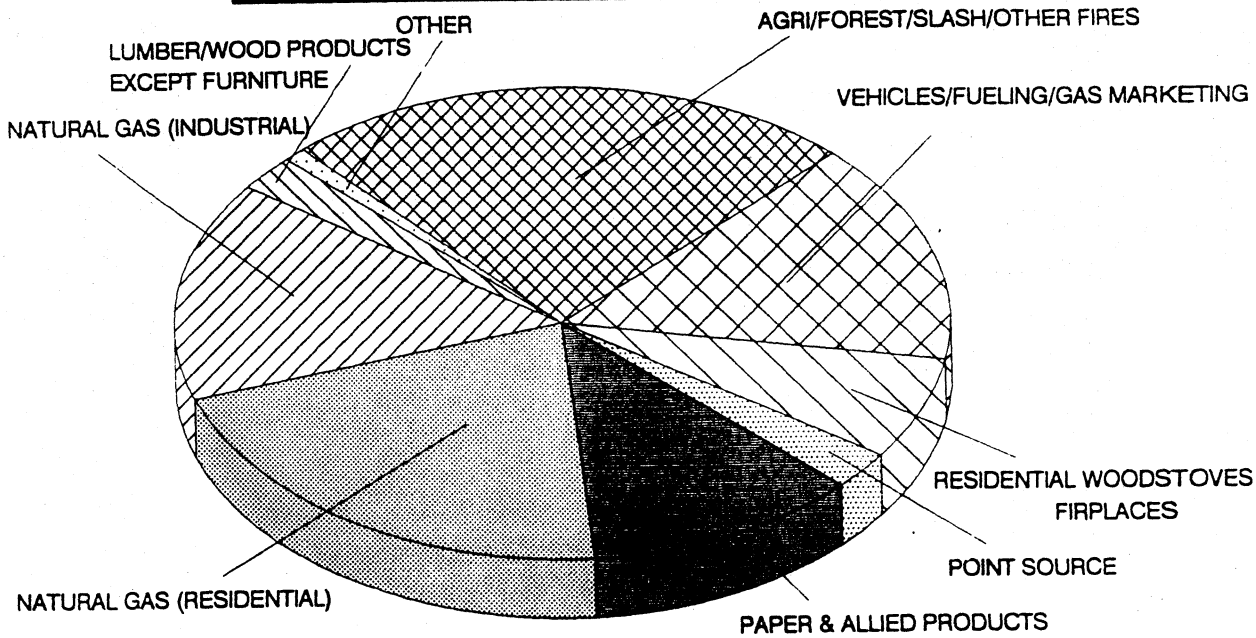
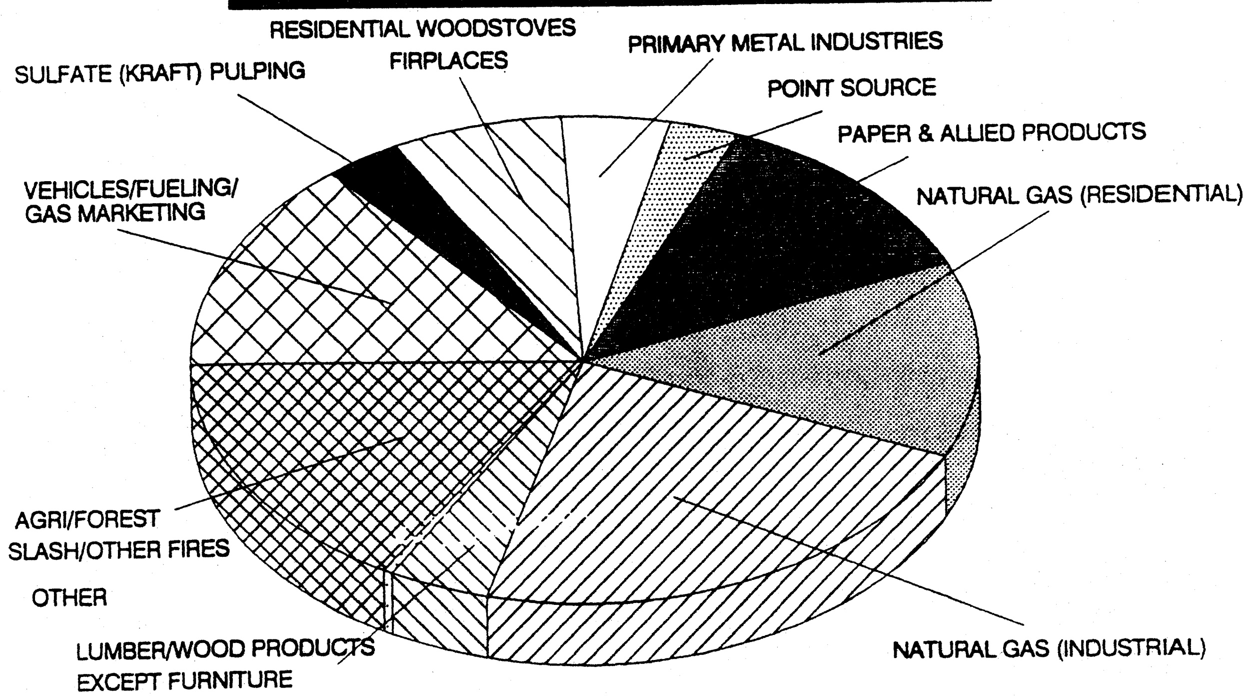


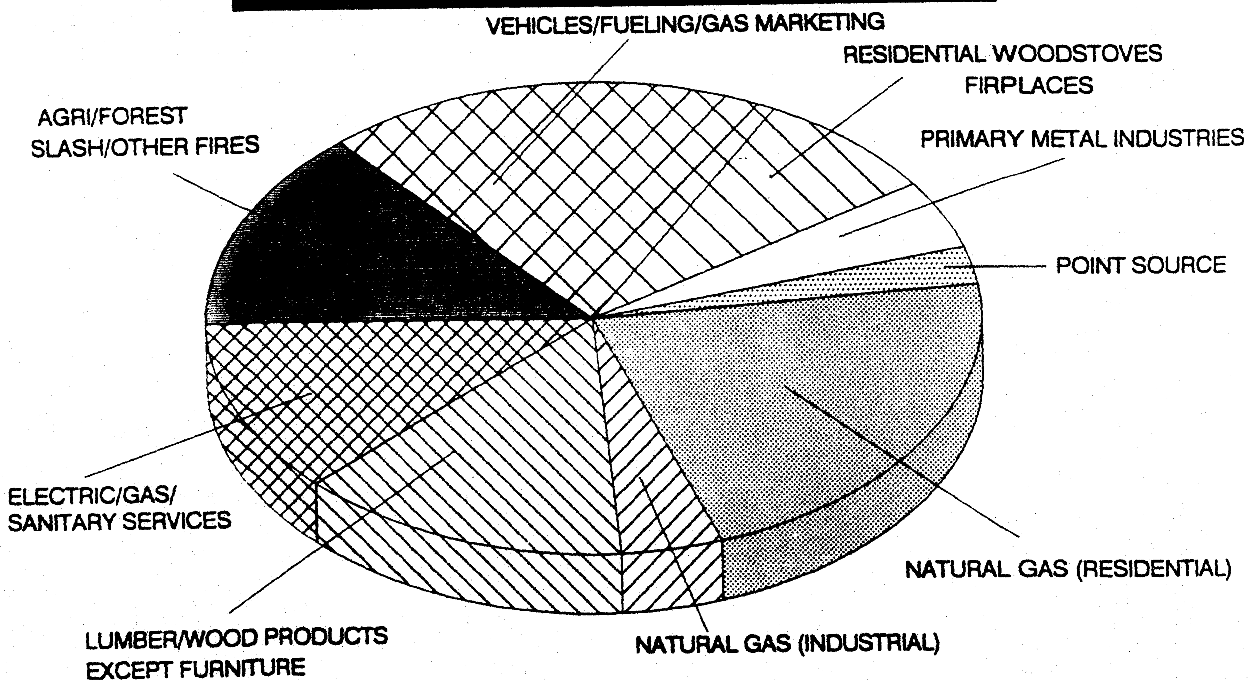
TOXIC EMISSIONS IN THE NORTHWEST REGION FOR 1984



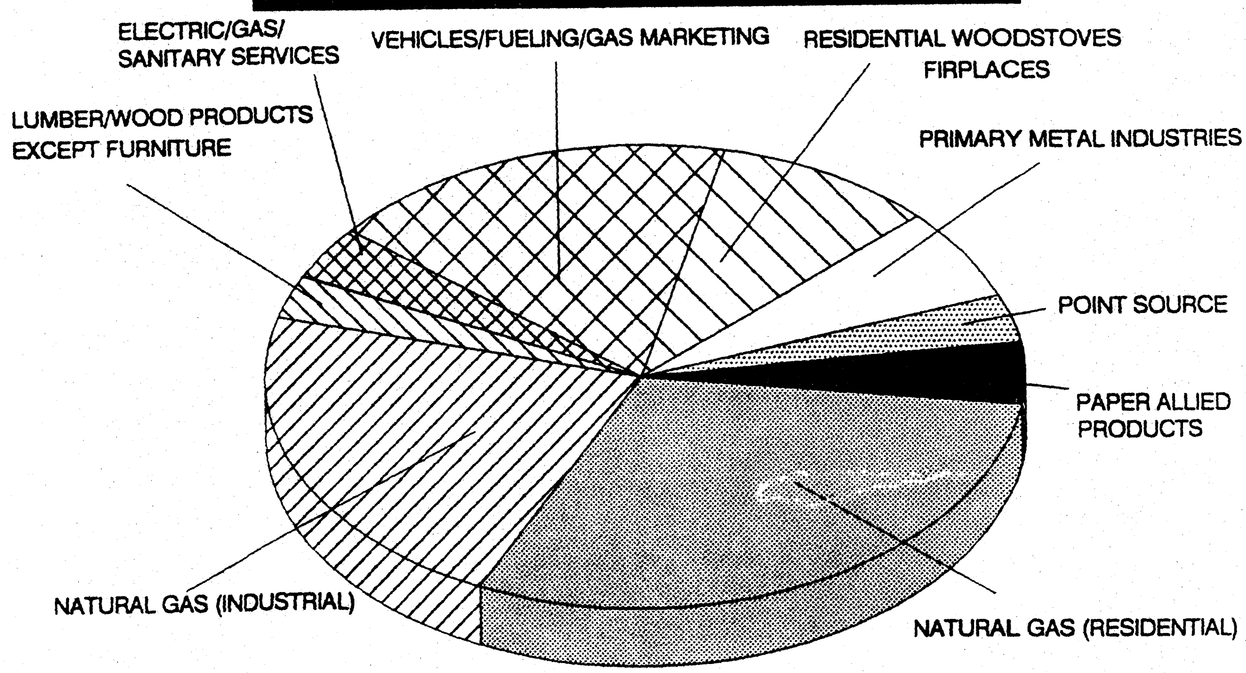
TOXIC EMISSIONS IN THE SOUTHWEST REGION FOR 1984



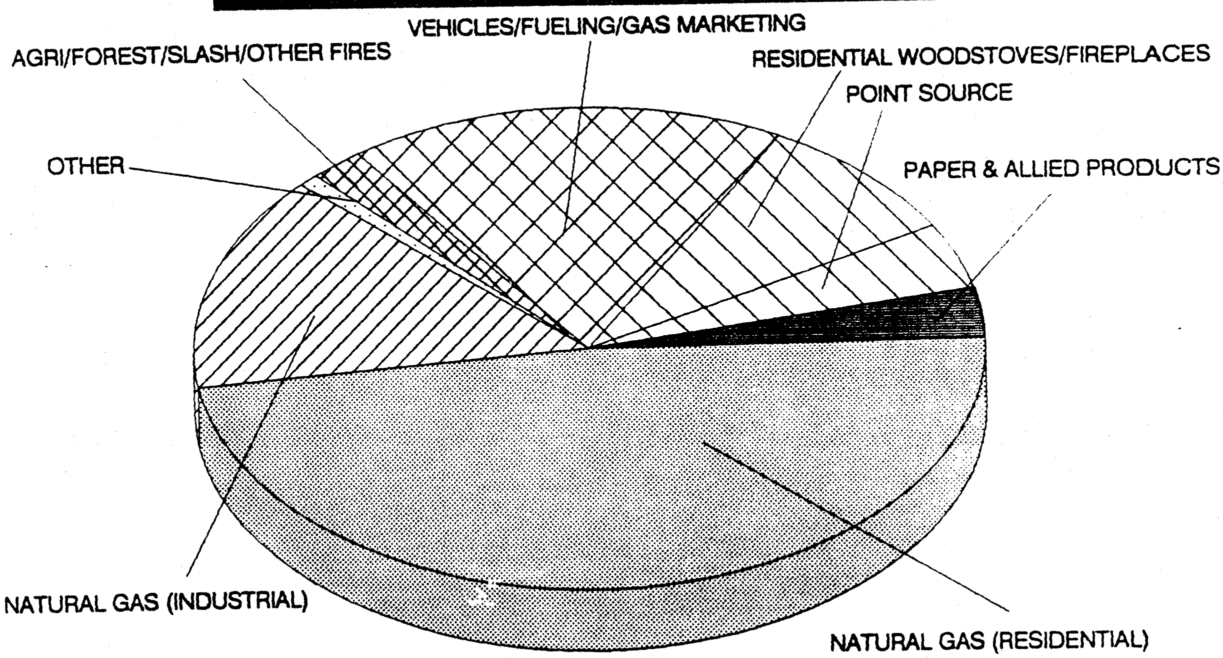
TOXIC EMISSIONS IN THE
NORTERN REGION FOR 1984



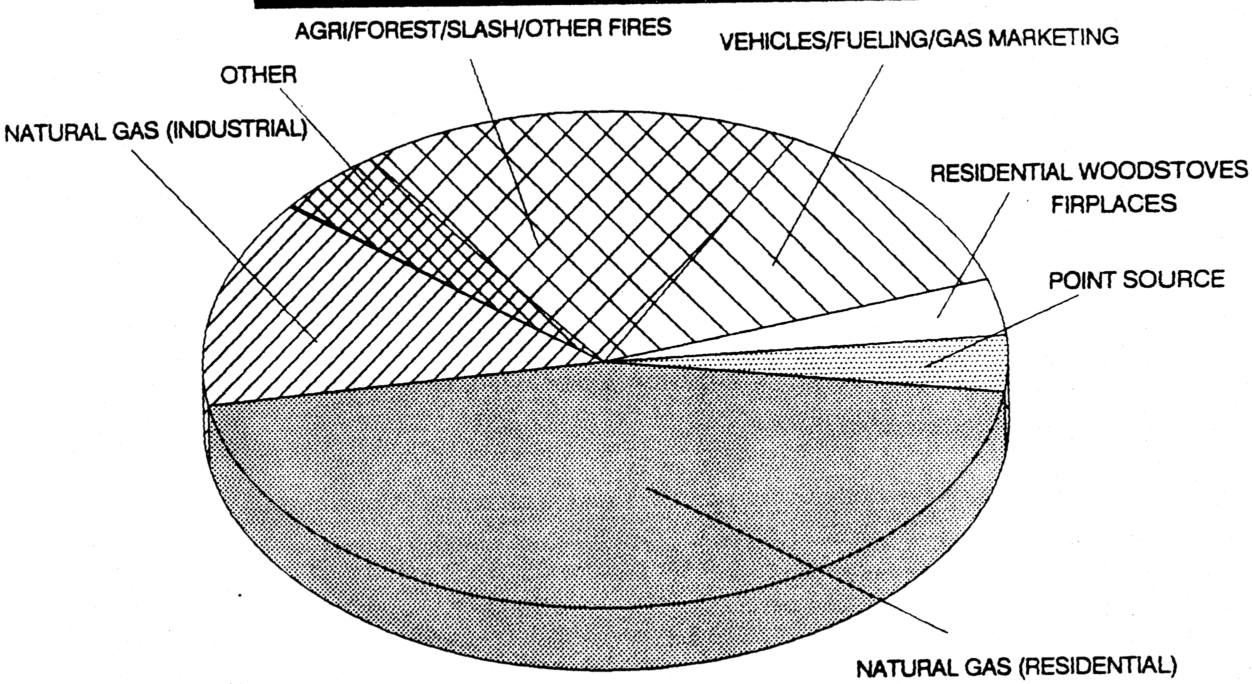
TOXIC EMISSIONS IN THE
SOUTH CENTRAL REGION FOR 1984



TOXIC EMISSIONS IN THE
PUGET SOUND REGION FOR 1984

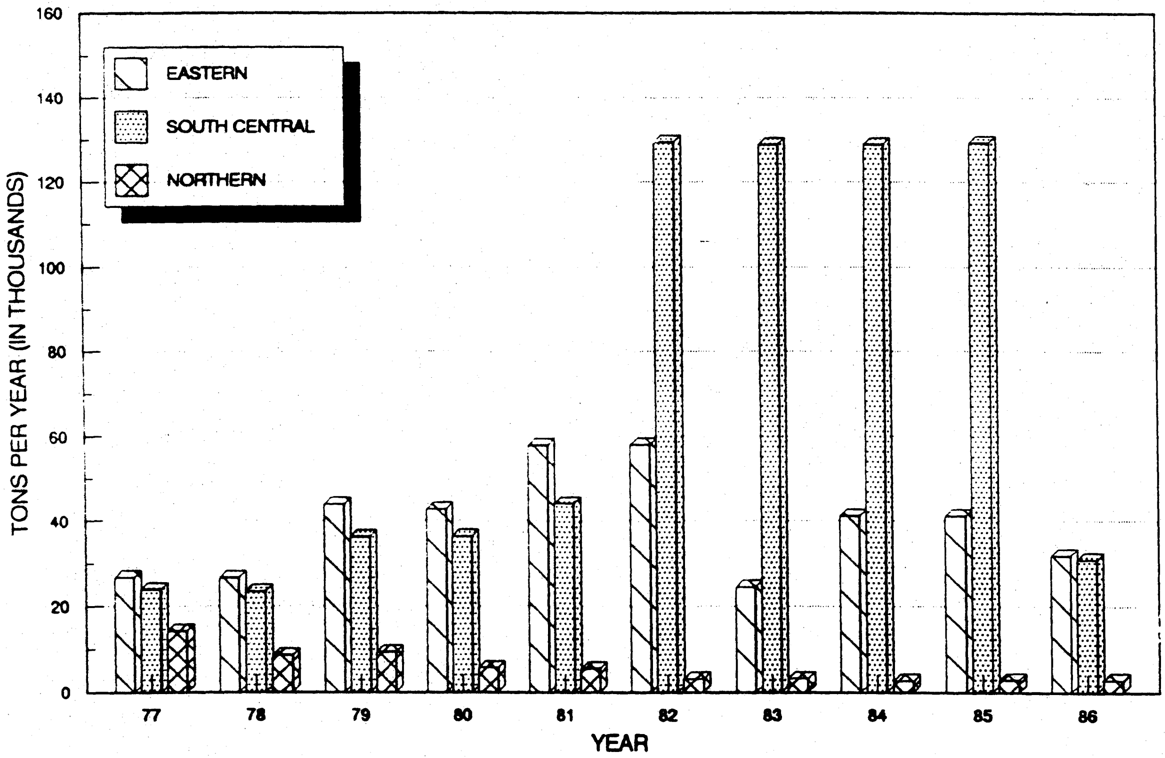


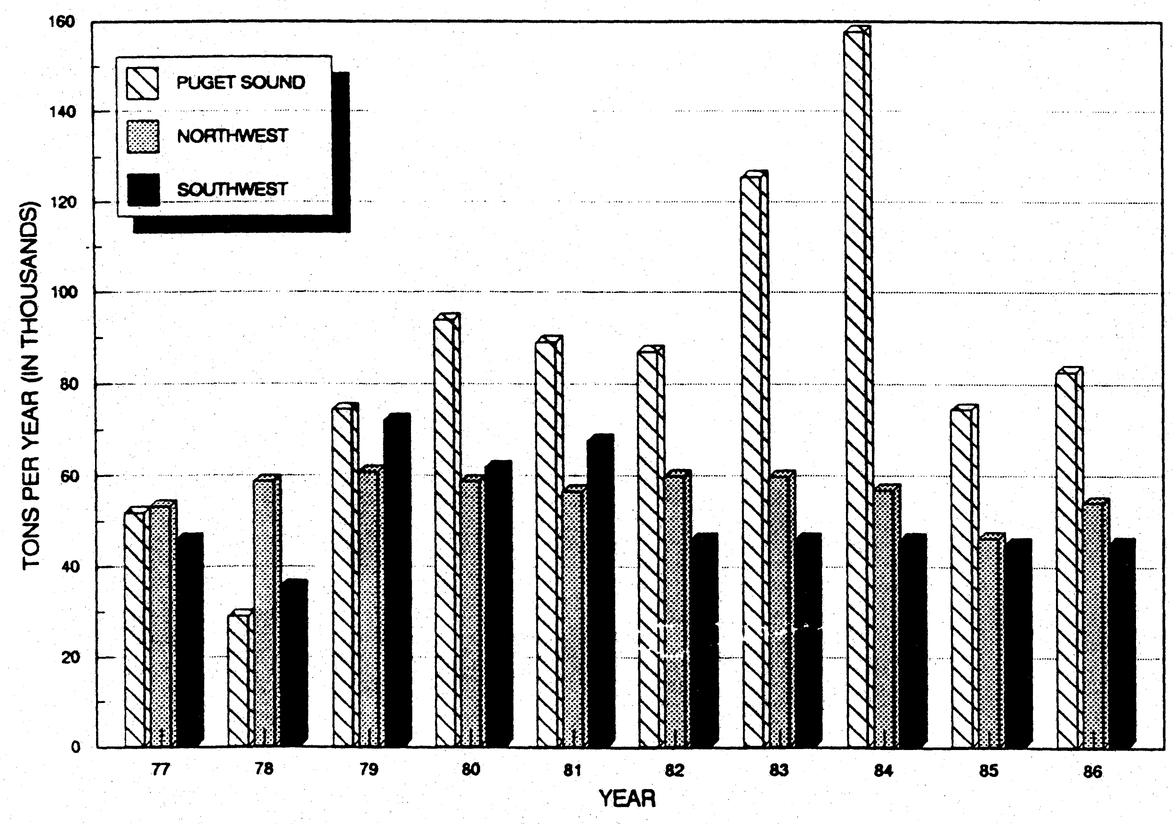
TOXIC EMISSIONS IN THE
EASTERN REGION FOR 1984



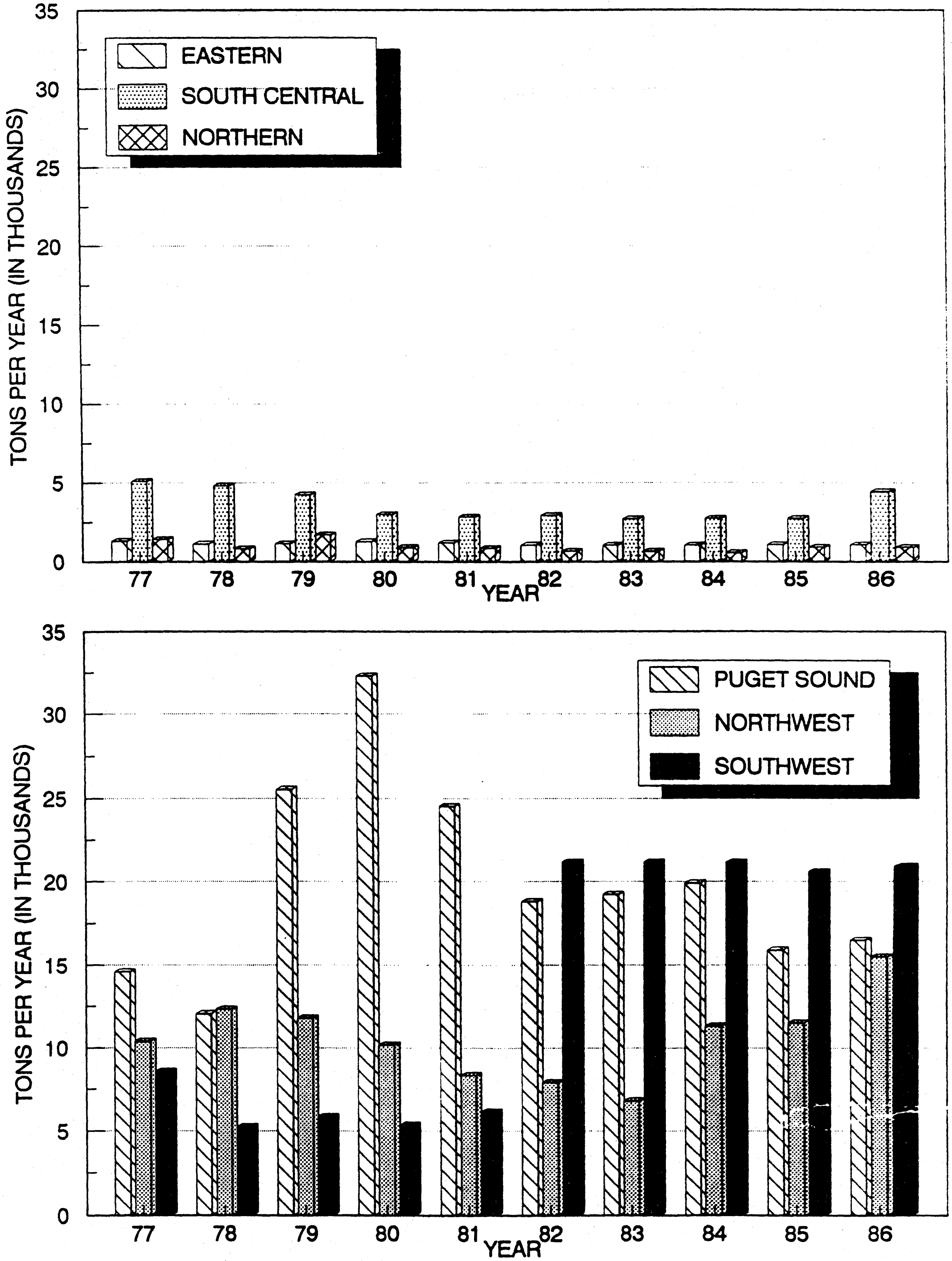
APPENDIX B

CARBON MONOXIDE EMISSIONS

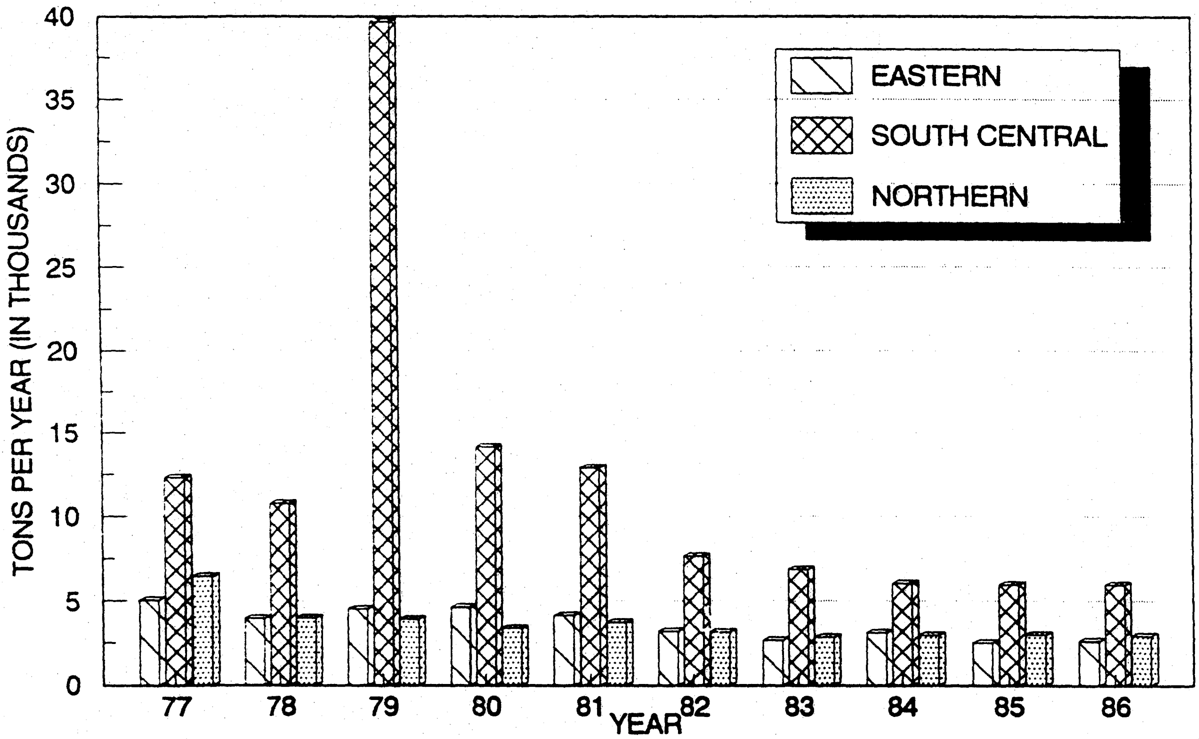


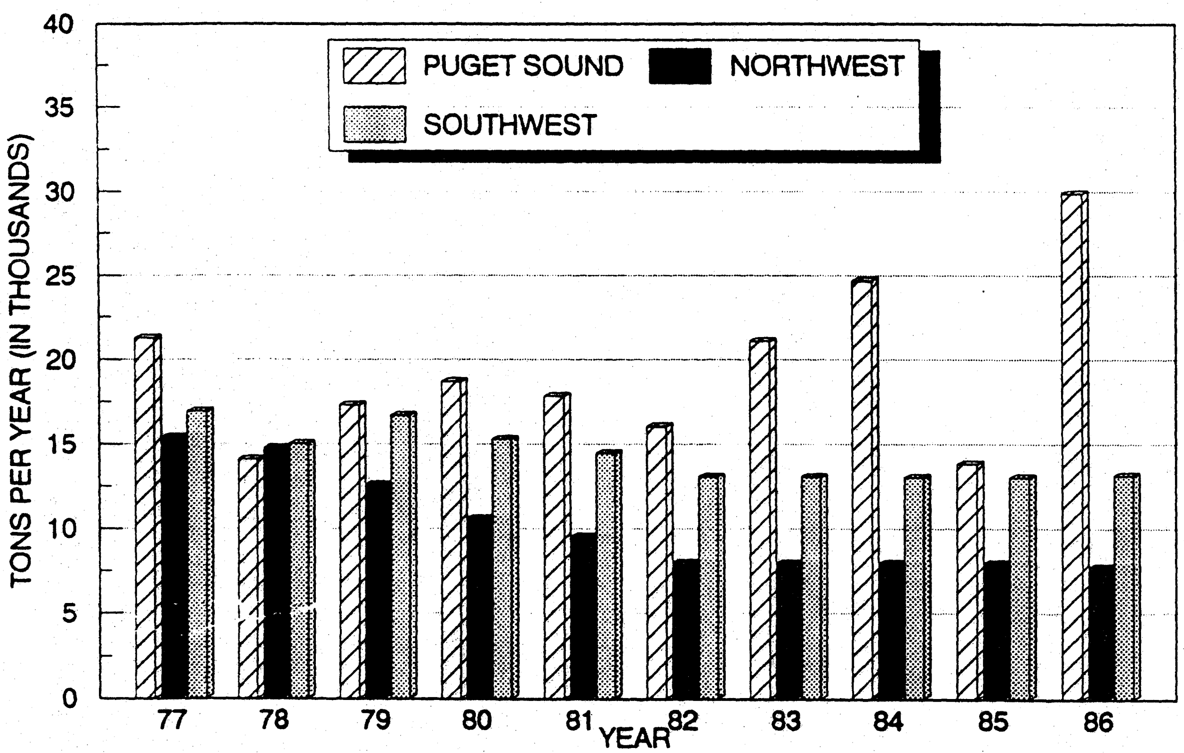


VOLATILE ORGANIC EMISSIONS

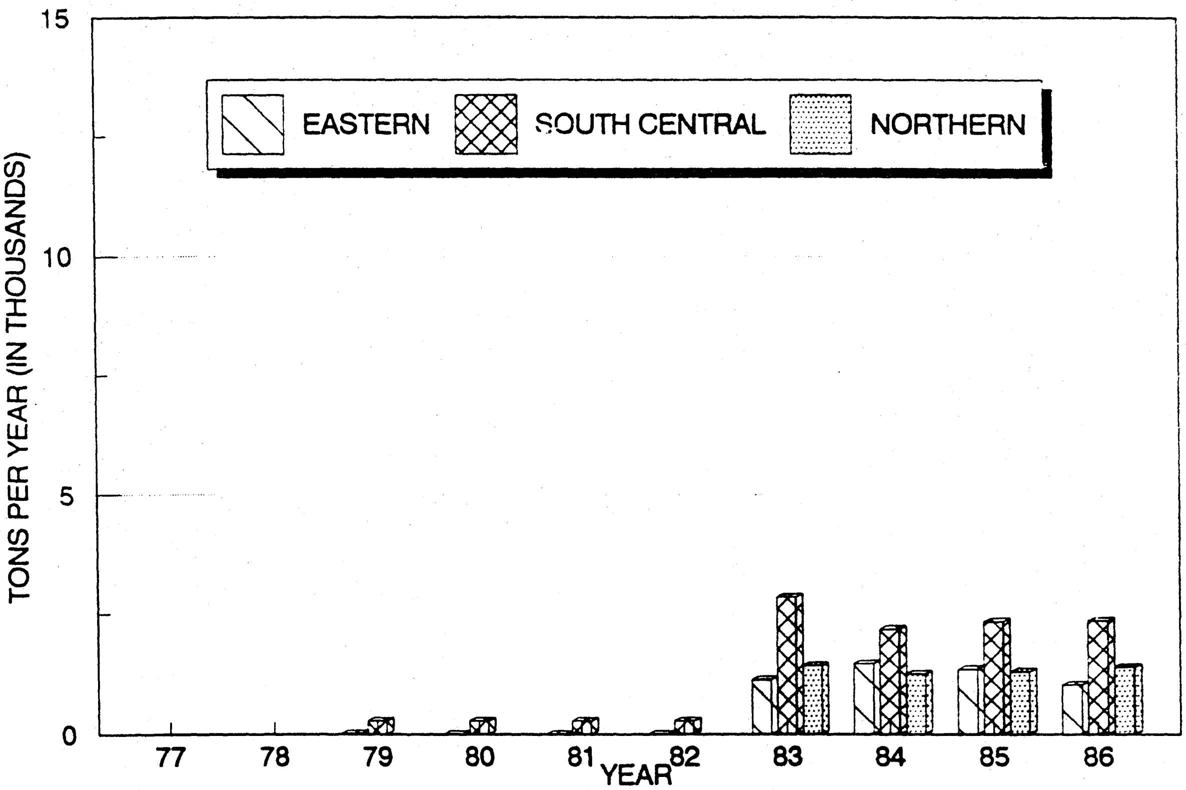


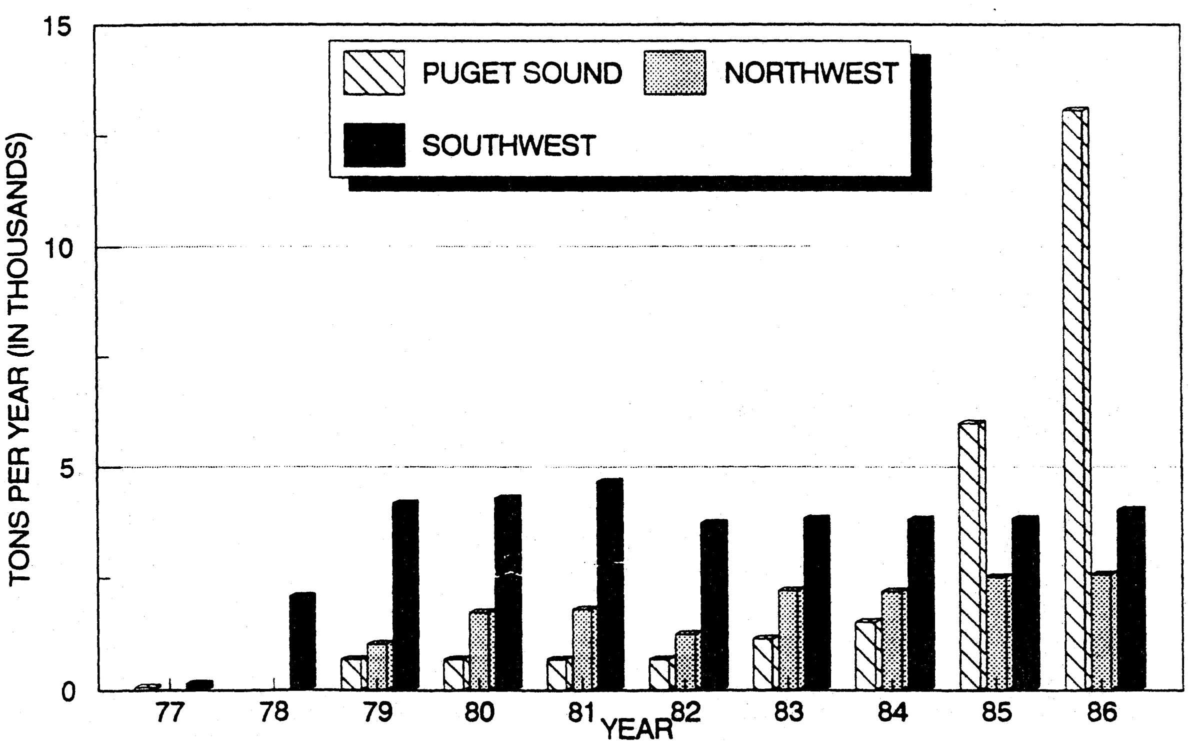
TOTAL PARTICULATE EMISSIONS



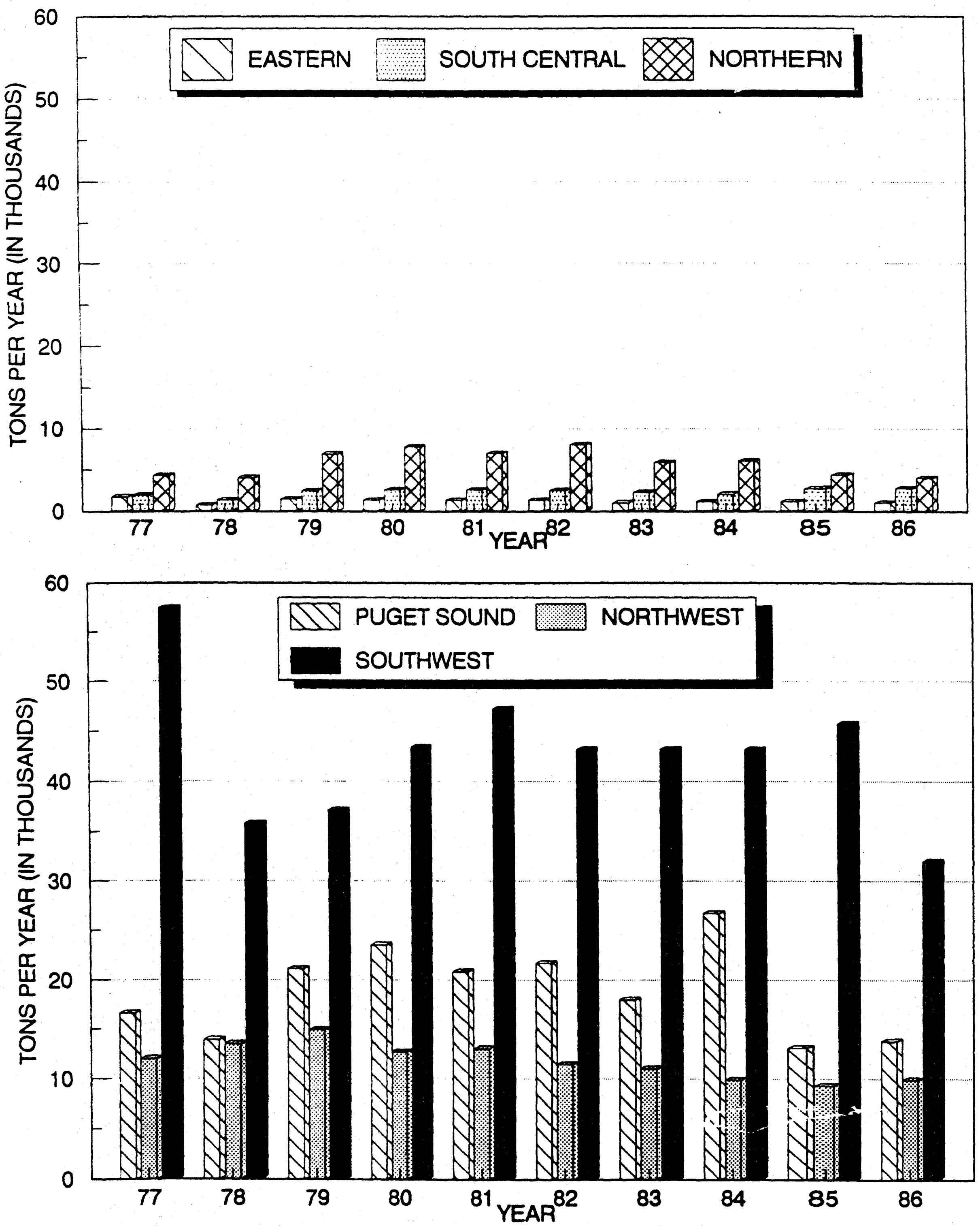


FINE PARTICULATE EMISSIONS



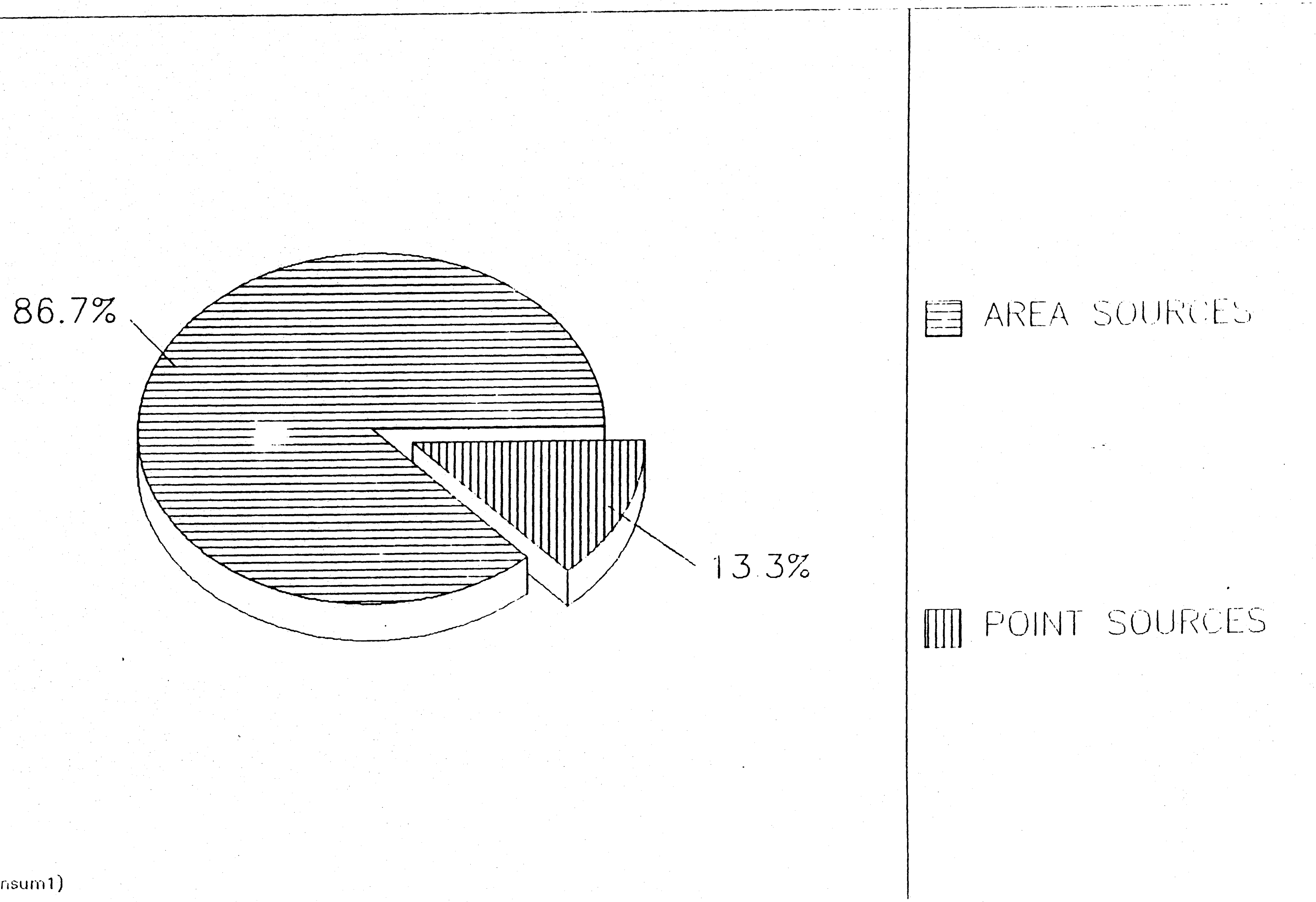


NITROGEN DIOXIDE EMISSIONS



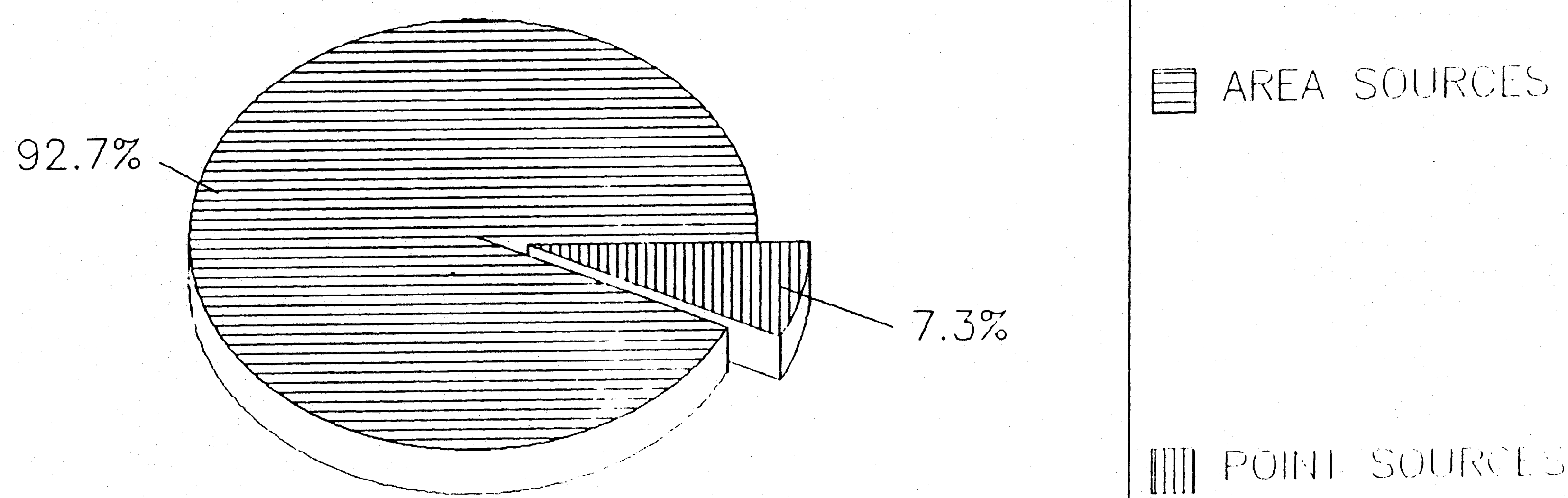
APPENDIX C

STATEWIDE TOTAL
AREA VERSUS POINT SOURCES
TOTAL OF ALL TOXICS



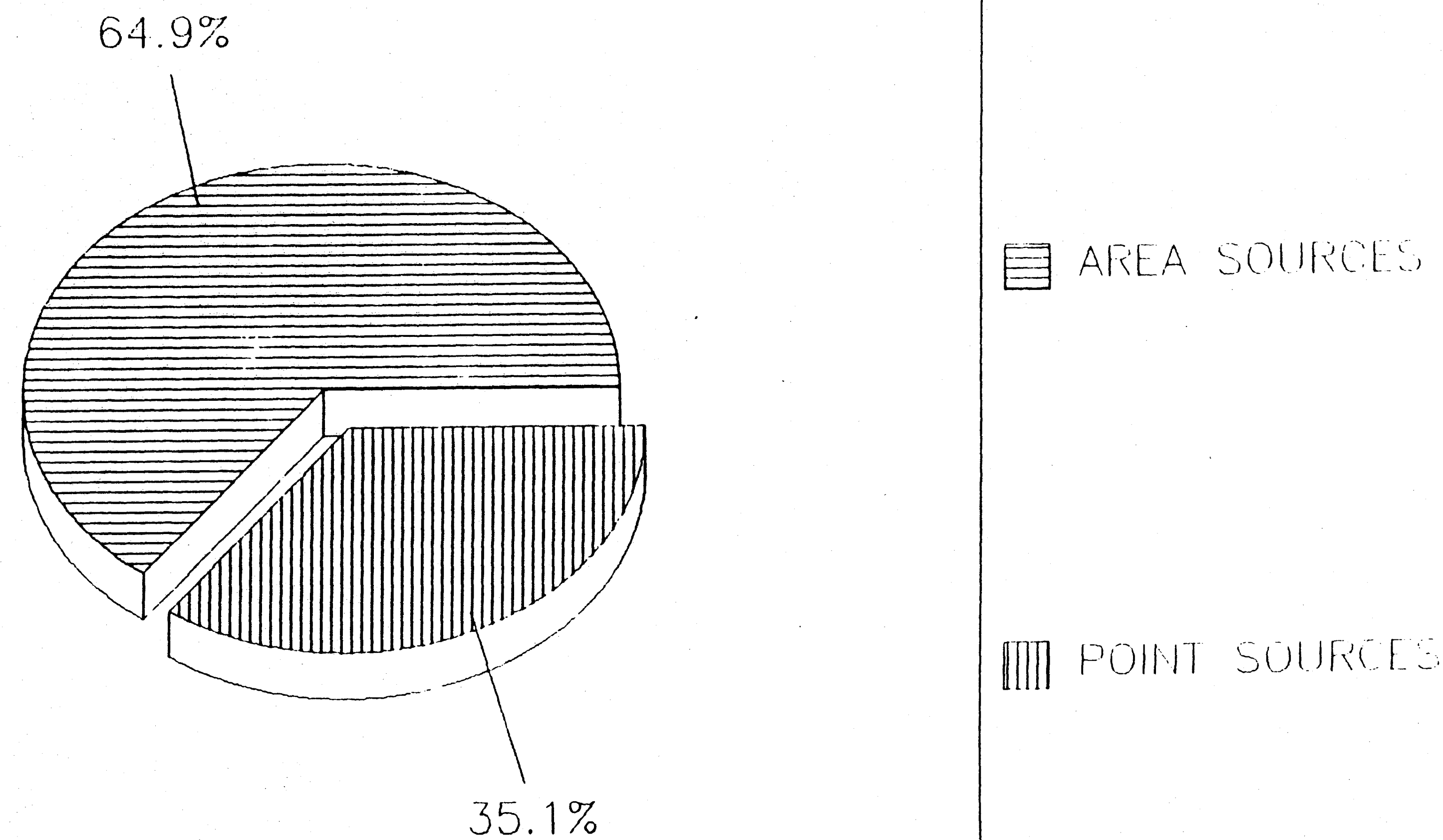
r_pt/ivnsum1)

EASTERN WASHINGTON INTERSTATE
AREA VERSUS POINT SOURCES
TOTAL OF ALL TOXICS



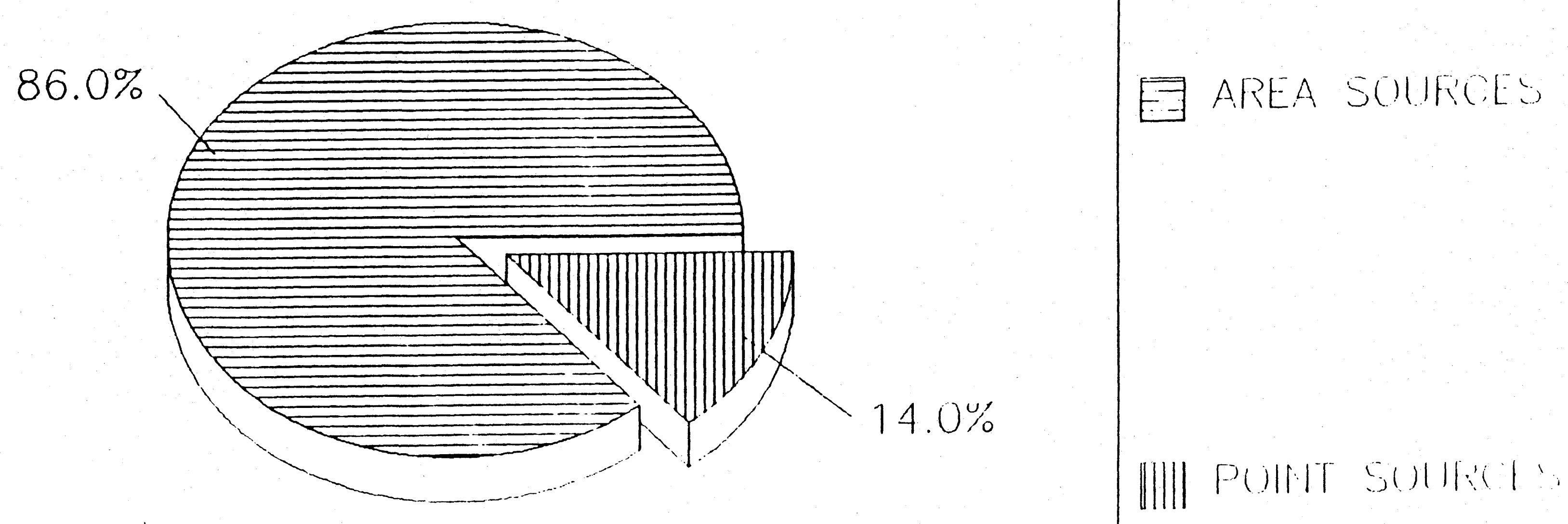
(a:ur pt/ivnsum1)

NORTHERN WASHINGTON INTRASTATE
AREA VERSUS POINT SOURCES
TOTAL OF ALL TOXICS



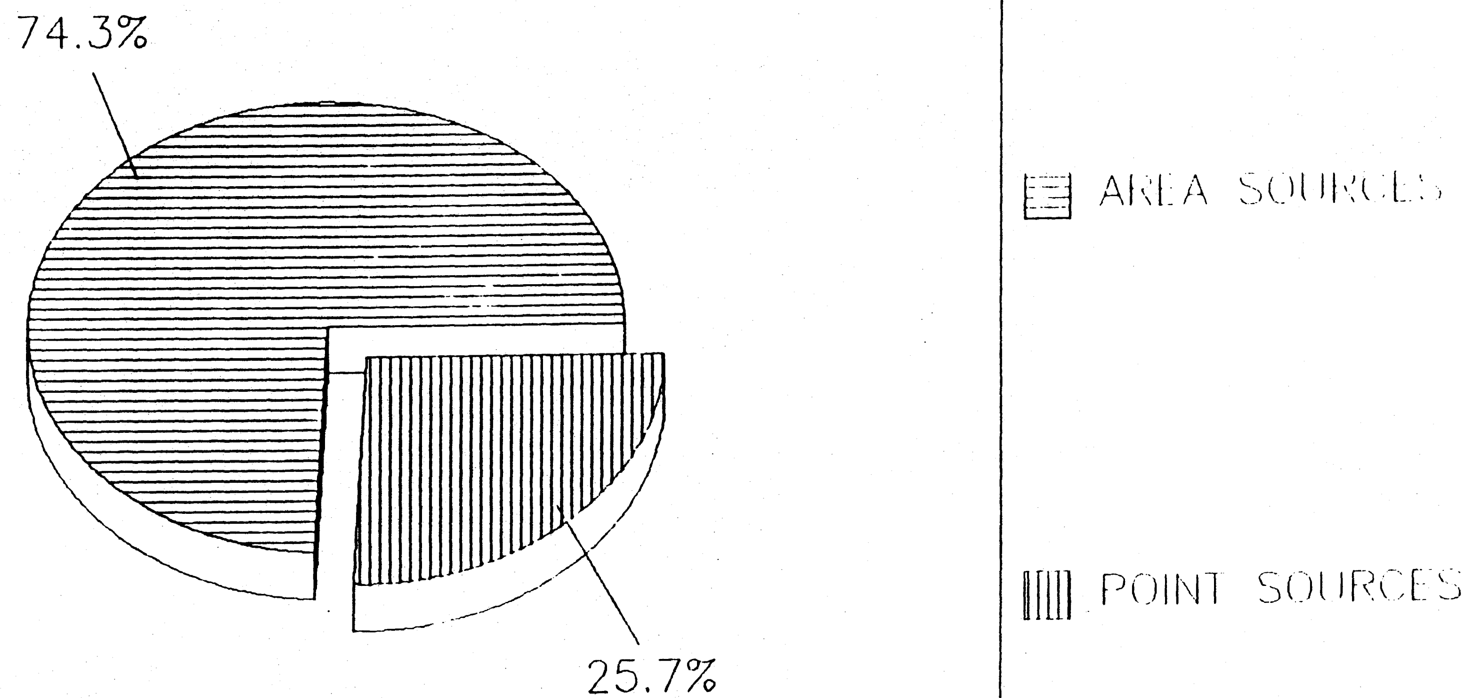
(a:ar_pt/ivnsum1)

SOUTH CENTRAL WASHINGTON INTRASTATE
AREA VERSUS POINT SOURCES
TOTAL OF ALL TOXICS



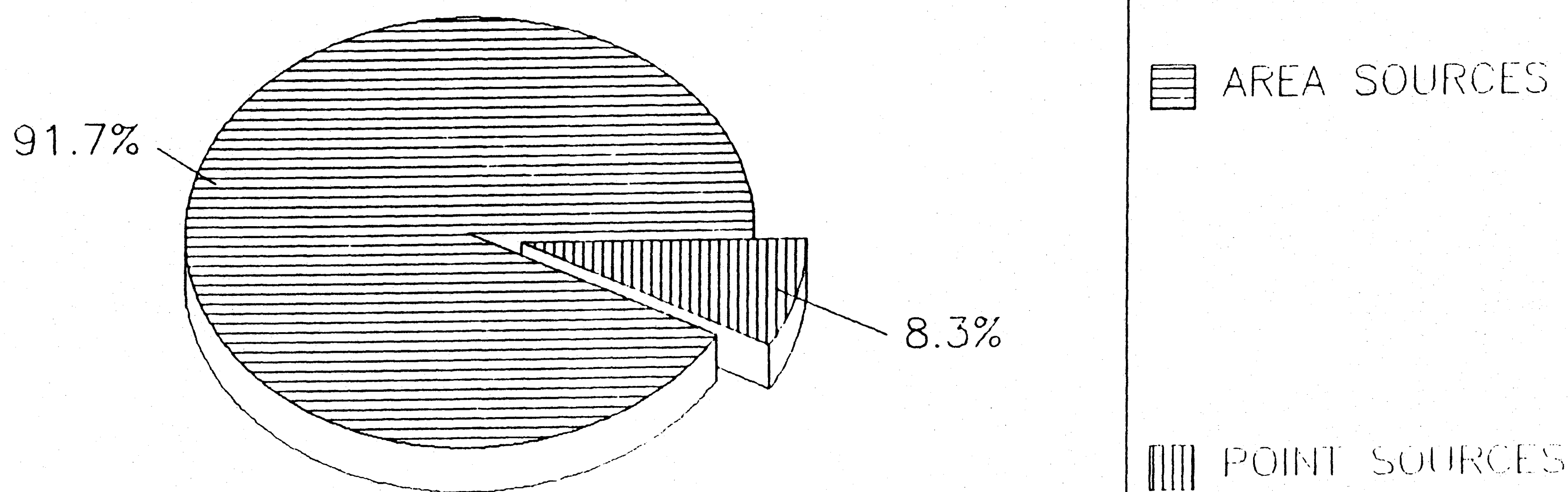
(a:ar_pt/ivnsum1)

SOUTHWEST WASHINGTON INTERSTATE
AREA VERSUS POINT SOURCES
TOTAL OF ALL TOXICS



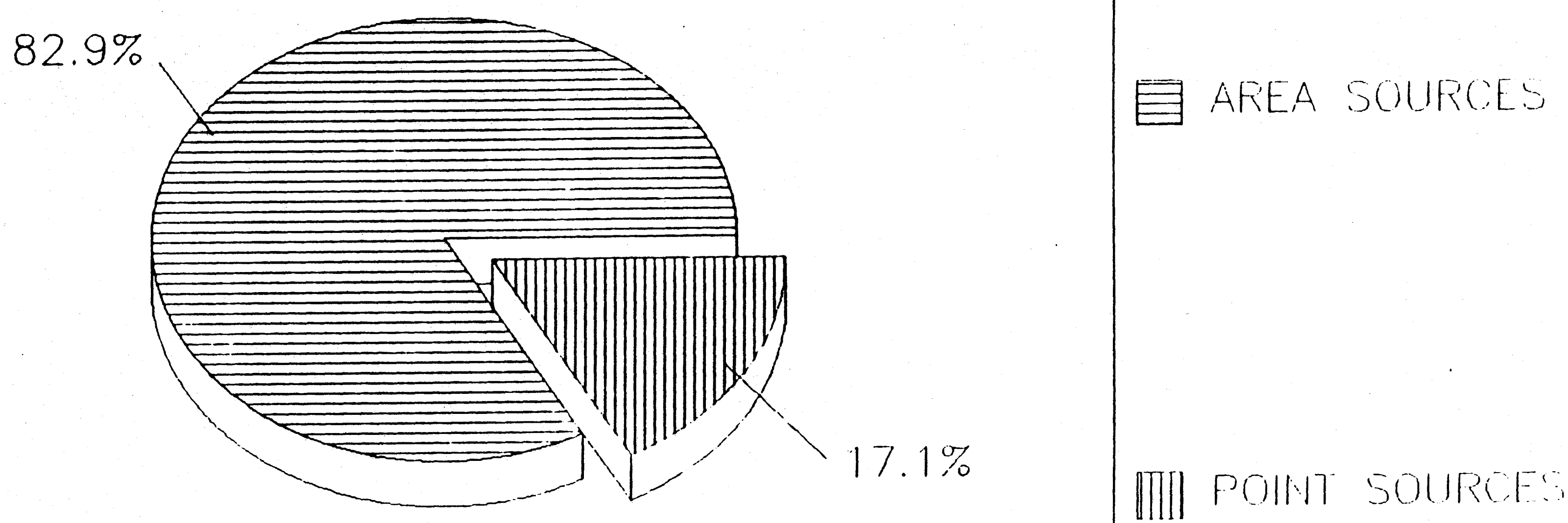
(a:ar_pt/ivnsum1)

PUGET SOUND INTRASTATE
AREA VERSUS POINT SOURCES
TOTAL OF ALL TOXICS



(a:ar.pt/ivnsum1)

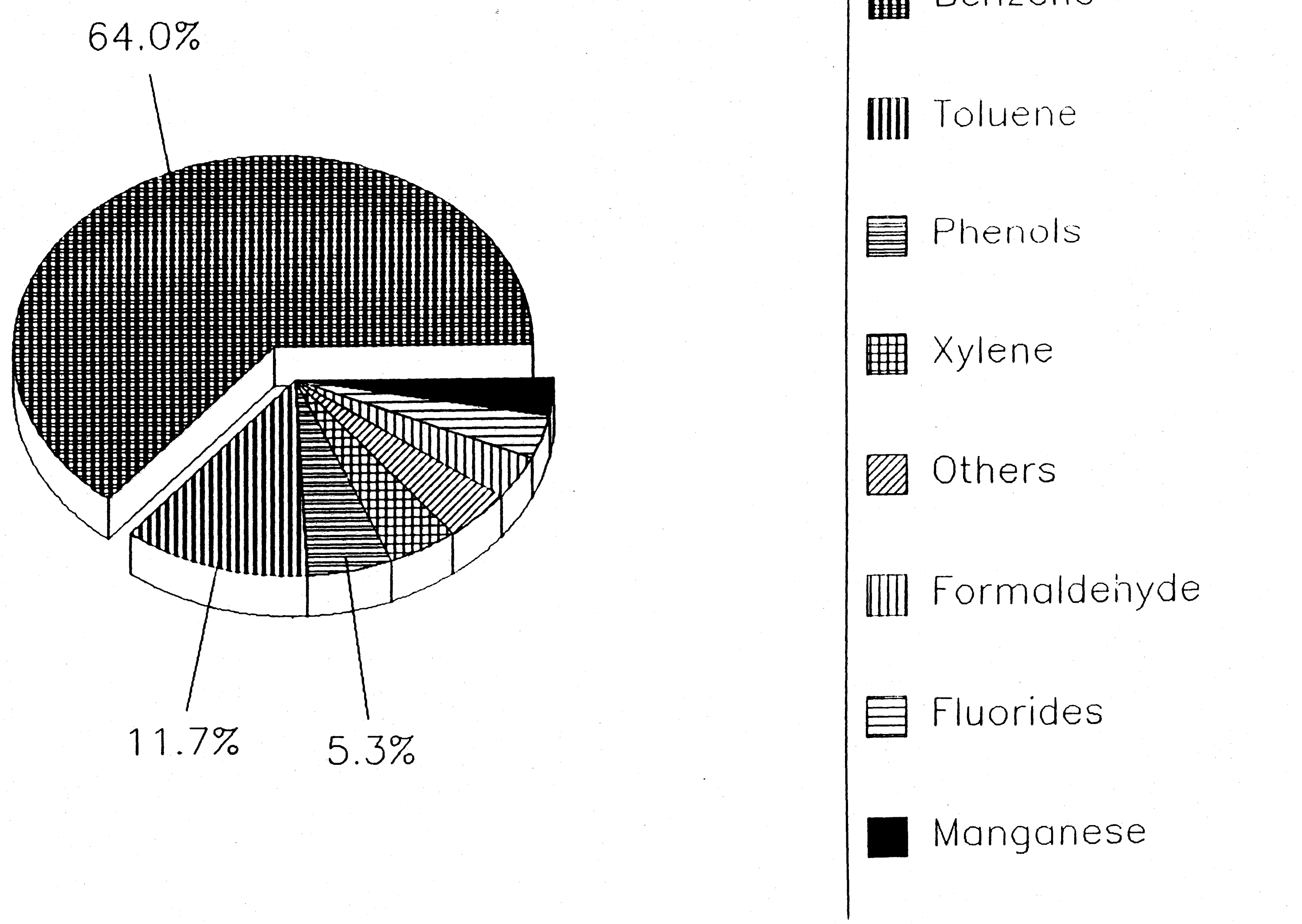
OLYMPIC-NORTHWEST WASHINGTON INTRASTATE
AREA VERSUS POINT SOURCES
TOTAL OF ALL TOXICS



(a:or_pt/ivnsum1)

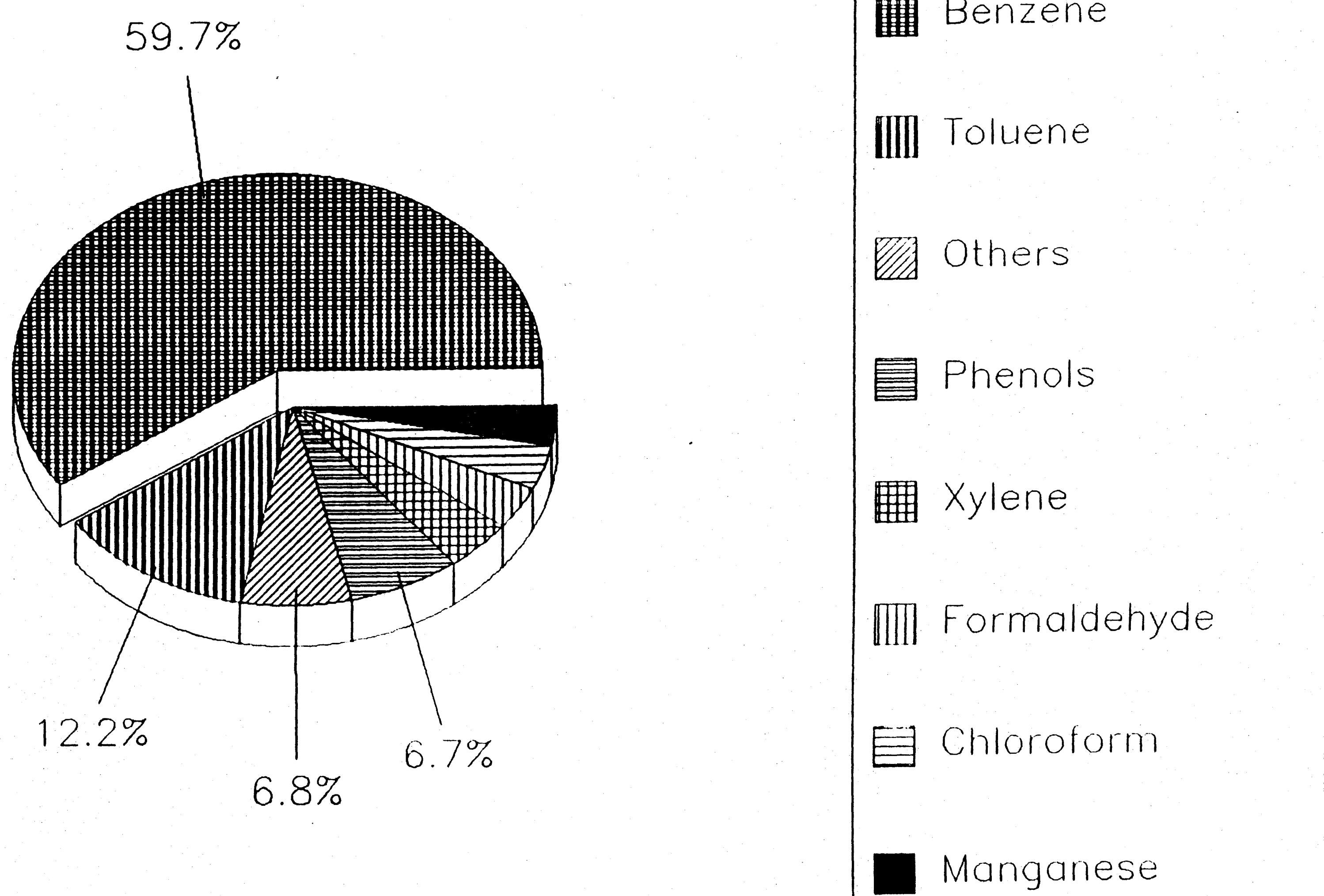
APPENDIX D

EASTERN WASHINGTON
TOXICS RANKED BY TOTAL EMISSIONS



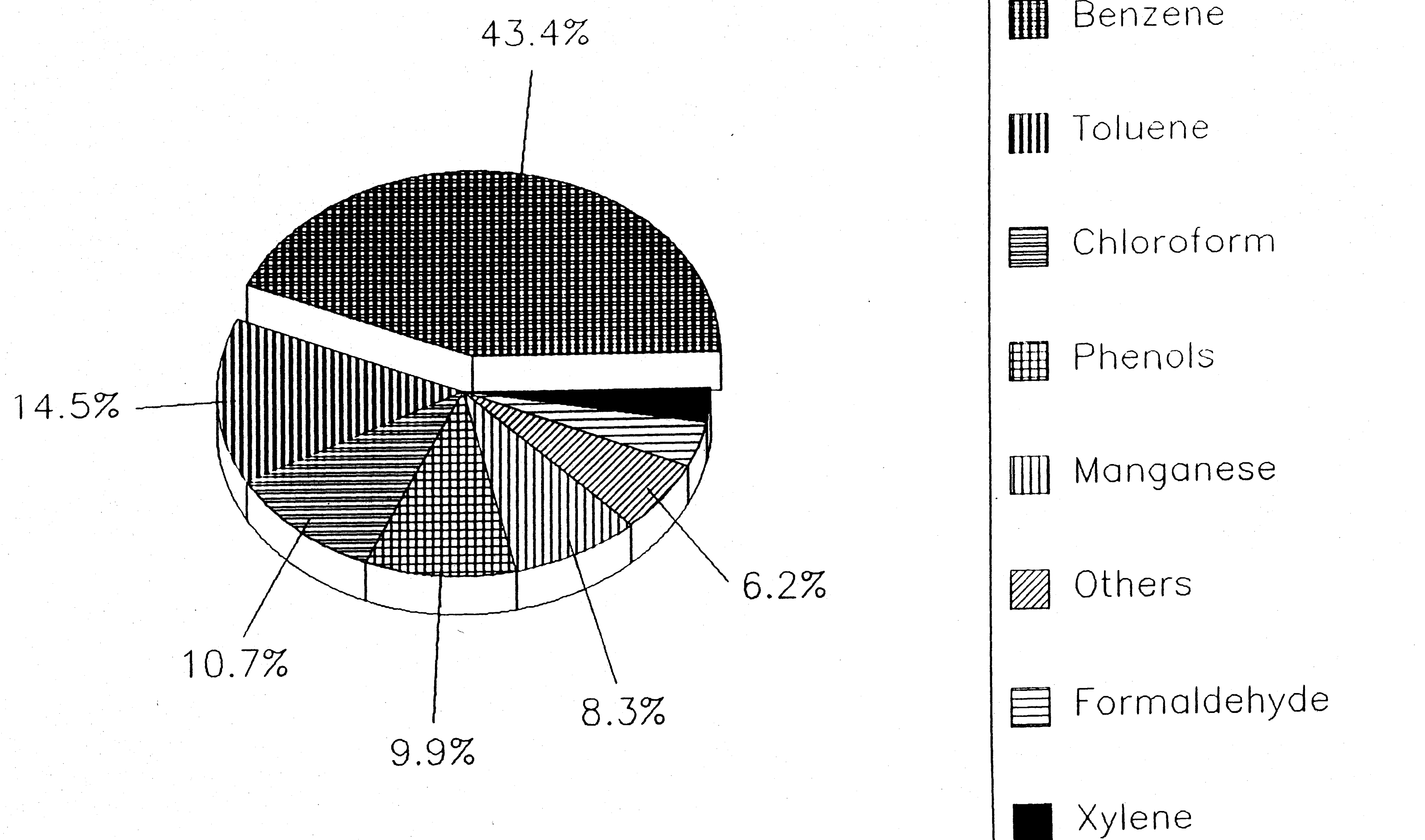
›ymost/most)

SOUTH CENTRAL WASHINGTON INTRASTATE TOXICS RANKED BY TOTAL EMISSIONS



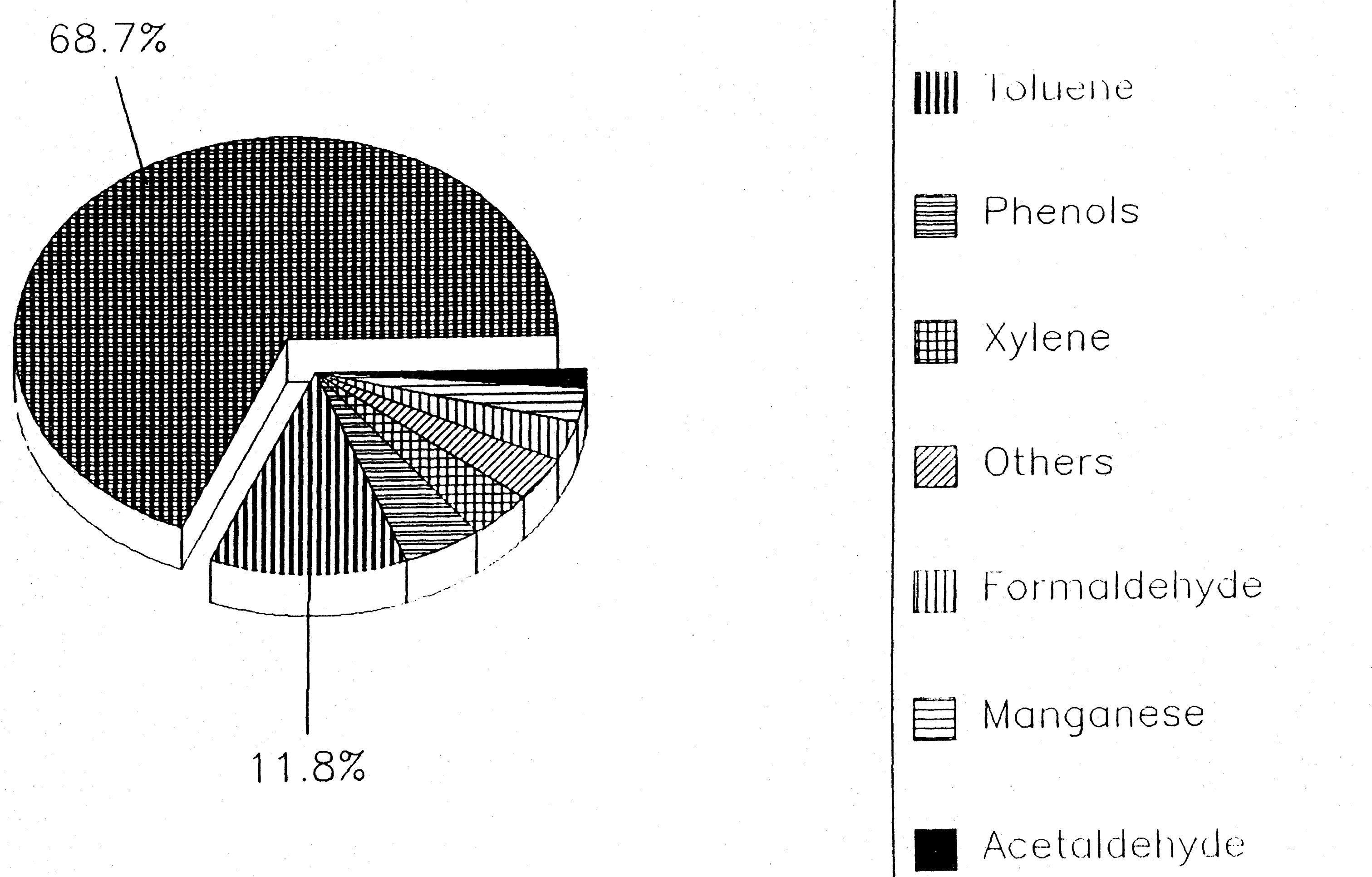
i:bymost/most)

SOUTHWEST WASHINGTON INTERSTATE TOXICS RANKED BY TOTAL EMISSIONS



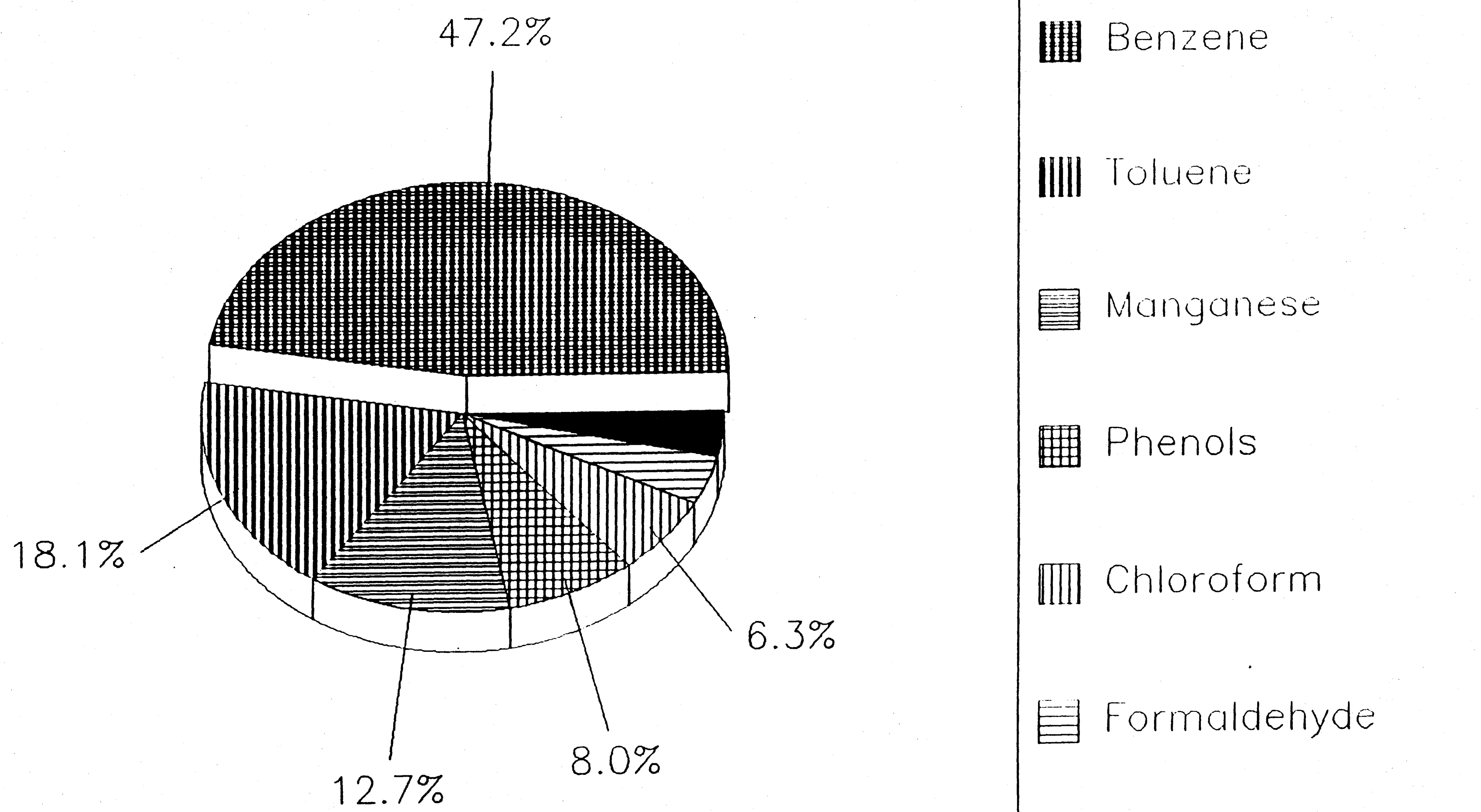
bymost/most)

PUGET SOUND INTRASTATE
TOXICS RANKED BY TOTAL EMISSIONS



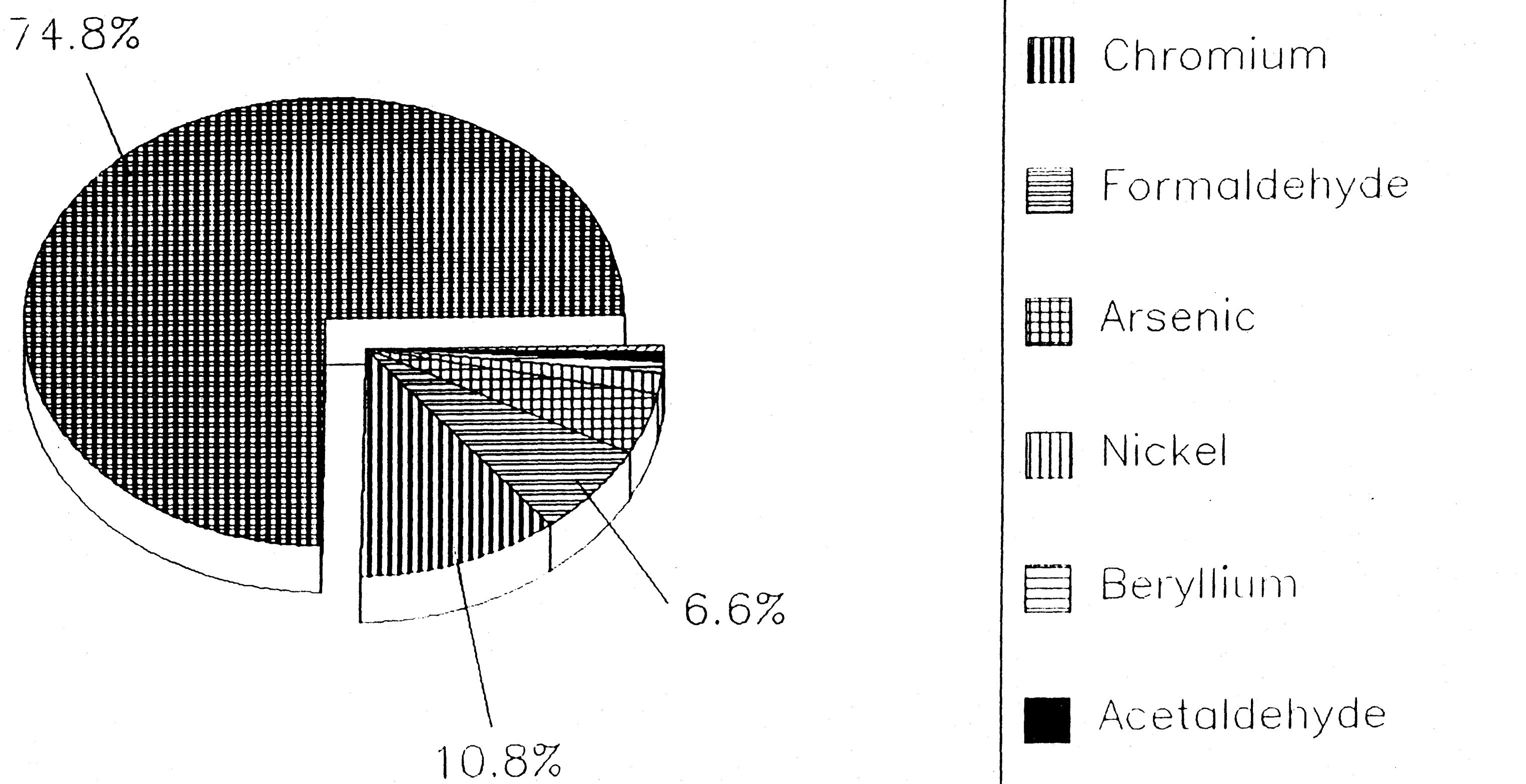
a:bymost/most)

EASTERN WASHINGTON INTERSTATE TOXICS RANKED BY TOTAL EMISSIONS



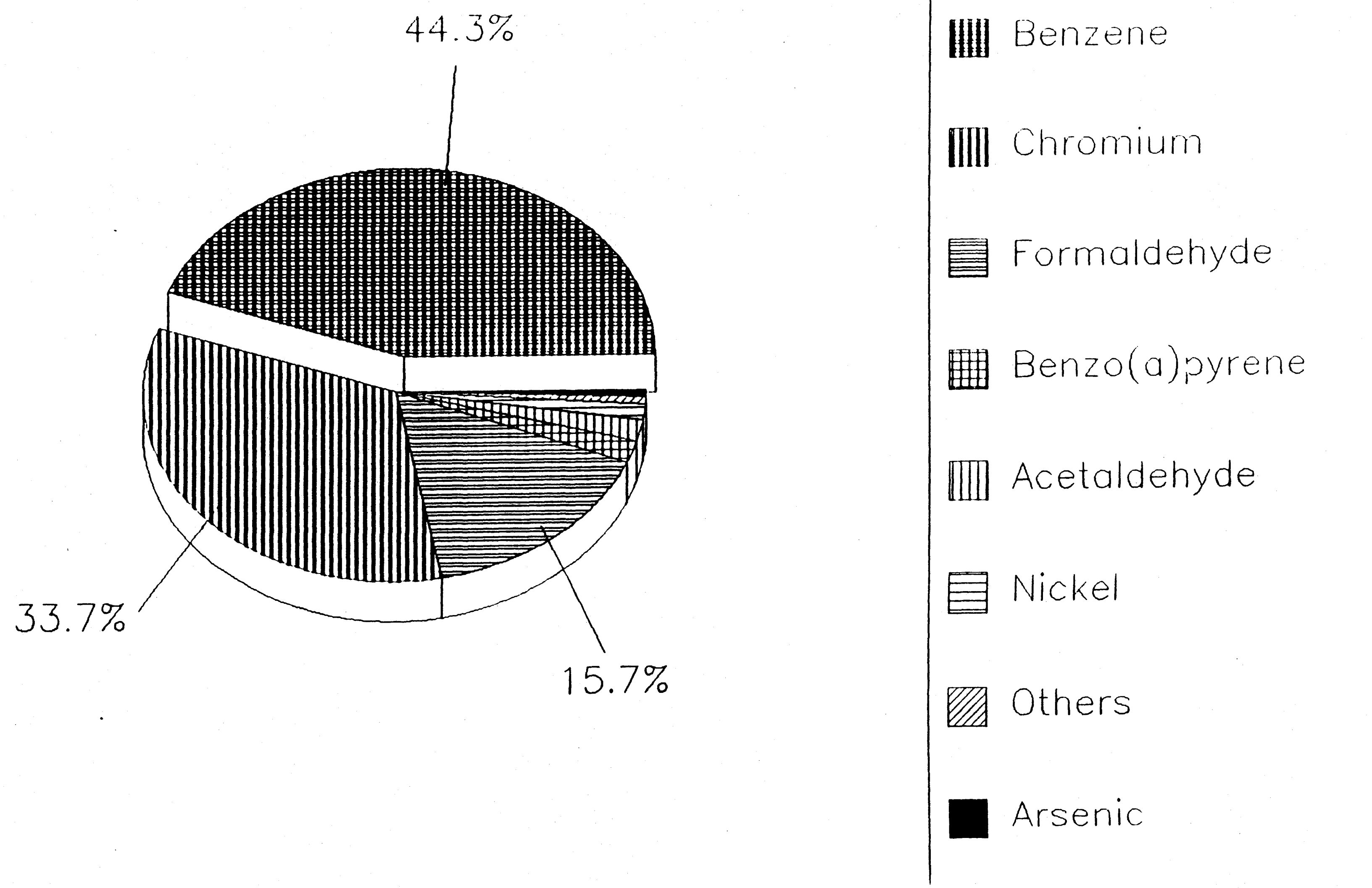
ɔymost/most)

EASTERN WASHINGTON INTERSTATE TOXICS RANKED BY RISK (excluding Dioxin)



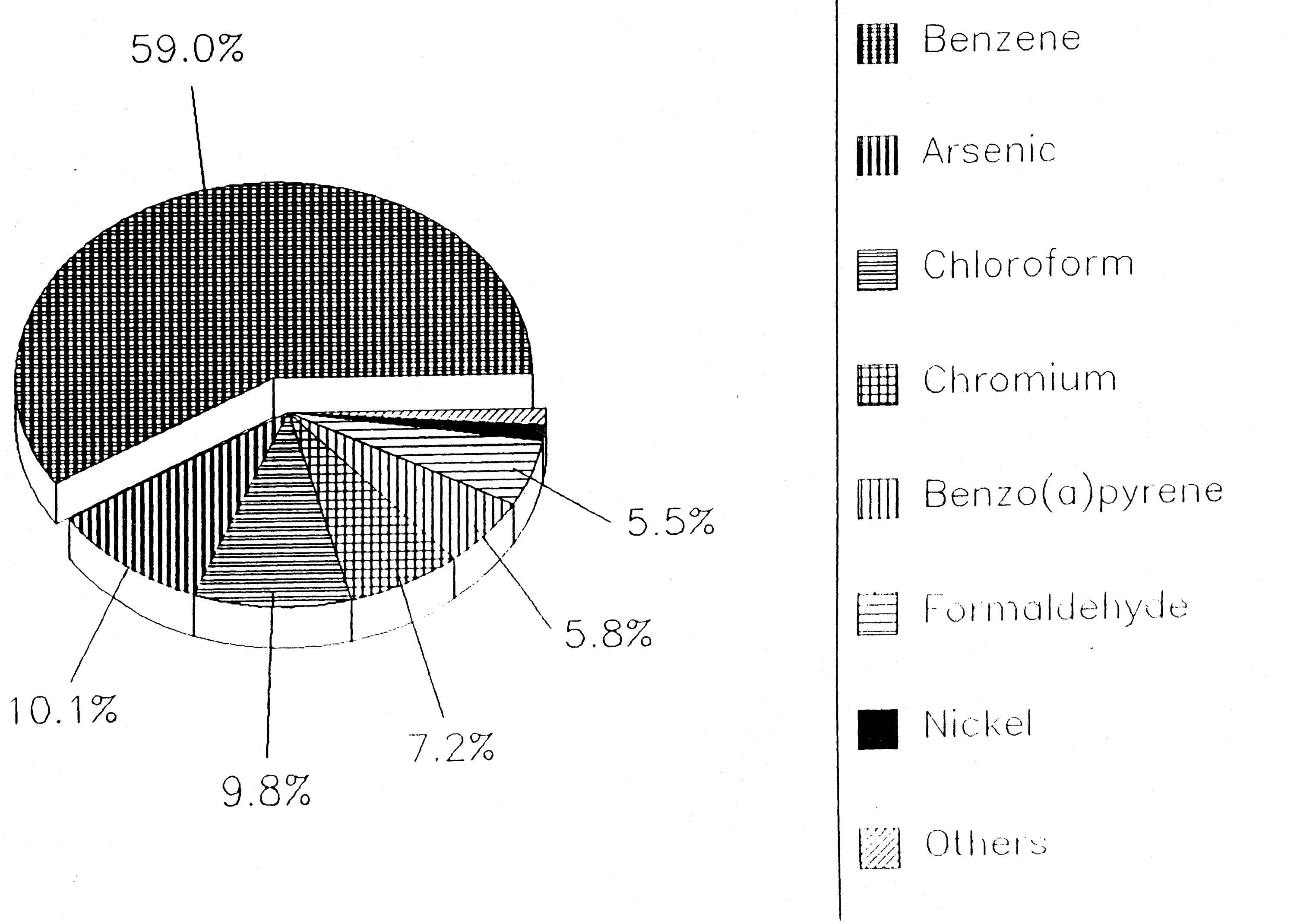
i:hazrank/haz)

NORTHERN WASHINGTON INTRASTATE TOXICS RANKED BY RISK (excluding Dioxin)



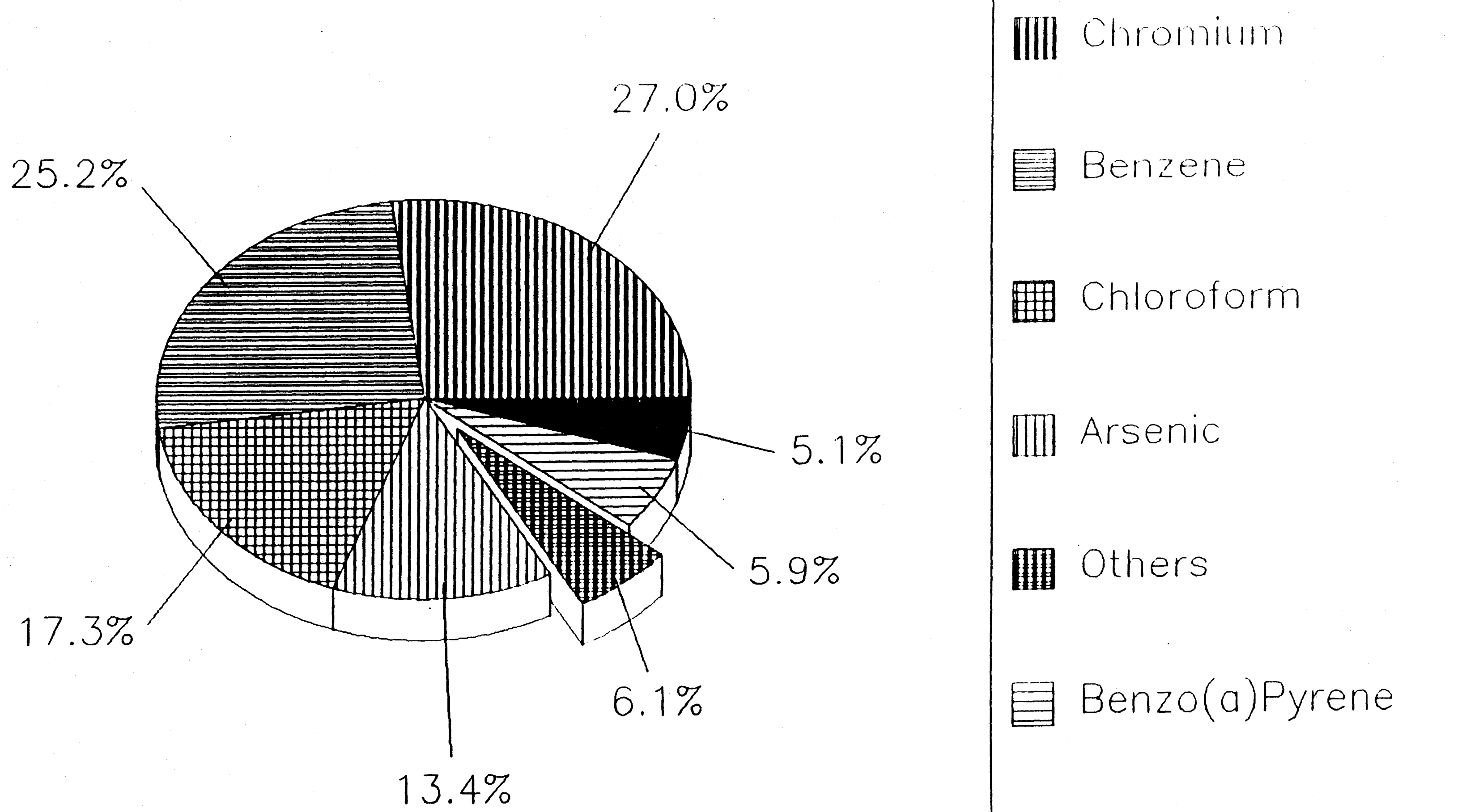
azrank/haz)

SOUTH CENTRAL WASHINGTON INTRASTATE TOXICS RANKED BY RISK (excluding Dioxin)



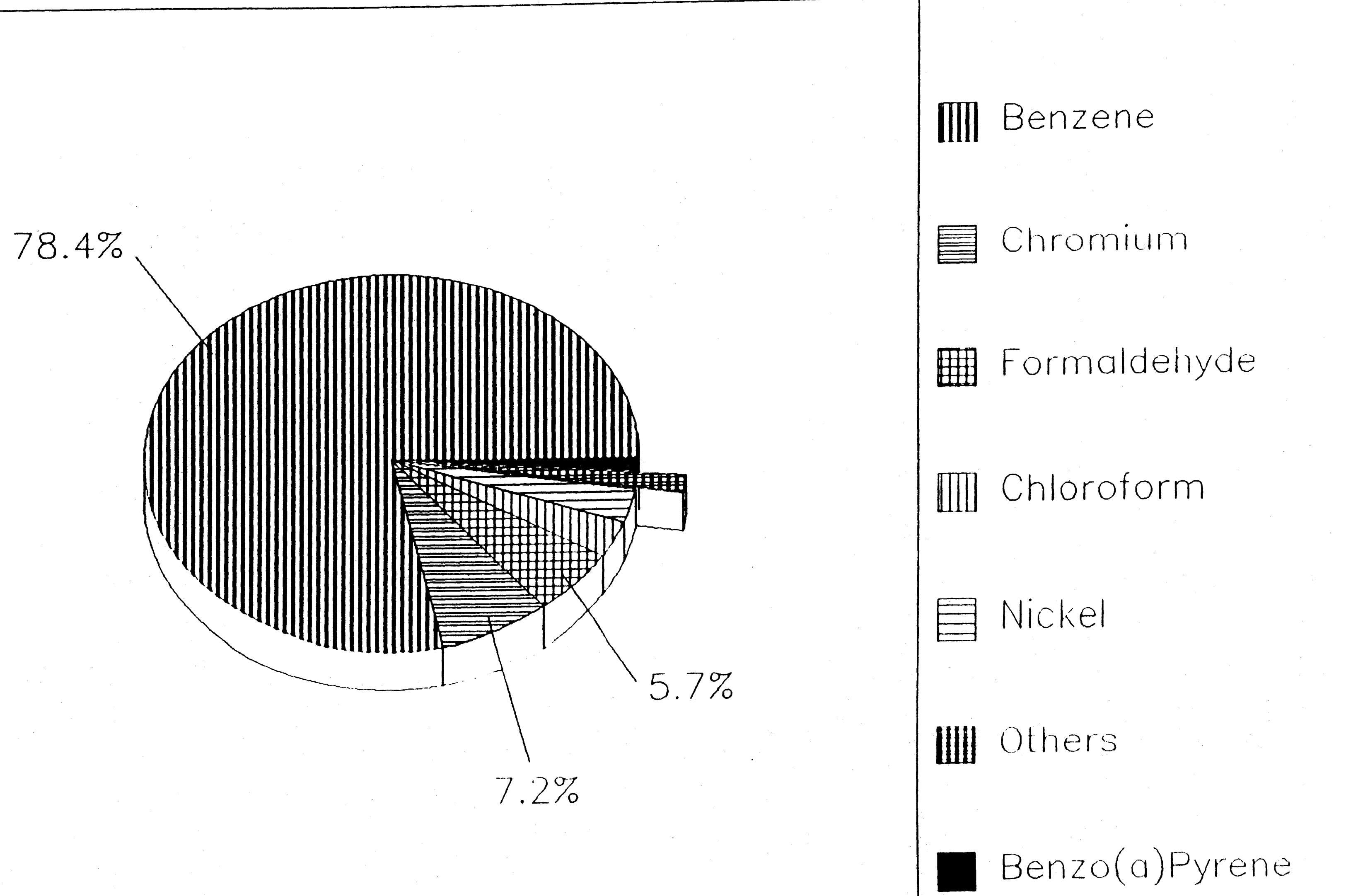
i:hazrank/haz)

SOUTHWEST WASHINGTON INTERSTATE TOXICS RANKED BY RISK (excluding Dioxin)



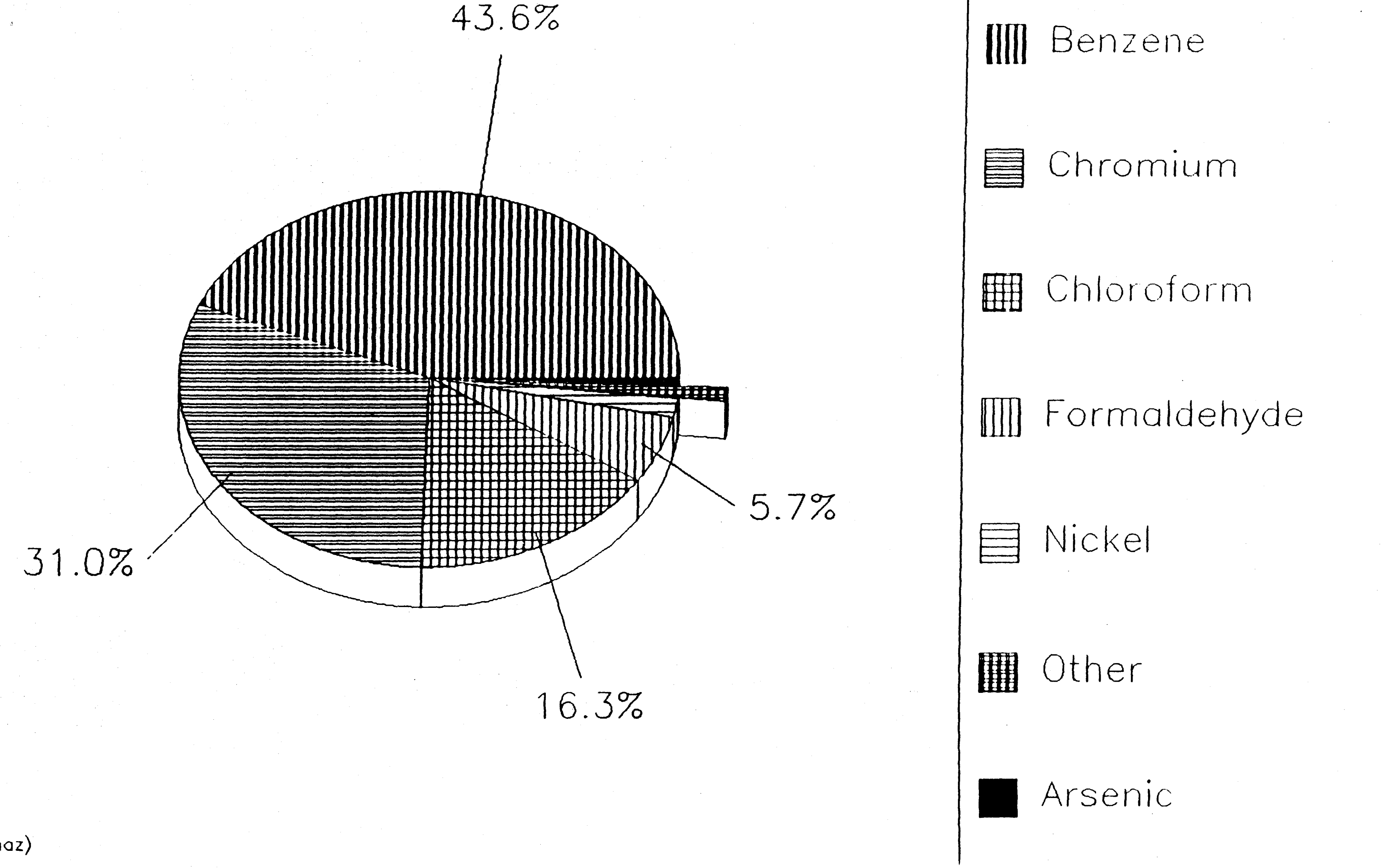
ızrank/haz)

PUGET SOUND
TOXICS RANKED BY RISK
(excluding Dioxin)



:hazrank/haz)

OLYMPIC–NORTHWEST WASHINGTON INTRASTATE TOXICS RANKED BY RISK (excluding Dioxin)

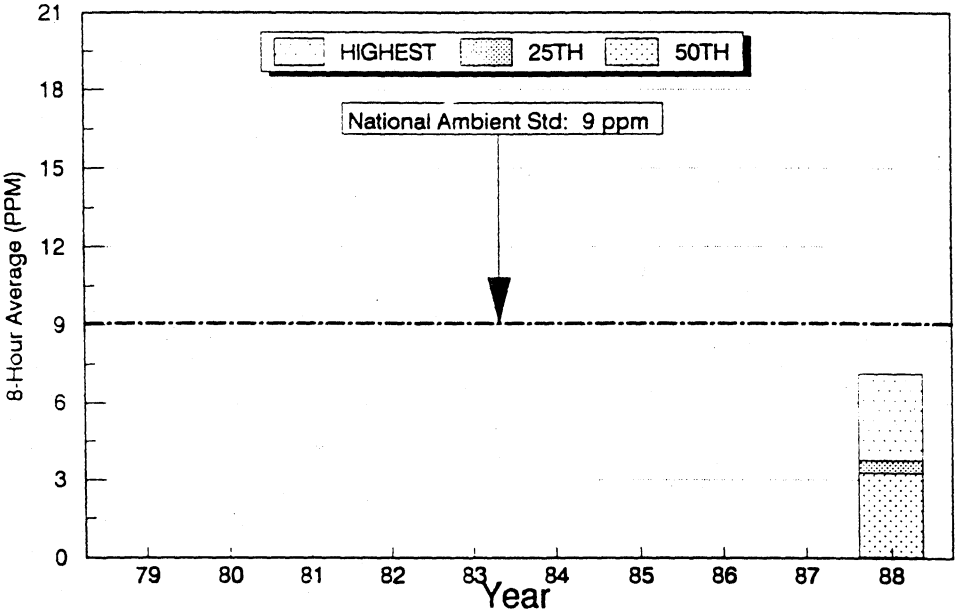


rank/haz)

APPENDIX E

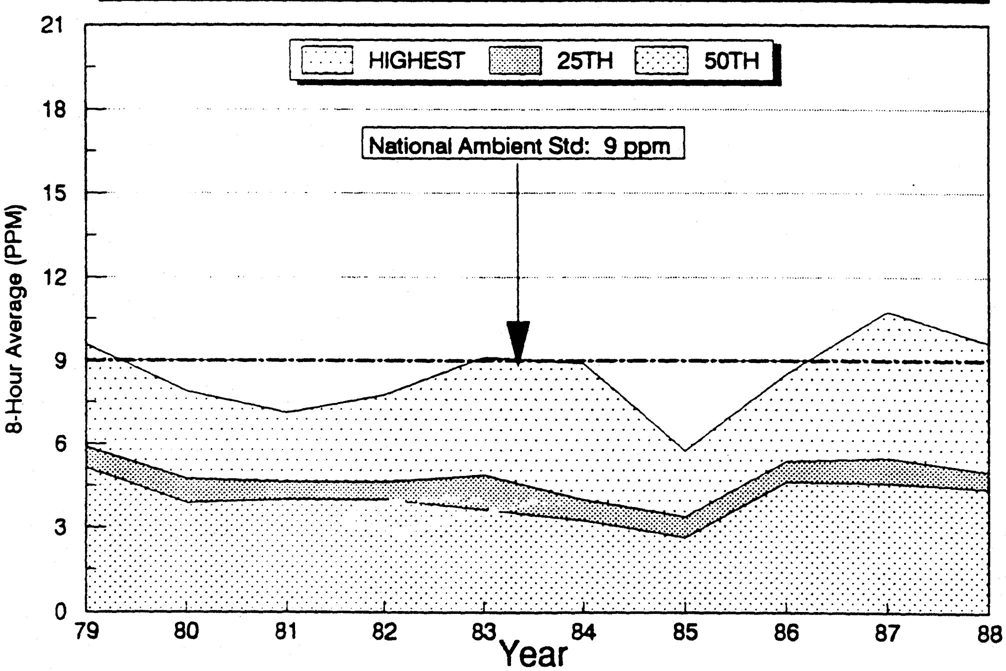
AVERAGE CARBON MONOXIDE CONCENTRATION

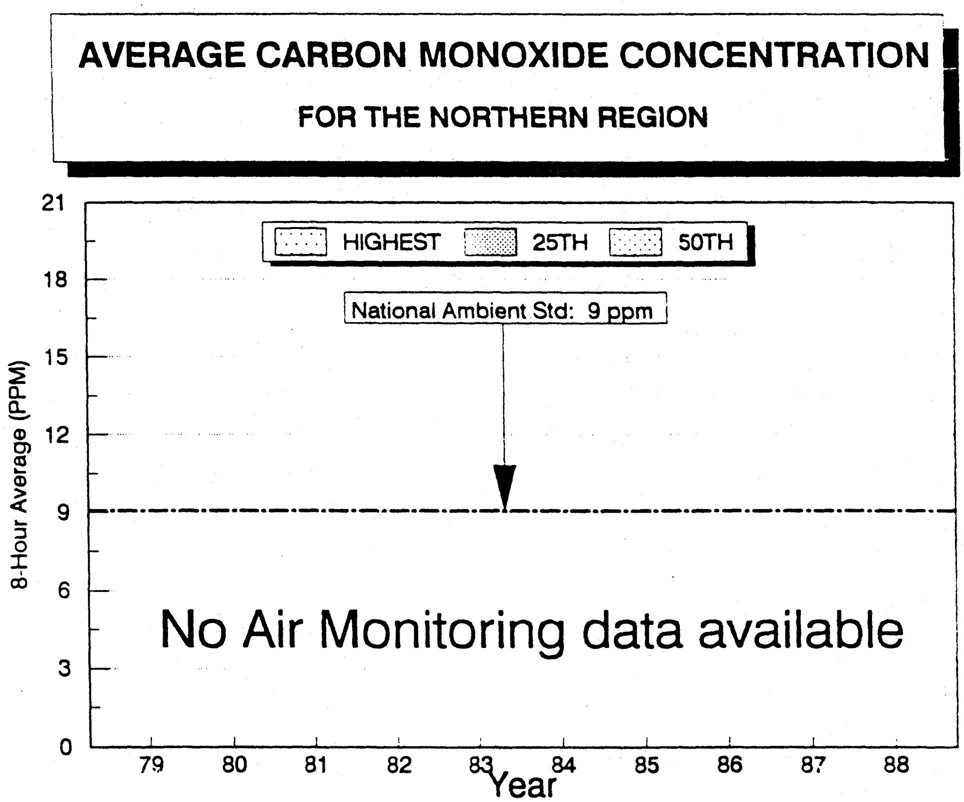
FOR THE NORTHWEST REGION

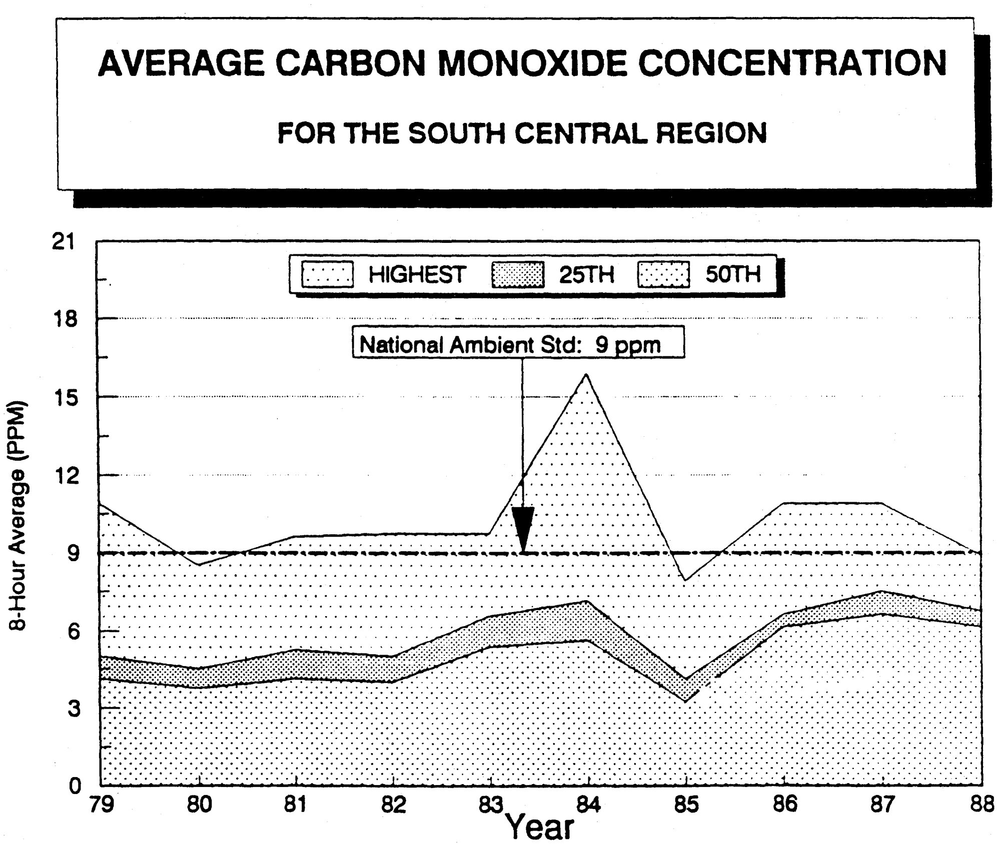


AVERAGE CARBON MONOXIDE CONCENTRATION

FOR THE SOUTHWEST REGION

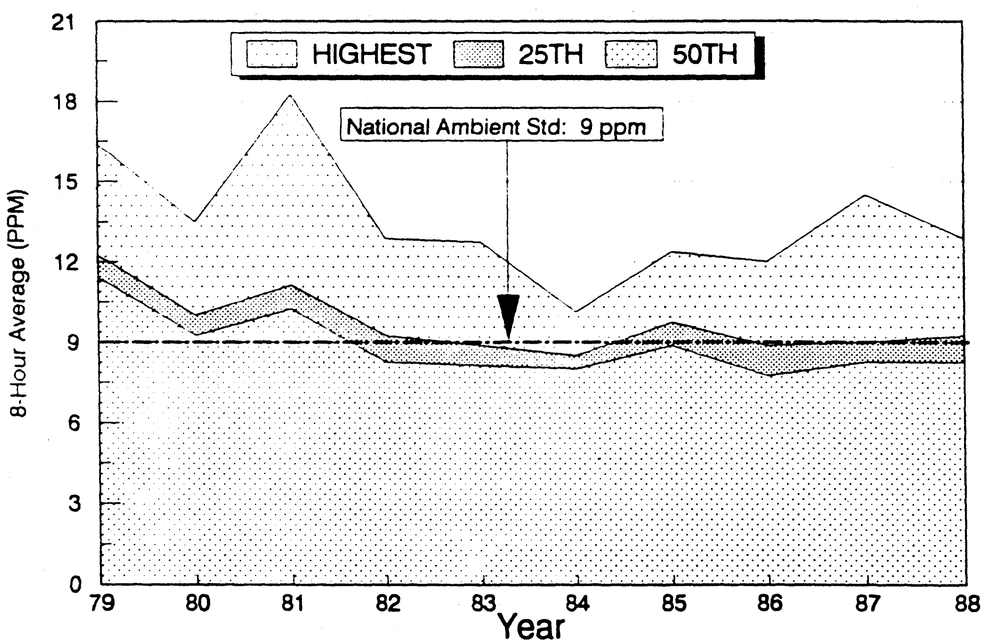



AVERAGE CARBON MONOXIDE CONCENTRATION
FOR THE NORTHERN REGION
HIGHEST
25TH
50TH
National Ambient Std: 9 ppm
No Air Monitoring data available
8-Hour Average (PPM)
Year
0
3
6
9
12
15
18
21
79
80
81
82
83
84
85
86
87
88


AVERAGE CARBON MONOXIDE CONCENTRATION
FOR THE SOUTH CENTRAL REGION
HIGHEST
25TH
50TH
National Ambient Std: 9 ppm
8-Hour Average (PPM)
Year
0
3
6
9
12
15
18
21
79
80
81
82
83
84
85
86
87
88

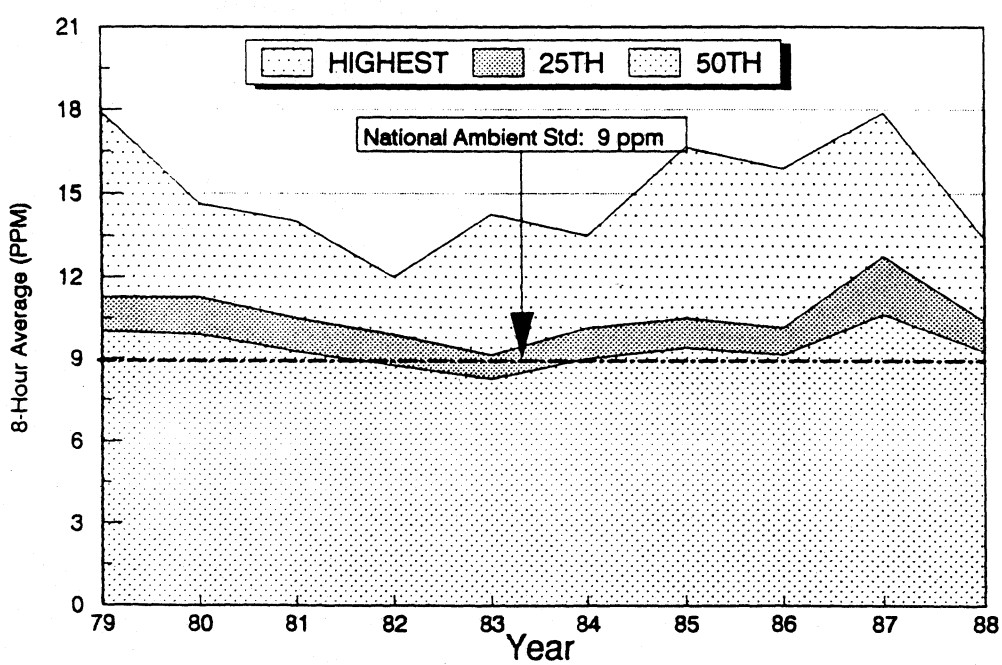
AVERAGE CARBON MONOXIDE CONCENTRATION

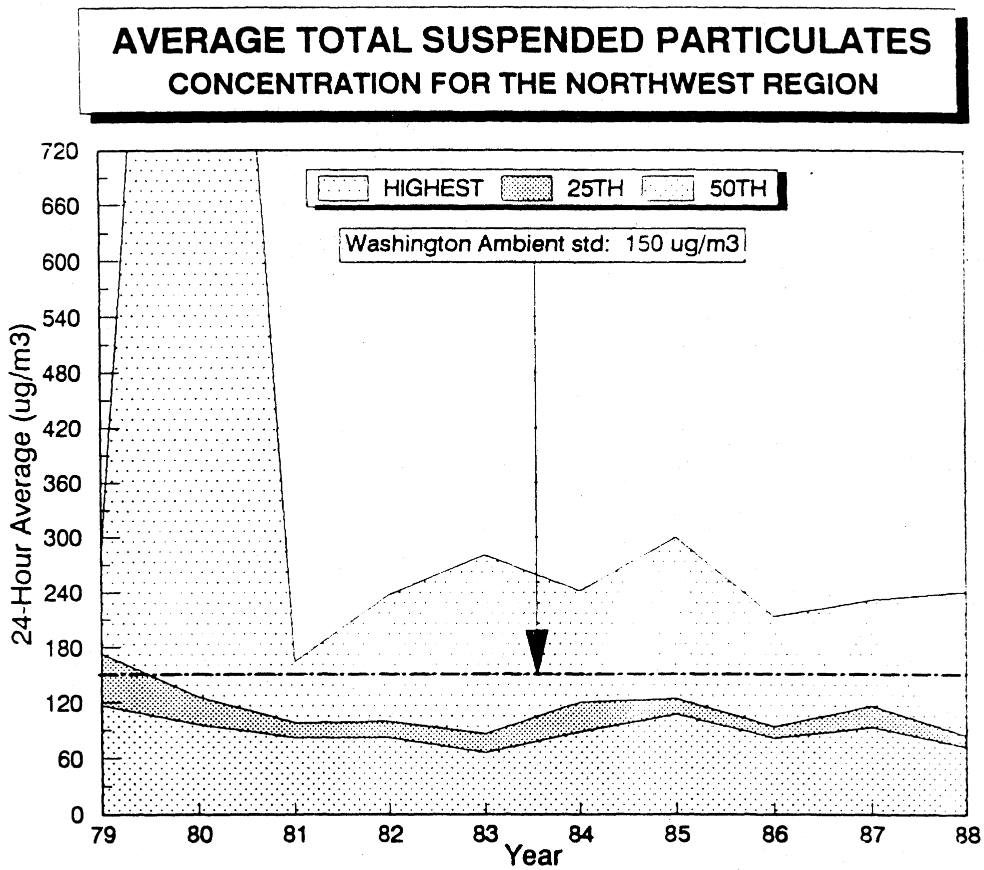
FOR THE PUGET SOUND REGION

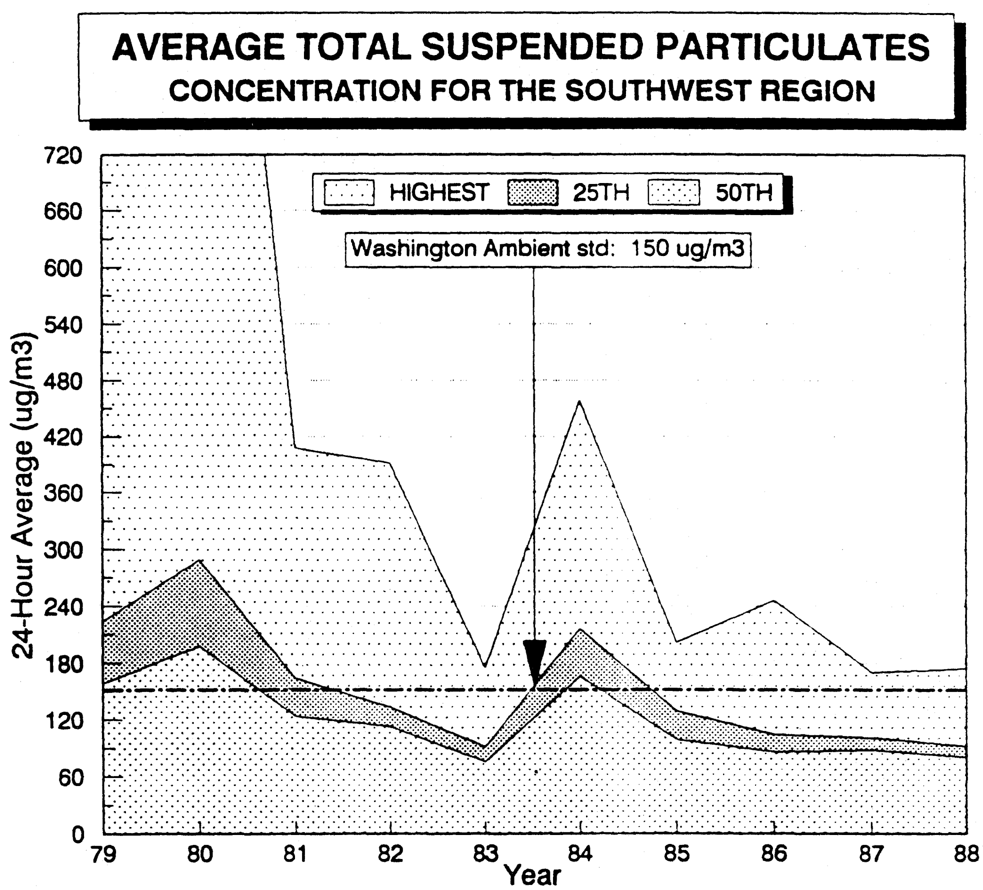


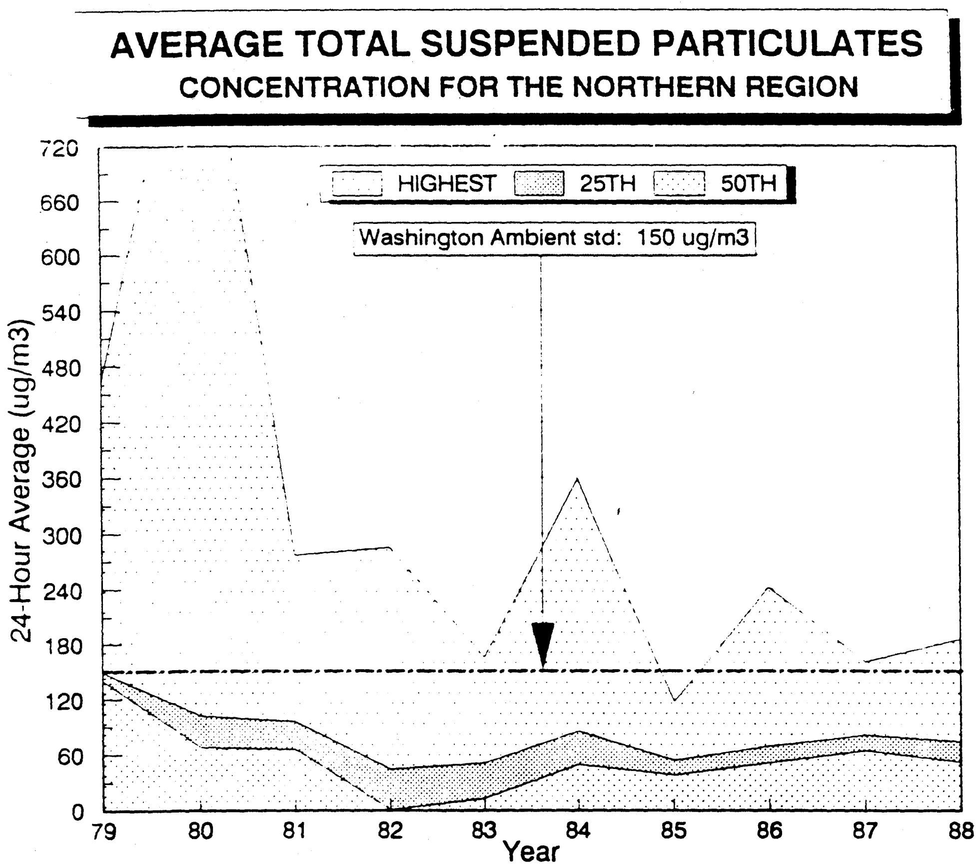
AVERAGE CARBON MONOXIDE CONCENTRATION

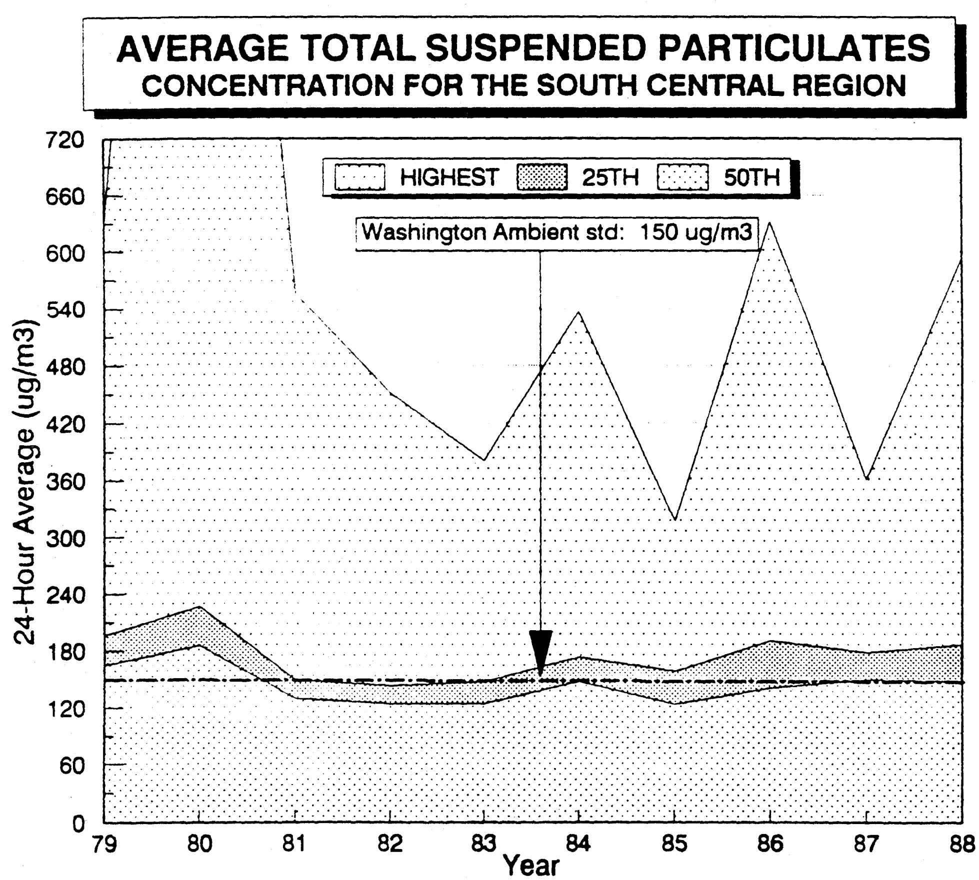
FOR THE EASTERN REGION



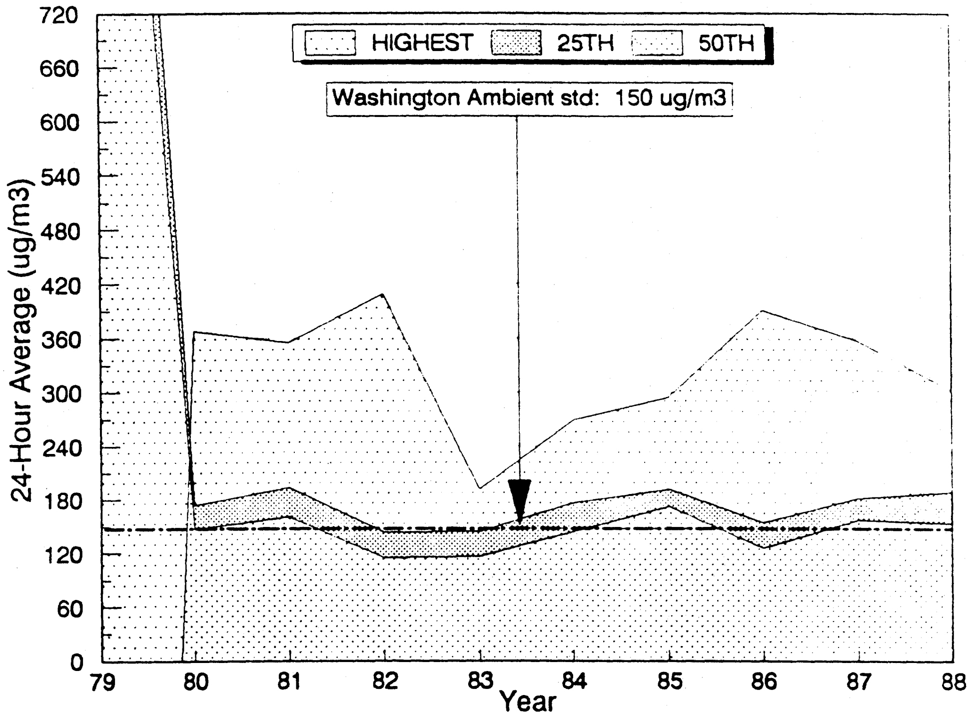

AVERAGE TOTAL SUSPENDED PARTICULATES
CONCENTRATION FOR THE NORTHWEST REGION
HIGHEST
25TH
50TH
Washington Ambient std: 150 ug/m3
24-Hour Average (ug/m3)
720
660
600
540
480
420
360
300
240
180
120
60
0
79
80
81
82
83
84
85
86
87
88
Year


AVERAGE TOTAL SUSPENDED PARTICULATES
CONCENTRATION FOR THE SOUTHWEST REGION
HIGHEST
25TH
50TH
Washington Ambient std: 150 ug/m3
24-Hour Average (ug/m3)
720
660
600
540
480
420
360
300
240
180
120
60
0
79
80
81
82
83
84
85
86
87
88
Year

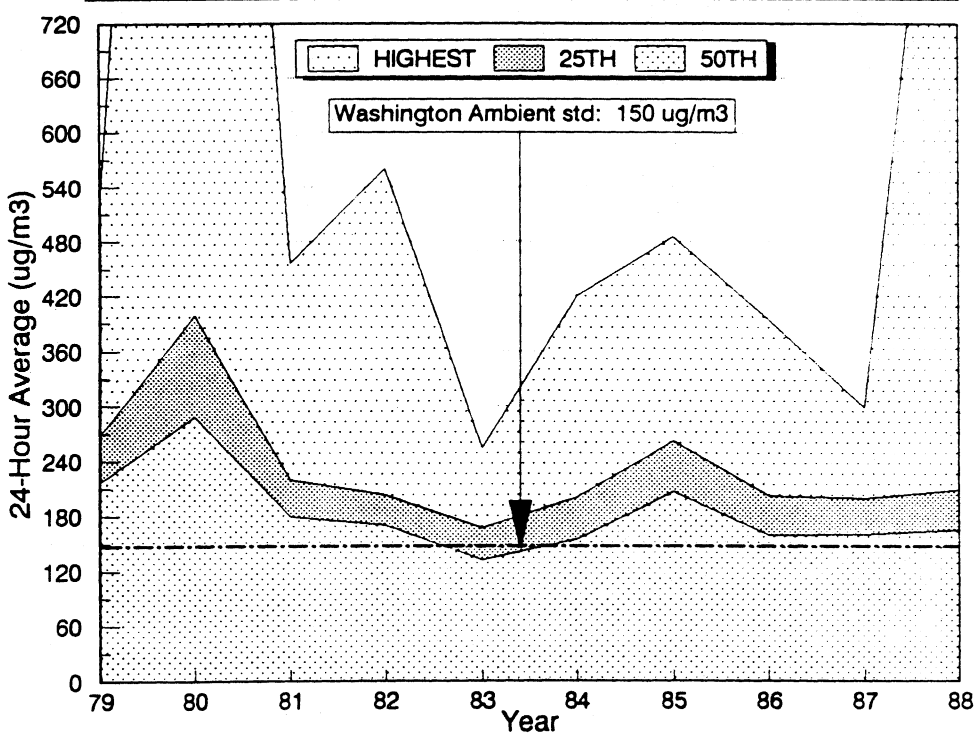

AVERAGE TOTAL SUSPENDED PARTICULATES
CONCENTRATION FOR THE NORTHERN REGION
HIGHEST
25TH
50TH
Washington Ambient std: 150 ug/m3
24-Hour Average (ug/m3)
720
660
600
540
480
420
360
300
240
180
120
60
0
79
80
81
82
83
84
85
86
87
88
Year


AVERAGE TOTAL SUSPENDED PARTICULATES
CONCENTRATION FOR THE SOUTH CENTRAL REGION
HIGHEST
25TH
50TH
Washington Ambient std: 150 ug/m3
24-Hour Average (ug/m3)
720
660
600
540
480
420
360
300
240
180
120
60
0
79
80
81
82
83
84
85
86
87
88
Year

AVERAGE TOTAL SUSPENDED PARTICULATES
CONCENTRATION FOR THE PUGET SOUND REGION

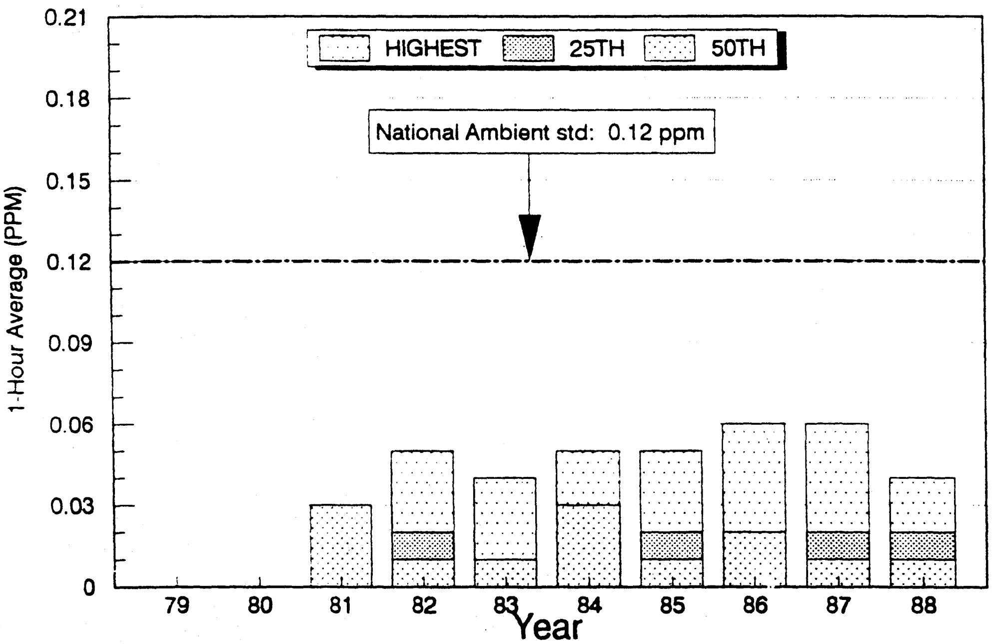


AVERAGE TOTAL SUSPENDED PARTICULATES
CONCENTRATION FOR THE EASTERN REGION



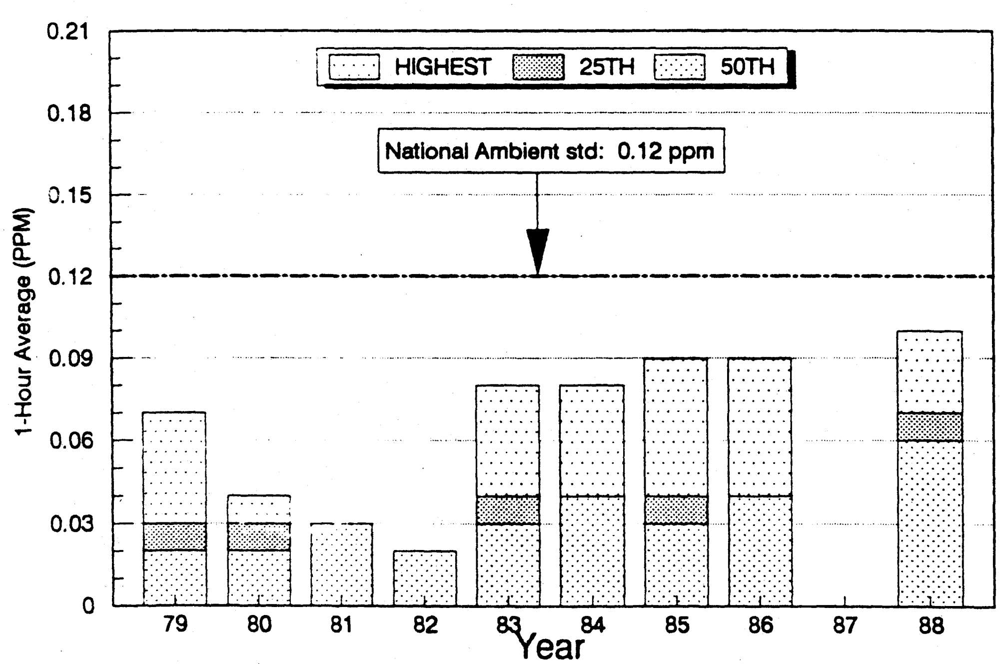
AVERAGE OZONE CONCENTRATION

FOR THE NORTHWEST REGION



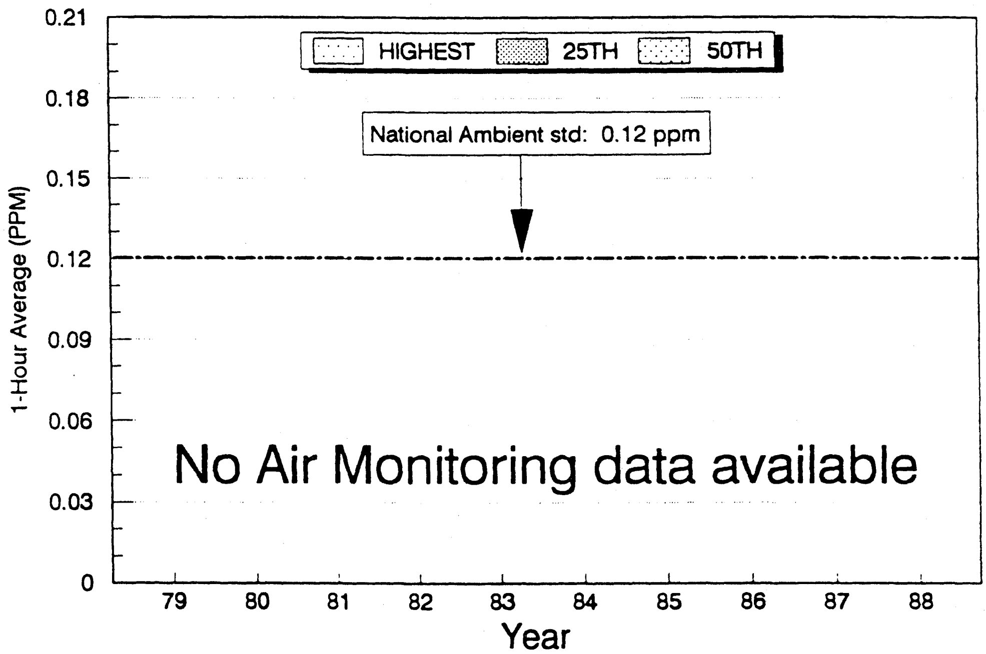
AVERAGE OZONE CONCENTRATION

FOR THE SOUTHWEST REGION



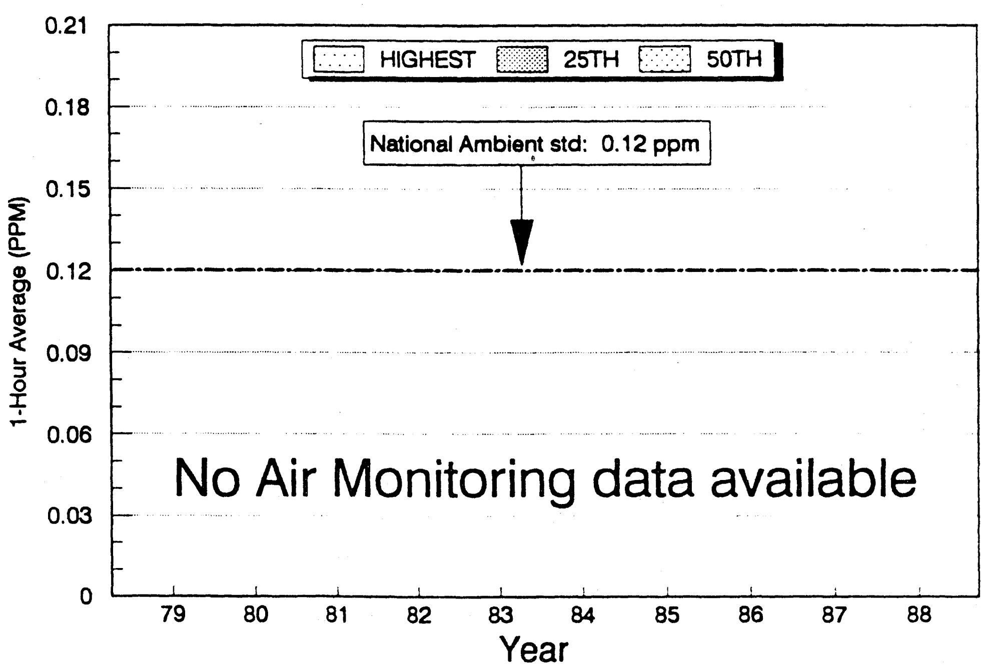
AVERAGE OZONE CONCENTRATION

FOR THE NORTHERN REGION



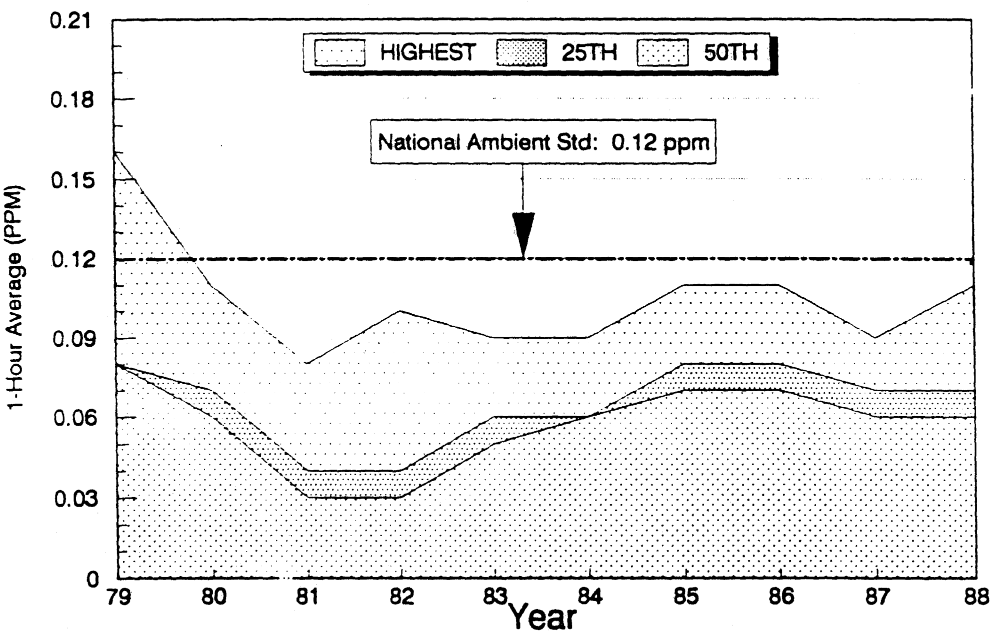
AVERAGE OZONE CONCENTRATION

FOR THE SOUTH CENTRAL REGION



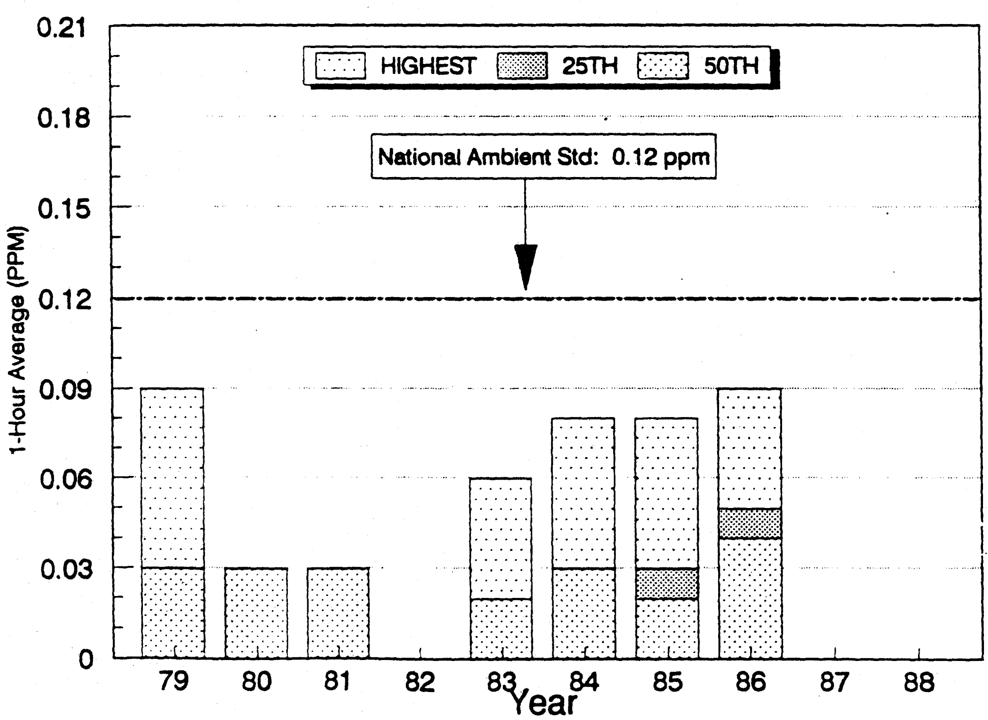
AVERAGE OZONE CONCENTRATION

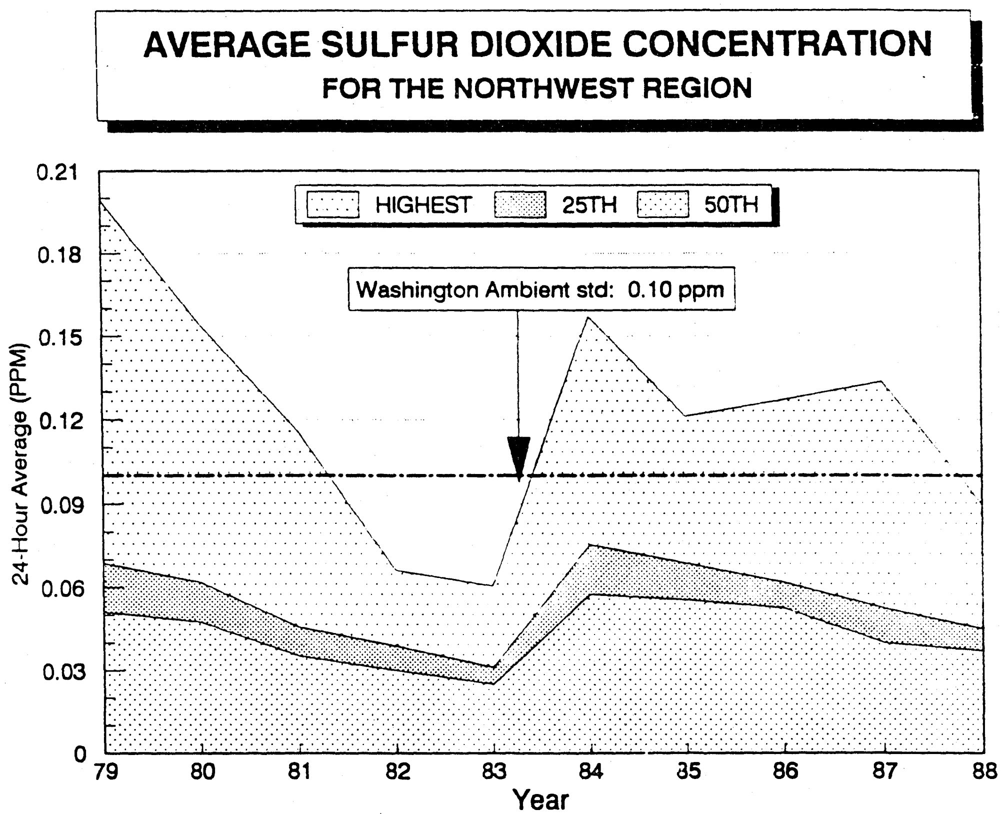
FOR THE PUGET SOUND REGION

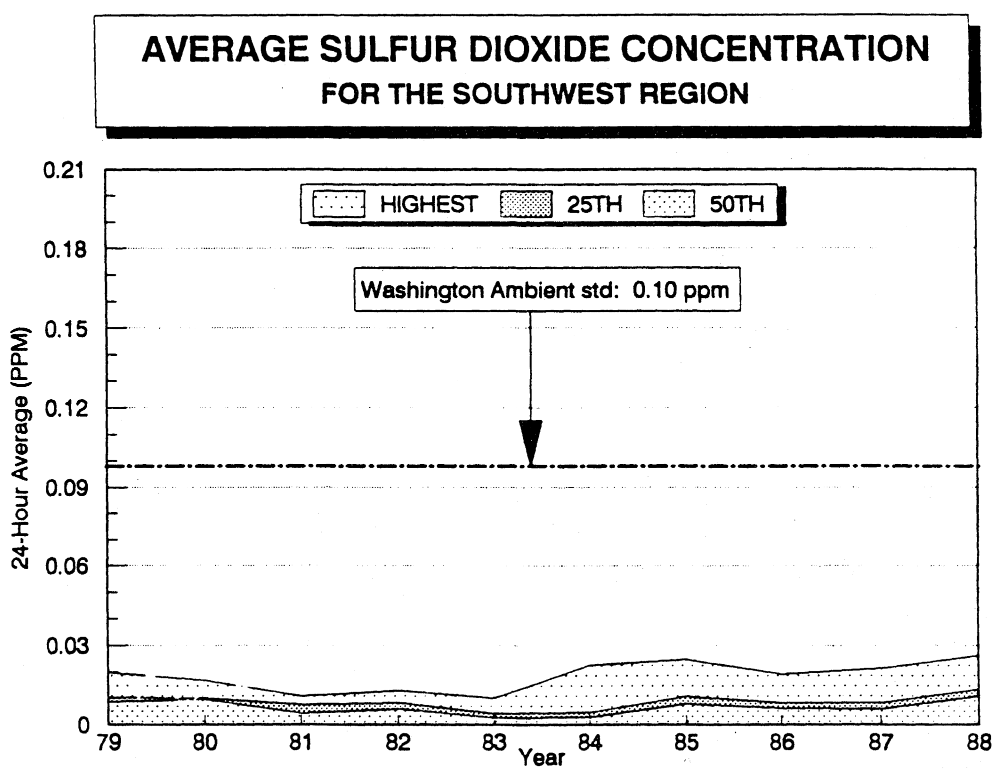


AVERAGE OZONE CONCENTRATION

FOR THE EASTERN REGION

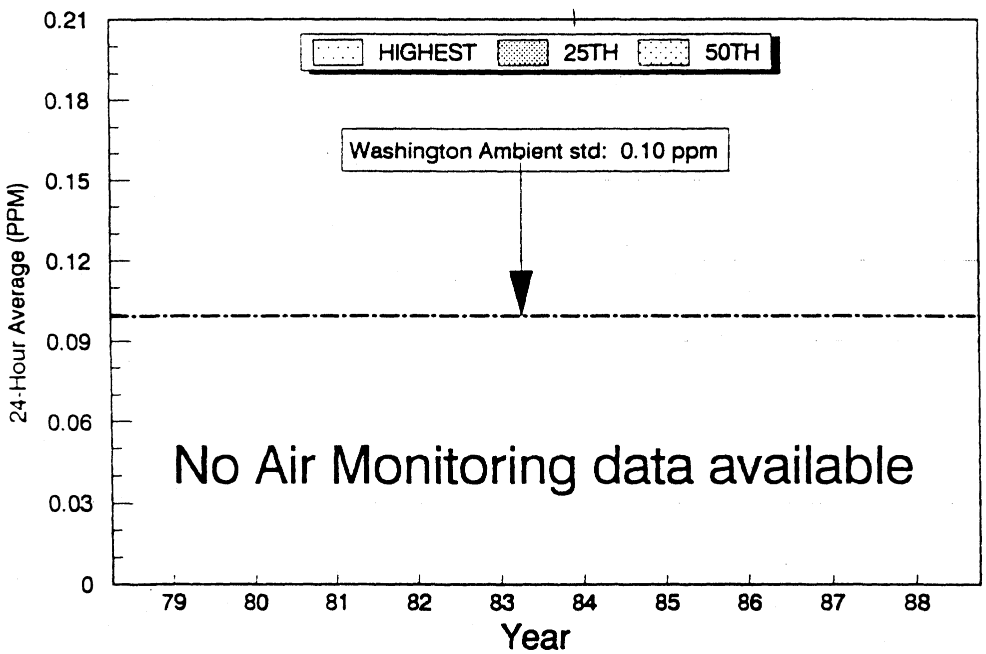



AVERAGE SULFUR DIOXIDE CONCENTRATION
FOR THE NORTHWEST REGION
HIGHEST
25TH
50TH
Washington Ambient std: 0.10 ppm
24-Hour Average (PPM)
0.21
0.18
0.15
0.12
0.09
0.06
0.03
0
79
80
81
82
83
84
85
86
87
88
Year


AVERAGE SULFUR DIOXIDE CONCENTRATION
FOR THE SOUTHWEST REGION
HIGHEST
25TH
50TH
Washington Ambient std: 0.10 ppm
24-Hour Average (PPM)
0.21
0.18
0.15
0.12
0.09
0.06
0.03
0
79
80
81
82
83
84
85
86
87
88
Year

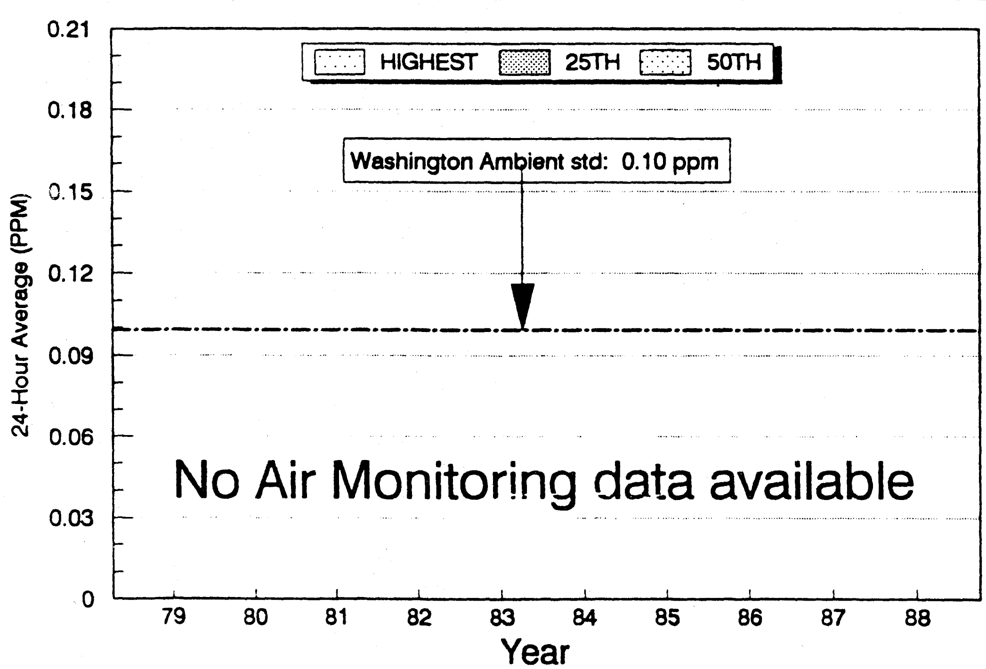
AVERAGE SULFUR DIOXIDE CONCENTRATION

FOR THE NORTHERN REGION



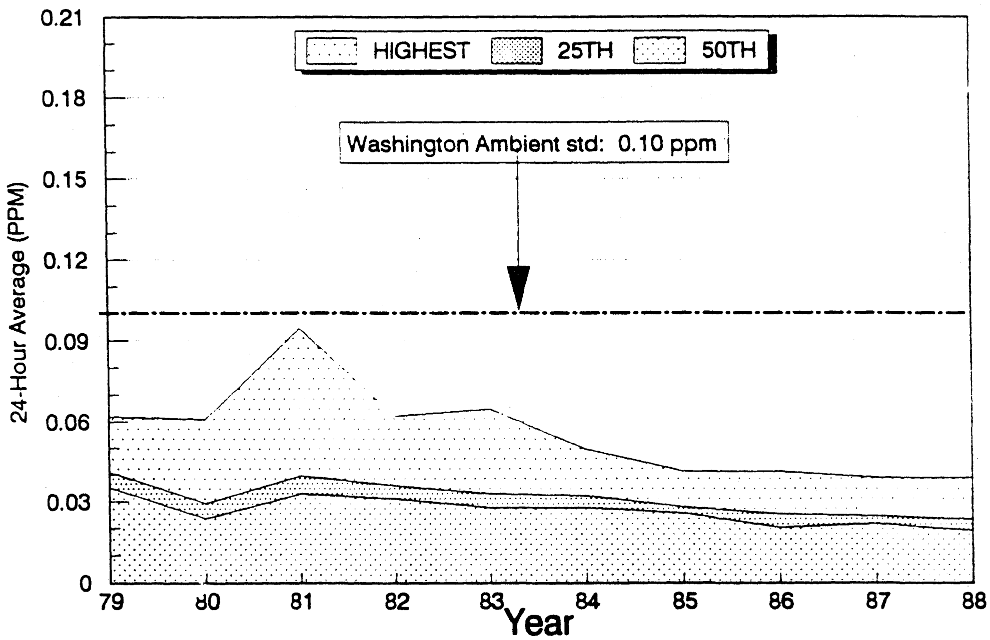
AVERAGE SULFUR DIOXIDE CONCENTRATION

FOR THE SOUTH CENTRAL REGION



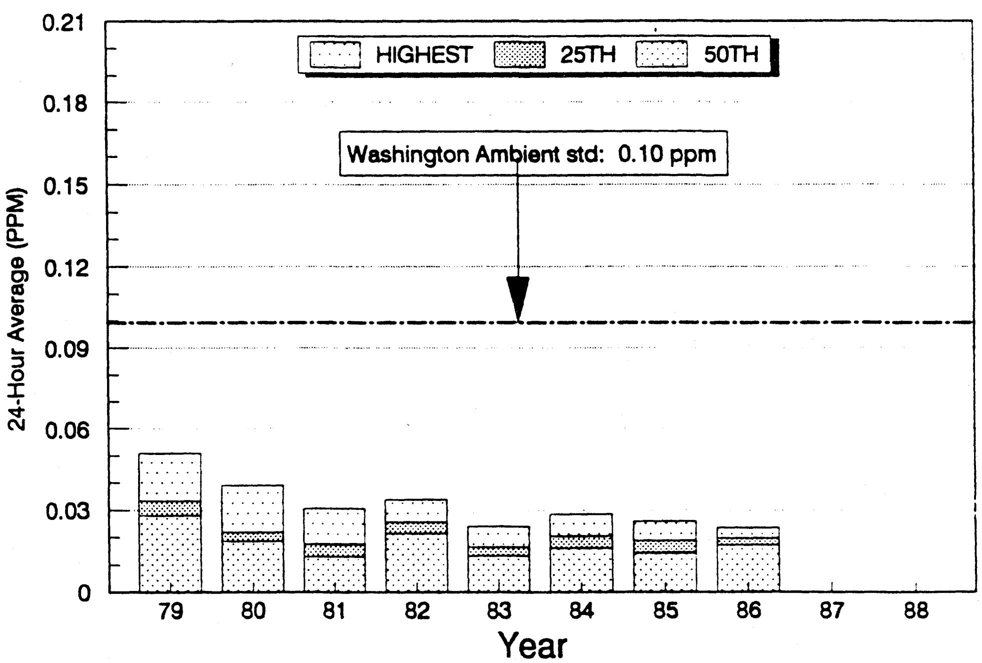
AVERAGE SULFUR DIOXIDE CONCENTRATION

FOR THE PUGET SOUND REGION



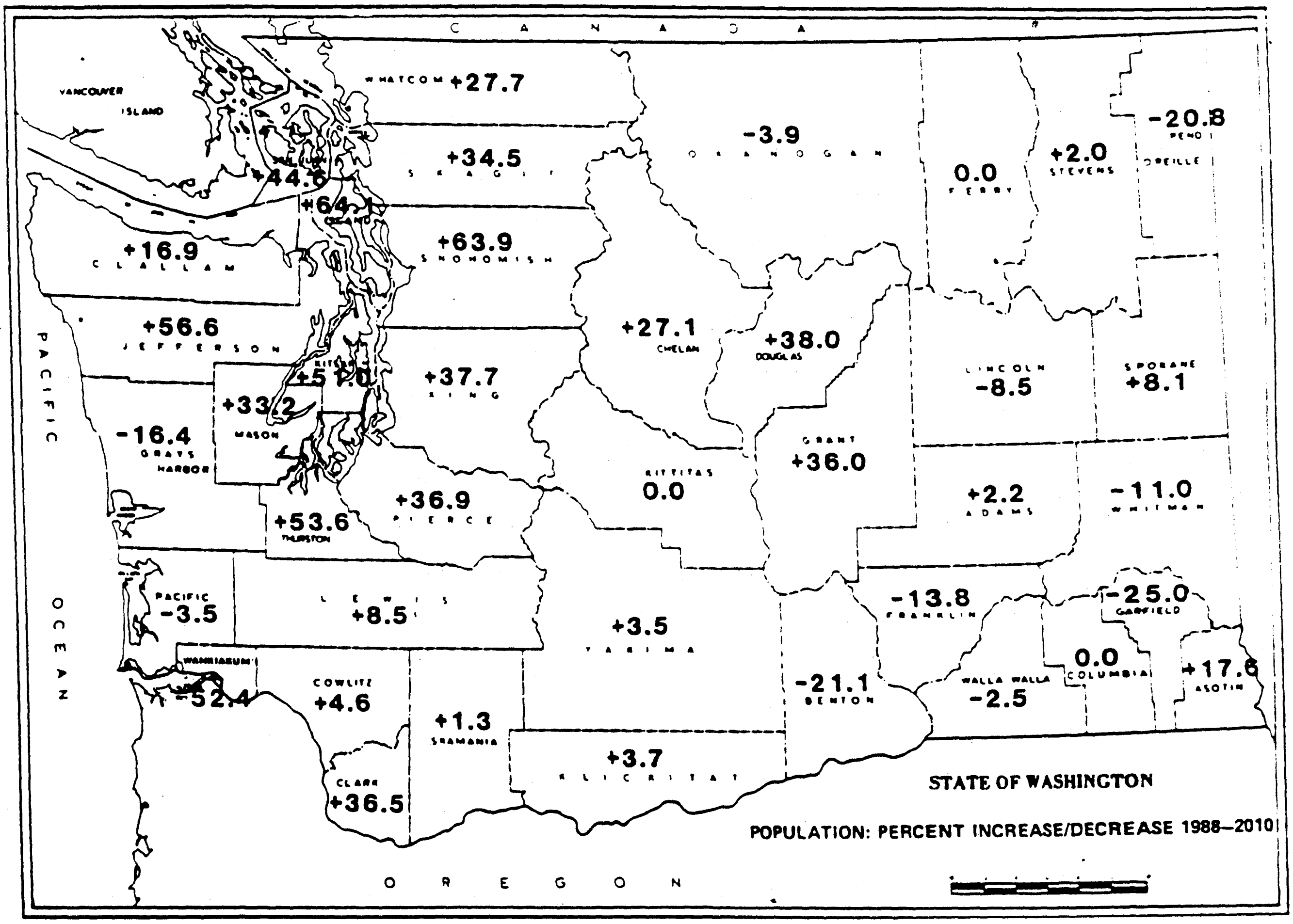
AVERAGE SULFUR DIOXIDE CONCENTRATION

FOR THE EASTERN REGION



APPENDIX F

The following table projects population increases, and the resulting population density changes for each of Washington's 39 counties. These estimates are grouped by air quality control regions, and the resulting regional statistics are presented. These projections were used elsewhere in this report, in conjunction with estimated emission rates from each of the regions (see Appendix G) in our estimates of future air quality levels.



The percentage difference between 1984 county populations and projected 2010 population as shown on this map are based on county population estimates that were extrapolated from official statewide population projections for 1984 and 1988, using a ratio calculation. The 1984 and 1985 statewide projections, provided by the Washington State Office of Financial Management (OFM), were derived from U. S. Bureau of Census Reports.

Projected county population estimates have not yet been adjusted by Office of Financial Management (OFM), therefore the pecentages shown here do not reflect adjusted population forcasts. Adjustments would take into account certain special circumstances that may account for population fluctuations between 1984 and 1988 populations. What this means is that forecasted population decreases, especially those showing more than a 20 percent decrease, may reflect a greater decrease than will be projected once figures are adjusted at the county level.

Southwest Washington Interstate

	1984	Population: Percent Increase 1984-1988	Population Census: 1988	Population Forecast 2010	Population: Percent Increase 1988-2010	Area (Sq. Mi.)	Density (Sq. Mi.) 1988	Density (Sq. Mi.) 2010	Density Difference 1988-2010
Clark	201,700	+6.3%	214,500	292,751	+36.5%	627	342.1	466.9	+124.8
Cowlitz	79,900	+0.8%	80,500	84,168	+ 4.6%	1,144	70.4	73.6	+ 3.2
Lewis	56,600	+1.4%	57,400	62,291	+ 8.5%	2,449	23.4	25.4	+ 1.997
Skamania	7,900	+1.3%	8,000	8,611	+ 1.3%	1,672	0.5	5.2	+ 4.672
Wahkiakum	3,800	-7.9%	3,500	1,666	-52.4%	261	13.4	6.4	- 7.022
Total	349,900		363,900	449,487	19.04				

Olympia - Northwest Washington Intrastate

	1984	Population: Percent Increase 1984-1988	Population Census: 1988	Population Forecast 2010	Population: Percent Increase 1988-2010	Area (Sq. Mi.)	Density (Sq. Mi.) 1988	Density (Sq. Mi.) 2010	Density Difference 1988-2010
Clallam	52,900	+ 2.8%	54,400	63,570	+16.9%	1,753	31.0	36.3	+ 5.2
Grays Harbor	65,100	- 2.6%	63,400	53,007	-16.4%	1,910	33.2	27.7	- 5.4
Island	47,800	+11.7%	53,400	87,635	+64.1%	212	251.9	413.4	+161.5
Jefferson	17,000	+ 9.4%	18,600	28,381	+52.6%	1,805	10.3	15.8	+ 5.4
Mason	34,800	+ 5.7%	34,800	49,027	+33.2%	962	36.2	51.0	+ 14.8
Pacific	17,700	- 0.6%	17,600	16,989	- 3.5%	908	19.4	18.7	- 0.7
San Juan	8,900	+ 7.9%	9,600	13,879	+44.6%	179	53.6	77.5	+ 23.9
Skagit	66,800	+ 6.0%	70,800	95,253	+34.5%	1,735	40.8	54.9	+ 15.0
Thurston	136,200	+ 9.6%	149,300	229,385	+53.6%	714	209.1	321.3	+112.2
Whatcom	113,700	+ 4.7%	119,100	152,112	+27.7%	2,126	56.0	71.5	+ 15.5
Total	560,900		591,000	789,238	25.12%				

Puget Sound Intrastate

	1984	Population: Percent Increase 1984-1988	Population Census: 1988	Population Forecast 2010	Population: Percent Increase 1988-2010	Area (Sq. Mi.)	Density (Sq. Mi.) 1988	Density (Sq. Mi.) 2010	Density Difference 1988-2010
King	1,326,600	+ 6.6%	1,413,900	1,947,596	+37.7%	2,131	663.5	913.9	+250.4
Kitsap	162,500	+ 9.1%	177,300	267,778	+51.0%	393	451.1	681.4	+230.3
Pierce	514,600	+ 6.4%	547,700	750,052	+36.9%	1,676	326.8	447.5	+120.7
Snohomish	366,700	+11.7%	409,500	671,151	+63.9%	2,098	195.2	319.9	+124.7
Total	2,370,400		2,548,400	3,636,577	29.92%				

Southcentral Washington Interstate

	1984	Population: Percent Increase 1984-1988	Population Census: 1988	Population Forecast 2010	Population: Percent Increase 1988-2010	Area (Sq. Mi.)	Density (Sq. Mi.) 1988	Density (Sq. Mi.) 2010	Density Difference 1988-2010
Benton	107,700	-3.3%	104,100	82,092	-21.1%	1,722	60.5	47.7	-12.8
Franklin	36,300	-2.2%	35,500	30,609	-13.8	1,260	28.2	24.3	- 3.9
Kittitas	25,000	+0.0	25,500	25,500	+ 0.0	2,320	11.0	11.0	+ 0.0
Klickitat	16,500	+0.6%	16,600	17,211	+ 3.7%	1,908	8.7	9.0	+ 0.3
Walla Walla	48,500	-0.4%	48,300	47,077	- 2.5%	1,267	38.1	37.2	- 0.9
Yakima	180,000	+3.5	186,300	224,814	+ 3.5%	4,271	43.6	52.6	+ 9.0
Total	323,700		416,300	427,303	2.6%				

Eastern Washington Northern Idaho Interstate

	1984	Population: Percent Increase 1984-1988	Population Census: 1988	Population Forecast 2010	Population: Percent Increase 1988-2010	Area (Sq. Mi.)	Density (Sq. Mi.) 1988	Density (Sq. Mi.) 2010	Density Difference 1988-2010
Adams	13,700	+2.2%	14,000	15,834	+ 2.2%	1,894	7.4	8.4	+ 1.0
Asotin	16,900	+3.0%	17,400	20,457	+17.6%	633	27.5	32.3	+ 4.8
Columbia	4,100	+0.0%	4,100	4,100	+ 0.0%	860	4.8	4.8	+ 0.0
Garfield	2,500	-4.0%	2,400	1,789	-25.0%	713	3.4	2.5	- 0.9
Grant	49,500	+6.3%	52,600	71,551	+36.0%	2,680	19.6	26.7	+ 7.1
Lincoln	9,800	-1.0%	9,700	9,089	- 8.5%	2,306	4.2	3.9	- 0.3
Spokane	349,400	+1.3%	354,100	382,833	+ 8.1%	1,758	201.42	217.8	+16.4
Whitman	39,700	-1.8%	39,000	34,721	-11.0%	2,166	18.0	16.0	+ 2.0
Total	485,600		493,300	540,374	8.71%				

Northern Washington Intrastate

	1984	Population: Percent Increase 1984-1988	Population Census: 1988	Population Forecast 2010	Population: Percent Increase 1988-2010	Area (Sq. Mi.)	Density (Sq. Mi.) 1988	Density (Sq. Mi.) 2010	Density Difference 1988-2010
Chelan	47,500	+4.6%	49,700	63,149	+17.1%	2,926	17.0	21.6	+4.6
Douglas	22,600	+6.6%	24,100	33,270	+38.0%	1,839	13.1	18.1	+5.0
Ferry	6,100	+0.0%	6,100	6,100	+ 0.0%	2,202	2.8	2.8	+0.0
Okanogan	31,900	-0.6%	31,700	30,477	- 3.9%	5,301	6.0	5.7	-0.3
Pend Oreille	9,100	-3.3%	8,800	6,966	-20.8%	1,402	6.3	5.0	-1.3
Stevens	30,100	+0.3	30,200	30,811	+ 2.0%	2,481	12.2	12.4	+0.2
Total	147,300		150,600	170,773	11.8%				

APPENDIX G

The following tables show the estimated change in air pollution emissions resulting from population growth. As explained in the text of this report, under Assumptions, we forecast that, with the exception of transportation related emissions, the change in air pollution emissions in each county and region will be directly proportional with the change in population. For transportation related emissions, we forecast that emissions will increase or decrease at twice the rate as population. The resulting 2010 emission estimates for each county, air quality control region, and the state as a whole are presented in the following tables.

The following data were used to estimate percent increases in current air quality for each of the air quality control regions. No negative or positive current trends were assumed, so that percent increase could be estimated by simply multiplying the percent increase in emissions between now and the year 2010 (taken from the following tables) for each pollutant by the fraction of that pollutant from anthropogenic (manmade or man caused) sources. See section V.A. and B. for a discussion of this procedure. For particulate matter, 90% anthropogenic sources was assumed for the regions on the west side of the mountains and 50% on the east side.

Olympic-Northwest Intrastate Washington
Air Quality Control Region
Criteria Pollutant Increase
1984-2010
(Tons/Year)

	Sulfur Dioxide	Carbon Monoxide	Toxics	Nitrogen Oxides	Volatile Organic Compounds	Particulates
Total: 1984	25,087.2	272,064.2	21,115.5	42,880.9	62,073.2	29,397.5
Non-Transportation Related Increase 1984-2010	6,776.8	23,607.4	5,183.1	4,538.5	10,280.0	4,856.2
Transportation-related Increase 1984-2010	997.0	110,582.4	1,880.9	15,793.9	15,442.5	7,338.1
Total Increase: 1984-2010	7,773.8	134,187.8	7,064.0	20,332.4	25,722.5	12,194.3
Total: 2010	32,861.0	406,254.0	28,179.5	63,213.3	87,795.7	41,591.8

Projected

Eastern Washington Intrastate
Air Quality Control Region
Criteria Pollutant Increase
1984-2010
(Tons/Year)

	Sulfur Dioxide	Carbon Monoxide	Toxics	Nitrogen Oxides	Volatile Organic Compounds	Particulates
Total: 1984	4,264.1	71,329.4	13,837.9	30,328.9	48,821.9	28,442.2
Non-Transportation Related Increase 1984-2010	284.6	3,858.8	1,138.6	588.1	1,973.4	1,211.8
Transportation-related Increase 1984-2010	852.8	6,548.3	490.4	4,889.4	5,817.4	3,264.8
Total Increase: 1984-2010	1,137.4	10,407.1	1,629.0	5,477.5	7,790.8	4,476.6
Total: 2010	5,401.5	81,736.5	15,466.8	35,806.4	56,612.7	32,918.8

Projected

Northern Washington Intrastate
Air Quality Control Region
Criteria Pollutant Increase
1984-2010
(Tons/Year)

	Sulfur Dioxide	Carbon Monoxide	Toxics	Nitrogen Oxides	Volatile Organic Compounds	Particulates
Total: 1984	3,198.9	105,519.6	4,959.0	12,773.1	19,537.0	16,155.7
Non-Transportation Related Increase 1984-2010	373.1	8,029.4	561.2	627.2	1,734.9	1,879.9
Transportation-related Increase 1984-2010	149.5	13,486.7	266.2	1,161.0	2,000.9	763.9
Total Increase: 1984-2010	522.6	21,516.1	827.4	1,788.2	3,735.7	2,643.7
Total: 2010	3,721.5	127,035.7	6,347.6	14,561.3	23,273.5	18,799.4

Puget Sound Intrastate
Air Quality Control Region
Criteria Pollutant Increase
1984-2010
(Tons/Year)

	Sulfur Dioxide	Carbon Monoxide	Toxics	Nitrogen Oxides	Volatile Organic Compounds	Particulates
Total: 1984	119,425.9	326,015.1	56,202.4	103,674.7	170,847.9	85,820.4
Non-Transportation Related Increase 1984-2010	76,178.8	43,994.9	16,154.9	13,964.6	17,731.5	8,397.8
Transportation-related Increase 1984-2010	2,587.9	140,220.7	7,031.9	44,643.0	84,130.6	43,278.7
Total Increase: 1984-2010	43,093.0	184,215.6	23,186.8	58,607.7	101,862.1	51,676.5
Total: 2010	162,518.9	510,230.7	79,389.2	162,282.4	272,709.9	137,496.9

South Central Washington Intrastate
Air Quality Control Region
Criteria Pollutant Increase
1984-2010
(Tons/Year)

	Sulfur Dioxide	Carbon Monoxide	Toxics	Nitrogen Oxides	Volatile Organic Compounds	Particulates
Total: 1984	8,216.0	337,939.9	13,158.7	32,669.0	41,561.1	28,436.5
Non-Transportation Related Increase 1984-2010	1,675.9	39,497.2	2,602.8	2,816.6	4,428.7	4,205.2
Transportation-related Increase 1984-2010	591.8	83,216.8	1,110.5	10,047.8	11,091.8	5,239.2
Total Increase: 1984-2010	2,267.8	122,714.0	3,713.4	12,864.5	15,520.6	9,444.3
Total: 2010	10,483.7	460,653.9	16,872.1	45,533.4	57,081.7	37,880.8

Southwest Washington Intrastate
Air Quality Control Region
Criteria Pollutant Increase
1984-2010
(Tons/Year)

	Sulfur Dioxide	Carbon Monoxide	Toxics	Nitrogen Oxides	Volatile Organic Compounds	Particulates
Total: 1984	68,103.0	229,354.3	14,413.7	66,282.0	54,166.5	30,414.6
Non-Transportation Related Increase 1984-2010	14,748.6	19,590.5	2,726.0	10,914.4	7,640.7	4,464.6
Transportation-related Increase 1984-2010	486.2	61,734.8	890.1	7,335.2	8,551.8	4,453.2
Total Increase: 1984-2010	15,216.8	81,325.4	3,616.1	18,249.7	16,192.8	8,917.8
Total: 2010	83,319.8	310,679.7	18,029.8	84,531.7	70,359.0	39,332.4

THE STATE OF THE ENVIRONMENT REPORT

VOLUME II
Part 2

Water Resource Characterization Report

ENVIRONMENT 2010

State of Washington
October, 1989

Washington Environment 2010
State of the Environment Report
Volume II, Part 2

Water Resource Characterization

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Appendix A. Summary Graphs of Water Quality Problems by Type of Water Body

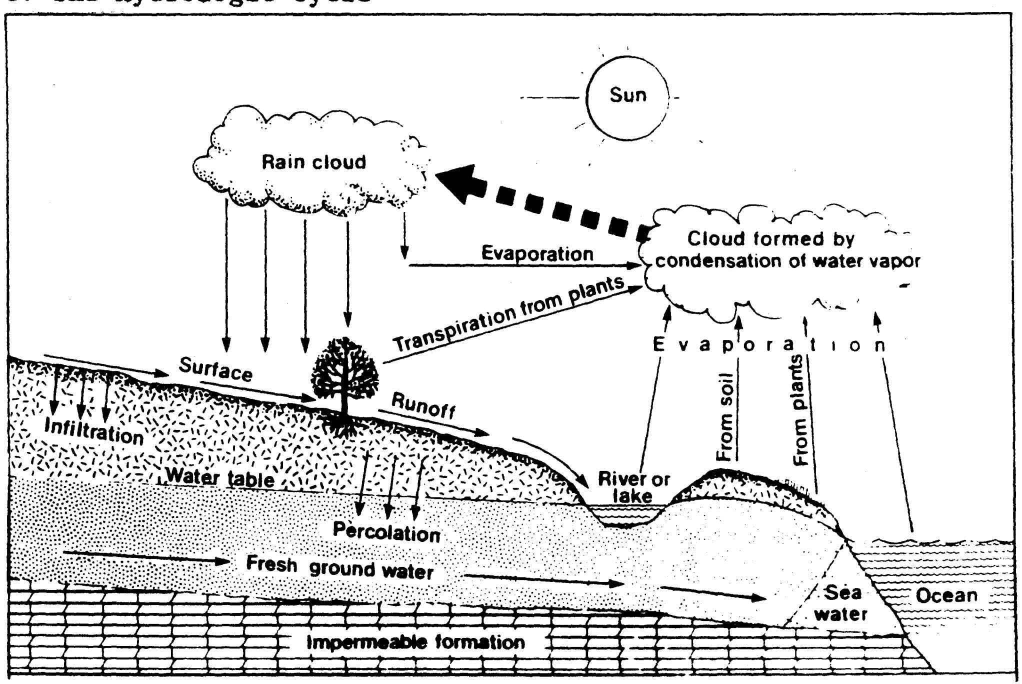
Almost every other substance becomes heavier, smaller, and more dense as it changes from a liquid to a solid. But water expands and grows lighter, so that ice floats. If that does not seem remarkable, it should. If water acted like other substances, its solid form, ice, would sink. The floor of the sea and the bottoms of lakes would accumulate ice. Gradually, winter after winter, the ice would lock up more and more water until there would be none running free on the planet. There would be no life on earth.

--The Cousteau Almanac

I. GENERAL DESCRIPTION OF WASHINGTON'S WATER RESOURCE

The hydrologic cycle is the circuit of water movement from the atmosphere to the earth and back to the atmosphere through various stages and processes--precipitation, runoff, infiltration, percolation, storage, evaporation, and transpiration (SCSA). Figure 1 provides an illustration.

Figure 1: The Hydrologic Cycle



The analysis for this resource characterization focuses on two major components--ground water and surface water--but as Figure 1 demonstrates, these components do not exist or function independently of the complexities of the hydrologic cycle. Of particular importance in an analysis of Washington State's water resource is the relationship between the two major components of the study, that is, how ground water and surface water interact. This resource characterization considers each separately while attempting to keep sight of the ways in which each influences the other.

I.A. Subcategories/Definitions

Each step of the analysis of the water resource considers both ground water and surface water. Within the surface water subcategory are the further subcategories of marine waters, rivers and streams, and lakes. The following subsections provide the basic definitions of the terms.

I.A.1. Ground Water

Beneath the earth's surface there are cracks in rocks and spaces between grains of sand. In the top subsurface layer these cracks and spaces are filled with air and water, and the layer is known as the unsaturated zone. This zone is almost always underlain by a zone where all the spaces are filled with water--the saturated zone. The term "ground water" refers to the water in the saturated zone (King County/Ecology).

Ground water is stored primarily in aquifers, which are geologic formations that transmit water in sufficient quantities to supply the needs for water development--enough water to yield usable amounts to wells or springs (SCSA). Ground water discharges to surface waters wherever the water table (the top surface of the saturated zone) intersects the land surface. Ground water and aquifers are recharged, that is, replenished with water, by precipitation that seeps into the ground, or by surface waters (EPA). Aquifers are often described by the kind of deposit in which they occur--"alluvial," for example, for sediments deposited by rivers, "glacial" for sand and gravel deposited by glaciers, and "basalt" for a type of rock deposited by volcanoes.

I.A.2. Surface Water

The surface waters of the state fall into the following subcategories: marine waters, rivers and streams, and lakes. (Wetlands, another category of surface waters, are considered in a separate resource characterization.)

Marine waters are those waters related to the sea. In Washington they include the Pacific Ocean coastal waters, the Strait of Juan de Fuca, and several important estuaries. An estuary is an area where fresh and marine waters mix. At the mouth of a river flowing into the ocean, for example, the ocean tide and the river current meet to form an estuary. Puget Sound is regarded as an estuary, as are Gray's Harbor and Willapa Bay.

I.B. Quantity and Distribution of the Water Resource

A recent Ecology document provides the following overview of the basic hydrology of the state:

The state of Washington can be divided into three major hydrologic regions: the Columbia River and its tributaries, Puget Sound and its adjacent waters, and the coastal drainage area. The Columbia River Basin dominates the surface drainage of the state, covering about 70 percent of the land area. The Columbia River originates in the Canadian Rockies, and also drains large portions of Montana, Idaho and Oregon as well as Washington. Major tributaries of the Columbia in Washington State include the Snake, Walla Walla, Yakima, Chelan, Entiat, Wenatchee, Methow, Okanogon, Spokane, Pend Oreille, Lewis, and Cowlitz rivers and Crab Creek in the Columbia Basin.

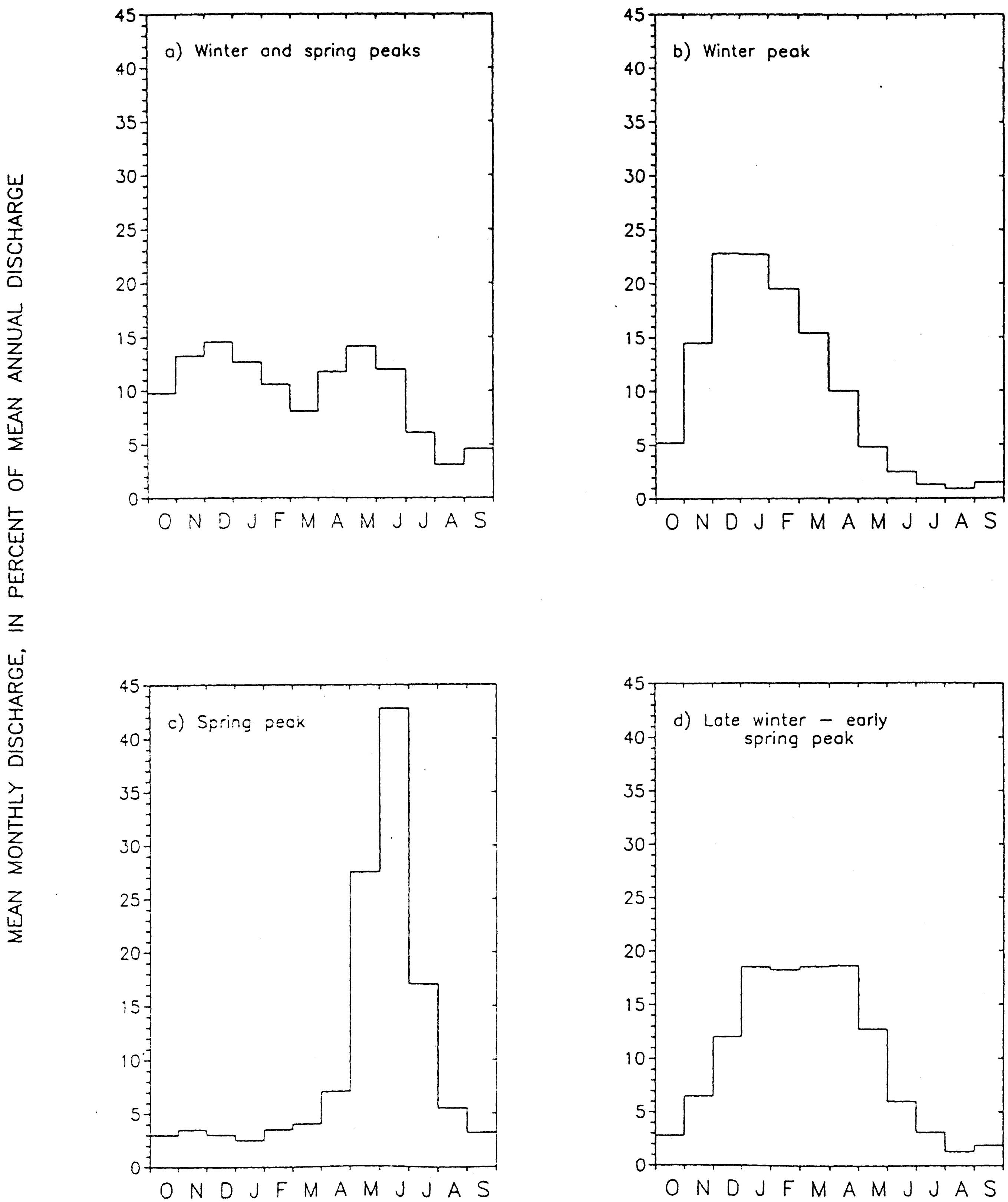
The Puget Sound drainage covers about 20 percent of the state's land area, including rivers that drain into Puget Sound, Hood Canal, the Strait of Georgia, and that part of the Strait of Juan de Fuca east from and including the Elwha River. Larger streams within the Puget Sound drainage generally originate in the Cascades or Olympic mountains, and are characterized by steep headwaters that grade into broad lowland river valleys. Major rivers in this province include the Nooksack, Skagit, Stillaguamish, Snohomish, Cedar, Green, Puyallup, Nisqually, Deschutes, Skokomish, Hamma Hamma, Duckabush, Dosewallips, Quilcene, Dungeness and Elwha.

Coastal drainages cover about 10 percent of the state and include all streams, except the Columbia, that flow directly into the Pacific Ocean or the Strait of Juan de Fuca west of the Elwha River. Coastal rivers originate in the Olympic mountains or the Coast Range and drain to saltwater. Major rivers in this region include the Quillayute, Hoh, Quinalt, Queets, Humptulips, Chehalis, and Willapa.

Surface water runoff varies widely over different parts of the state and through the seasons. Average annual runoff ranges from less than 0.5 inches near Potholes Reservoir in central Washington to 180 inches in the peaks of the Olympic mountains. Statewide, average annual runoff is 26 inches compared to a national average of less than 10 inches for the coterminous states.

Although the total quantity of runoff over the state is higher than the national average, low streamflows occur in both eastern and western Washington during mid to late summer and early fall. Seasonal patterns for nearly all Washington streams show high flows in the winter and spring and low flows in late summer, reflecting the prevailing precipitation and temperature pattern, but the exact timing of high and low flows depends on many factors. Four general seasonal patterns of streamflow can be identified for Washington streams as shown in Figure 2. The first type, Figure 2a is typical of high mountain streams that experience high flows in both early winter and spring. Low flows occur in winter due to precipitation being tied up in snow and ice, and late summer and early fall, when snowmelt has been depleted and precipitation levels are low. Figure 2b shows typical low to mid-elevation streams west of the Cascades that have low flows only in late summer and early fall. High winter and spring flows in these areas reflect high precipitation levels and snowmelt respectively; low summer and fall flows are due to snowmelt depletion, low precipitation, and receding ground water discharge to the channel. Figure 2c illustrates a typical northeastern Washington river pattern, where the colder winters result in relatively low flows throughout the winter, and spring snowmelt causes a sharp peak in early summer. Figure 2d shows a typical pattern for southeastern Washington, where the winters are milder and the elevations are generally lower than in northeastern Washington. The hydrograph shows a single broad peak that lasts from late winter to early spring, with low flows from July to October. Many smaller streams in Washington go dry during part of the low flow season during an average year, especially in eastern Washington.

Figure 2: Typical Streamflow Patterns in Washington



Seasonal low flows for individual streams in Washington are highly dependent on local basin characteristics and can vary considerably from one basin to the next. Low summer flows generally consist almost entirely of ground water discharge, which in turn is affected by the local geology, topography, and precipitation patterns...

The relationship between ground water and surface water plays an important role in the hydrology of the state. Ground water is usually a major contributor to streamflow, and as streamflow levels decline, the percentage of ground water-derived streamflow increases. In most unregulated streams, the ground water component of streamflow is close 100 percent for low flow periods nearly every year. East of the Cascades, many tributary streams lose part or all of their flow as they traverse semiarid or arid basins underlain by permeable deposits. However, the trunk streams draining those basins generally receive large quantities of ground water inflow, especially at the lower ends of the basins. West of the Cascades, recharge from precipitation is large enough in the alluvial basins that aquifers contribute to streams most of the time. (Ecology 1987a)

Ground water recharge and surface water runoff are important measures in an assessment of the water resource. Recharge refers to the amount of water that returns to ground water through infiltration, and runoff is the amount of water that returns to surface water directly. The base flows of streams are determined by ground water discharge, and all the water in a stream above the base flow is measured as runoff. Precipitation and snowmelt are the sources of runoff and recharge, and yearly variations in weather will cause variations in the annual runoff and recharge figures.

I.B.1. Ground Water Quantity and Distribution

The statewide estimate of water stored in near-surface aquifers is about 80 million acre-feet. (An acre-foot is the volume of water that will cover one acre to a depth of one foot.) The annual recharge of these aquifers is 7.5 million acre-feet, or 2.445 trillion gallons. Withdrawals of water in excess of the amount being recharged result in declining water tables and/or a reduction of the amount of water discharged to streams and springs (Ecology 1987b).

The Ecology document excerpted above also provides this description of ground water quantity and occurrence in the state:

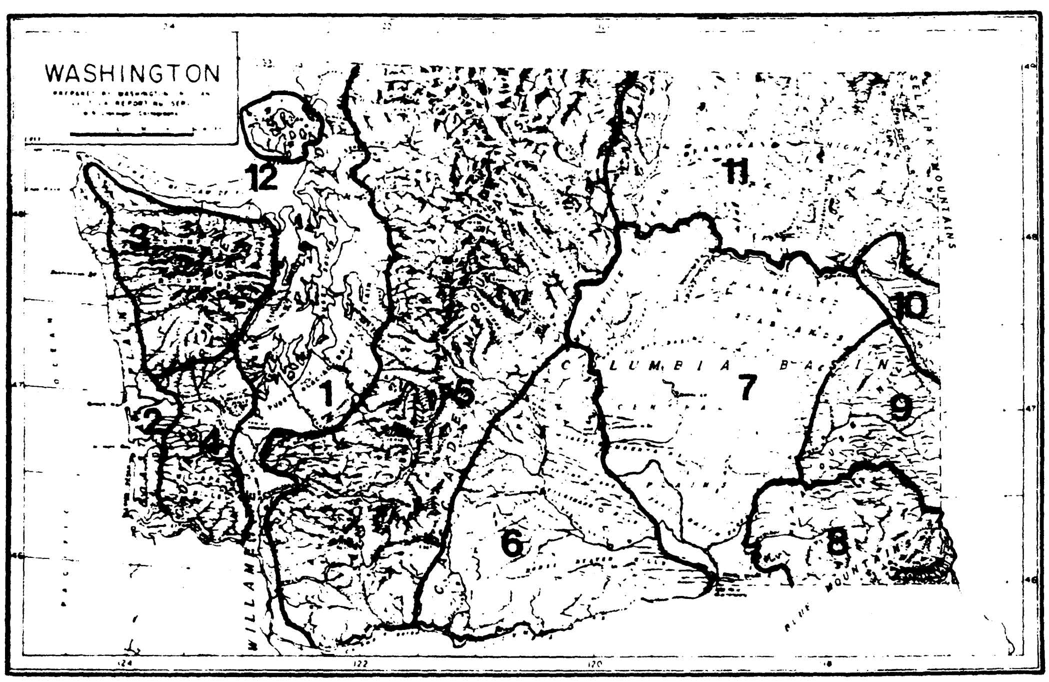
Ground water underlies all of Washington but only in certain areas is it available in sufficient quantities at a reasonable enough depth to be put to beneficial use. Well yields throughout the state vary from a few gallons to many thousands of gallons per minute. The depth to which a well must be drilled to obtain an adequate ground water supply may range from a few feet to more than a thousand feet. The differences in availability are related primarily to variations in geology, quantity of precipitation, topography, and surface drainage patterns.

In western Washington, the major aquifers are chiefly alluvial and glacial deposits consisting of sand and gravel with highly variable well yields. Much of eastern Washington is underlain by basalt aquifers that can yield as much as 2000 gallons per minute to large wells. Recharge from direct precipitation in eastern Washington is generally small, but many areas receive additional recharge from streams draining adjacent mountain areas or from irrigation seepage. The limited amount of direct recharge from precipitation and high levels of use for irrigation cause water level declines of over 10 feet per year in some areas of the Columbia plateau. Alluvial and glacially-derived deposits are important aquifers along the Columbia River downstream from Grand Coulee Dam, in the Spokane, Okanogon, Yakima, and Walla Walla River valleys and in the Ephrata-Moses Lake and Pasco areas...(Ecology 1987a)

A recent King County/Department of Ecology publication, Ground Water Resource Protection, identifies 12 main ground water provinces in the state. Figure 3 shows those provinces on a map. The 12 provinces are as follows:

1. Puget-Willamette Lowland
2. Coastal Areas
3. Olympic Mountains
4. Willapa Hills
5. Cascade Mountains
6. Yakima/Horse Heaven Hills
7. Central Columbia Basin
8. Blue Mountains
9. Palouse
10. Spokane
11. Okanogan
12. San Juan Islands (King County/Ecology).

Figure 3: Ground Water Provinces in Washington



Ecology's Water Resources Program is working with local governments, private citizens, and local interest groups to establish Ground Water Management Areas (GWMAs) throughout the state. The Washington Administrative Code identifies these objectives for the GWMA Program: "...to protect ground water quality, to assure ground water quantity, and to provide for efficient management of water resources for meeting future needs while recognizing existing water rights." (WAC)

I.B.2. Surface Water Quantity and Distribution

The marine waters of Washington include 163 miles of coastal shoreline and 2,943 square miles of estuaries. There are 40,492 miles of rivers and streams within the state, and an additional 346 miles in interstate rivers (the Snake and the Columbia). The state has over 8,000 lakes, ponds, and reservoirs for a total of 613,582 acres of surface area.

The United States Geological Survey (USGS) maintains gauges in streams throughout the state to measure the levels of stream flow. The water available at the mouth of a basin above the base flow of the stream is considered the runoff amount. (A basin is the area drained by a stream.) Runoff varies across the state according to climate, geology, topography, and other factors. The statewide total for 1985 was 72 trillion gallons. The region east of the Cascades accounted for 44 trillion gallons; the east Puget Sound region, 12 trillion gallons; and the southwestern region, including the Olympic Peninsula, 16 trillion gallons.

Ecology's Water Resources Program divides the state into 62 Water Resource Inventory Areas (WRIAs) for planning and management purposes. These WRIAs follow the natural divisions of the state's river basins. The Washington Administrative Code (WAC) provides for the development of a water resources management program for each WRIA or group of WRIAs.

II. CURRENT STATUS OF THE WATER RESOURCE

An evaluation of the condition of the water resource necessarily entails an assessment of both the quality and quantity of the state's waters. A discussion of water quantity must consider both capacity--ground water storage and streamflows, for example--and water use, for which the issues of water rights and water appropriation are central.

Water use also helps define water quality standards. The federal Clean Water Act establishes national water quality goals, and the Washington Water Resources Act of 1971 includes the following declaration of fundamentals: "Uses of water for domestic, stock watering, industrial, commercial, agricultural, irrigation, hydroelectric power production, mining, fish and wildlife maintenance and enhancement, recreational, and thermal power production purposes, and preservation of environmental and aesthetic values, and all other uses compatible with the enjoyment of the public waters of the state, are declared to be beneficial." (RCW 90.54.020) The Washington Administrative Code specifies water quality standards for surface waters in the state based on these "beneficial" or "characteristic" uses.

The WAC defines five water classes: AA, A, B, C, and Lake. Each class has a set of criteria that specifies which uses a water body in the class is to support. For Class AA, for example, the WAC identifies the following characteristic uses: "(i) Water supply (domestic, industrial, agricultural). (ii) Stock watering. (iii) Fish and shellfish: Salmonid migration, rearing, spawning, and harvesting. Other fish migration, rearing, spawning, and harvesting. Clam, oyster, and mussel rearing, spawning, and harvesting. Crustaceans and other shellfish (crabs, shrimp, crayfish, scallops, etc.) rearing spawning, and harvesting. (iv) Wildlife habitat. (v) Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment). (vi) Commerce and navigation." (WAC 173-201-045)

The WAC classifies all Washington surface water bodies in one of two ways. The specific classifications assign water bodies to one of the five classes on the basis of a use attainability analysis. The water body is evaluated to determine its appropriate assignment by what characteristic uses it can and should support. The general classifications assign all remaining water bodies according to the following criteria:

(1) All surface waters lying within national parks, national forests, and/or wilderness areas are classified Class AA or lake class.

(2) All lakes and their feeder streams within the state are classified lake class and Class AA respectively, except for those feeder streams specifically classified otherwise.

(3) All reservoirs with a mean detention time of greater than 15 days are classified lake class.

(4) All reservoirs with a mean detention time of 15 days or less are classified the same as the river section in which they are located.

(5) All reservoirs established on preexisting lakes are classified as lake class.

(6) All unclassified surface waters that are tributaries to Class AA waters are classified Class AA. All other unclassified surface waters within the state are hereby classified Class A. (WAC 173-201-070)

The following sections on water use, availability, and quality all attempt to evaluate the current status of the water resource in light of these indicators of condition.

II.A. WATER USE

The issue of water use is complicated by the distinction between use and consumption. In the strictest sense of the word, no "consumption"

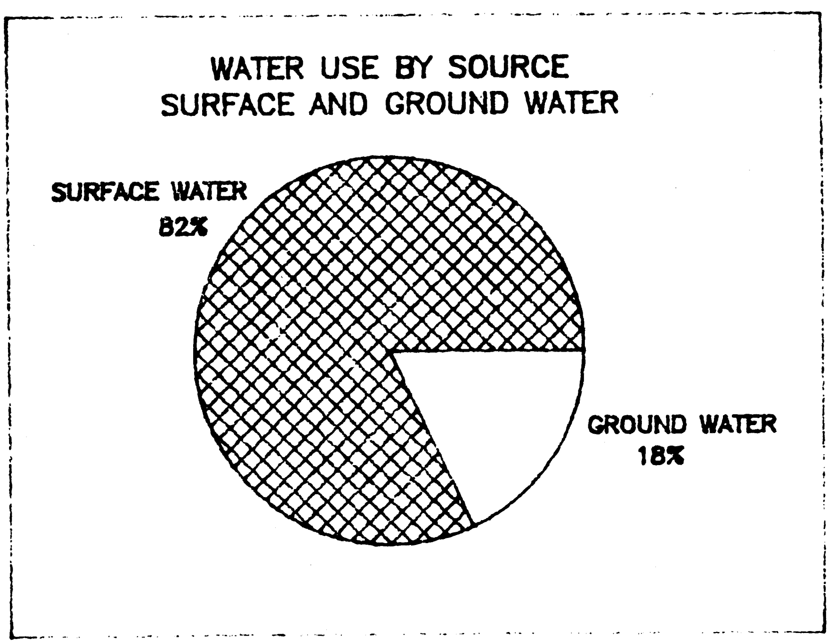
"consumption" of water ever occurs. According to the Cousteau Almanac, "Except for small quantities of water carried from the biosphere by astronauts and disposed of in space, nearly every molecule of water present when the seas formed on earth is still present on the planet." For planning and management purposes, however, the distinction between use and consumption is important.

The term "consumption" refers to that amount of water that is withdrawn from ground water or surface water bodies, and that subsequently evaporates or transpires into the atmosphere, or that becomes incorporated into plant or animal tissue or into industrial products (Shupe). This consumption amount contrasts with the full amount of water that may have been withdrawn for a specific use. In the case of irrigation, for example, some of the withdrawn water returns to ground water or to surface water; the total amount of water withdrawn for the irrigation use is greater than the amount consumed in the process. Water used for cooling purposes in industrial processes is another example: some water may evaporate, but most returns to surface or ground waters.

The state water regulations define "consumptive use" as "use of water whereby there is a diminishment of the water source," and "nonconsumptive use" as "a type of water use where either there is no diversion from a source body, or where there is no diminishment of the source" (WAC 173-500-050). By these definitions, the potential for consumptive use of ground water is high for virtually all withdrawals. The ground water source is diminished by volume change, by a location shift, or through a temporal effect.

Figure 4 provides an overview of water use in the state, for 1985, by the source of the use. As the pie chart illustrates, 82 percent of use comes from surface water with the remaining 18 percent coming from ground water.

Figure 4: Water Use by Source in Washington State, 1985



The specific types of water use fall into two general categories--instream and out-of-stream. Instream uses include some forms of generation of hydroelectric power, navigation, recreation, and the support of fisheries and wildlife habitat. Out-of-stream uses include municipal use, industrial use, irrigation, and drinking water not included in municipal use. (For the purposes of this report, the term "out-of-stream" refers to any and all water sources--streams, rivers, lakes, and even ground water.) The following sections discuss each of these uses.

II.A.1. Instream Uses

The Water Resources Act of 1971 provides that, "Perennial rivers and streams of the state shall be retained with base flows necessary to provide for preservation of wildlife, fish, scenic, aesthetic and other environmental values, and navigational values."

The instream uses discussed in this section apply only to surface waters. This exclusion of ground water, however, does not imply that ground water has no use unless it is withdrawn for human purposes. On the contrary, ground waters discharge to surface water, establishing and maintaining the base flows for streams, and to the extent that streams and other surface waters rely on ground water for replenishment, ground water supports the instream uses of surface waters. Ground water also serves other in-place purposes, which are treated more fully in the discussion of ground water depletion in the Water Quality section.

II.A.1. a. Hydroelectric Generation.

Although not identified specifically by law as an instream use, hydroelectric generation is an important water use that in some configurations does occur instream. According to a recent water use efficiency study, "In 1985 an estimated 76,900 billion watt-hours of electricity were generated by hydropower in Washington, supplying about 90% of the electricity consumed in the state." (Ecology 1988) Hydroelectric power plants are distributed throughout the state and include ten large federal dams on the Columbia and Snake rivers. These dams are capable of using all of the flow of these rivers nearly all of the time, and, according to the efficiency study, the use of water for hydroelectric power generation is particularly sensitive to annual variations in runoff (Ecology 1988). Hydropower generation on the Snake and Columbia Rivers also has the tendency to dictate streamflow patterns, affecting water depths and currents, and thus becoming a factor in navigation (Ecology 1987a).

II. A. 1. b. Navigation.

Several Washington rivers support commercial navigation, notably the Columbia, the Snake, and the Cedar River Basin including the Lake Washington Ship Canal. Locks and channel improvements built by the U.S. Army Corps of Engineers enable and facilitate this use. The estuaries of other rivers provide ports even though commercial navigation does not extend upstream. An Ecology report on instream resources notes that, "Navigation water requirements relate primarily to maintenance of safe water depths and lockage water," and that, "Navigation needs occasionally conflict with other water uses." Examples of this conflict include the Columbia and Snake rivers where lockage water is unavailable for hydropower use, and the Cedar River/Lake Washington system where water depth and lockage requirements conflict with municipal water supply withdrawals and fish flow needs (Ecology 1987a).

II.A.1.c. Recreation/Aesthetics.

Water-related recreation activities are a popular and growing pastime in Washington State. These activities occur throughout the state, and range from white-water kayaking and canoeing to other forms of boating, fishing, swimming, camping, hiking, and picnicking. The enjoyment of water resources for their aesthetic values are an important related activity. The State Scenic Rivers Act designates parts of the Skykomish, Beckler, and Tye rivers as state scenic river segments, and Ecology, under the authority of the Shoreline Management Act, has identified 91 rivers and streams as "Rivers of Statewide Significance." In addition, parts of the Skagit, Sauk, Suiattle, and Cascade rivers have been designated as National Wild, Scenic, or Recreational Rivers, and 20 other Washington rivers are included in a national inventory of river segments for potential inclusion in the system. (Ecology 1987a)

II.A.1.d. Fisheries/Other Wildlife Habitat.

The following excerpts from Ecology's instream resources study explain the essential issues regarding fisheries and wildlife habitat:

The inland waters of Washington provide habitat for 76 species of fish, of which 46 are native and 30 introduced. Fourteen of these species are anadromous: they spawn in freshwater but spend most of their adult lives in marine waters. Resident fish spend all of their lives in freshwater....Five species of Pacific salmon (coho, chum, chinook, pink, and sockeye) and two species of anadromous trout (rainbow, cutthroat) inhabit Washington streams...

Salmonid Habitat--These salmonids (salmon and trout) dominate streams and rivers in Washington by being well adapted to typical stream habitats in this region. Clean, oxygen-rich, cool flowing streams are needed for rearing along with clean gravels for spawning. The combination of abundant precipitation, steep gradients, and gravel left by glaciers has created over 10,000 individual streams draining to Puget Sound alone which are suitable for salmonids.

Natural stream channels contain log jams and large woody debris that create a complex aquatic habitat of riffles, pools, runs, glides, and side channels. Stream bottoms range from silt to clean gravels to boulders. Large woody debris and boulders provide 1) shade and cover from bird predation, 2) efficient feeding stations where little energy needs to be expended to maintain the fish's position in calm water but where nearby fast currents bring an array of insects for food, and 3) stability to the stream channel by holding gravels that high flows would otherwise move downstream out of the system and into the ocean.

Water flow is an important element of fish habitat. Too much flow can scour a streambed and reduce water quality. Too little flow may degrade or expose otherwise suitable habitat, desiccate eggs in the gravel, and result in increased water temperature. Stream flows fluctuate greatly under natural conditions. Land use conditions and land management practices are human activities that can considerably alter a stream's flow regime.

Each fish species/lifestage will reside in favorable microhabitat within the stream. For instance, water of approximately one to three feet depth and one to three feet per second velocity is preferred by most spawning salmon, whereas slower water over a broad range of depths is selected by rearing salmon. Other factors such as cover are also important selection criteria for many species/ lifestages. The abundance of suitable habitat varies greatly with varying rates of stream flow...

Large diversions and dam building have affected the natural salmonid production of a number of Washington streams. Construction of Grand Coulee Dam alone cut off passage to about one-third of the accessible salmon and steelhead habitat in the entire Columbia River basin. Other dams on the Columbia and Snake Rivers and their tributaries were at least partially responsible for the drastic reduction in the size of fish runs returning to the largest salmon-producing stream in the world. Irrigation storage and diversion projects on a number of Columbia River tributaries such as the Walla Walla, Okanogan and Yakima have severely reduced returning fish runs. Power developments on tributaries such as the Wenatchee, White Salmon, Cowlitz and Lewis Rivers have also seriously affected natural fish runs by blocking passage to upstream areas and inundating habitat. Estimates of average annual salmon and steelhead runs before development of the Columbia River drainage range from 10 to 16 million fish. Present (1986) average annual run size is about 2.5 million fish....In the Puget Sound drainage, power and water supply dams on many rivers affect natural fish production. Irrigation in basins such as Dungeness and Nooksack basins reduces stream flows formerly used by fish. On many of these streams, hatcheries have been constructed to replace lost or reduced natural fish production...

This discussion of wildlife resources and habitat focuses...on the riparian zone (the land along the bank of a stream or other water body). Riparian habitats are characterized by high diversity, density, and productivity of animal species. Numerous species can be affected by varying levels of streamflow...

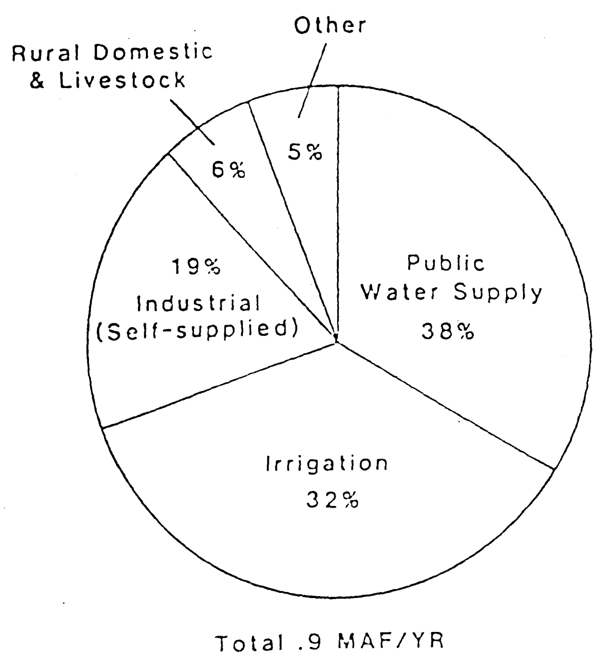
Riparian zones provide important habitat for a wide variety of terrestrial and aquatic wildlife. Wildlife have specific requirements for food, water, cover, breeding and rearing space, hiding and resting areas, and thermal protection. Riparian areas provide these requirements for many species. Many species not directly dependent on these areas use them as preferred habitat at times, or as travel corridors.

Some amphibians and mammals and many waterfowl are totally dependent upon riparian or wetland areas. Other species may live in different habitats but reach maximum population densities in riparian or wetland areas. Some may use several habitat types, spending a significant amount of time in these areas during part of their life cycle. Shorebirds and waterfowl use the waters or shorelines of riparian areas for feeding or resting. (Ecology 1987a)

II.A.2. Out-of-Stream Uses

The out-of-stream uses discussed in this section include both surface and ground waters. Figure 5 shows the distribution of ground water uses for 1980: 38 percent of ground water use went to public water supply, 32 percent to irrigation, 19 percent to industrial, 6 percent to livestock, and 5 percent to other uses. These figures represent a total ground water use of 293.4 billion gallons, or 10 percent of the total water use for that year. In 1985, ground water use increased by 46 percent over the 1980 figure to 427.9 billion gallons. The proportion of ground water use also increased to 18 percent of the total water use for 1985. These use figures do not include the water from those domestic supply wells that produce less than 5,000 gallons per day. Such wells do not require a permit from the state, and consequently, there are no records on these sources.

Figure 5: Ground Water Use in Washington State, 1980

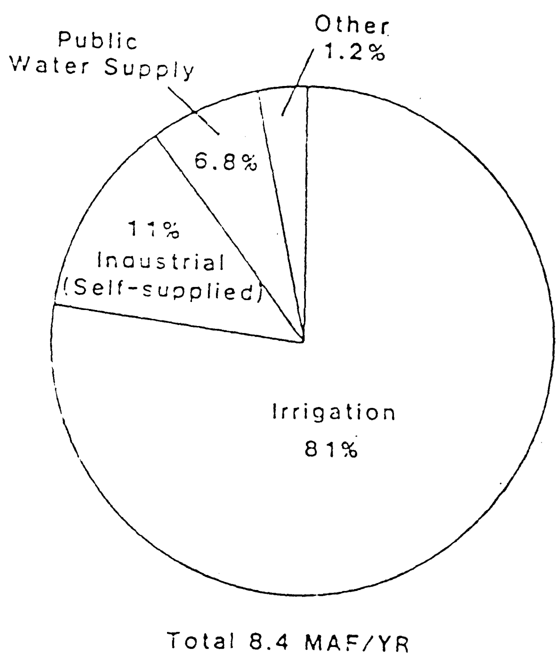


Total use = .9 million acre-feet/year
= 293.4 billion gallons/year

Figure 6 shows the surface water use for 1980. Irrigation represents 81 percent of surface water use; industrial, 11 percent; public supply, 6.8 percent; and other uses, 1.2 percent. The total surface water use (not including hydropower generation) for 1980 was 2,738.4 billion gallons, 90 percent of total water use for that year. In 1985, surface water use fell to 1,949.1 billion gallons, a 29 percent decrease from the 1980 use figure. The proportion of surface water use declined to 82 percent of total use.

(Hydropower would have by far the highest use in light of the huge hydraulic capacities of the Columbia and Snake River dams. Virtually the entire flows of these rivers go through a series of generators at dams along the way.)

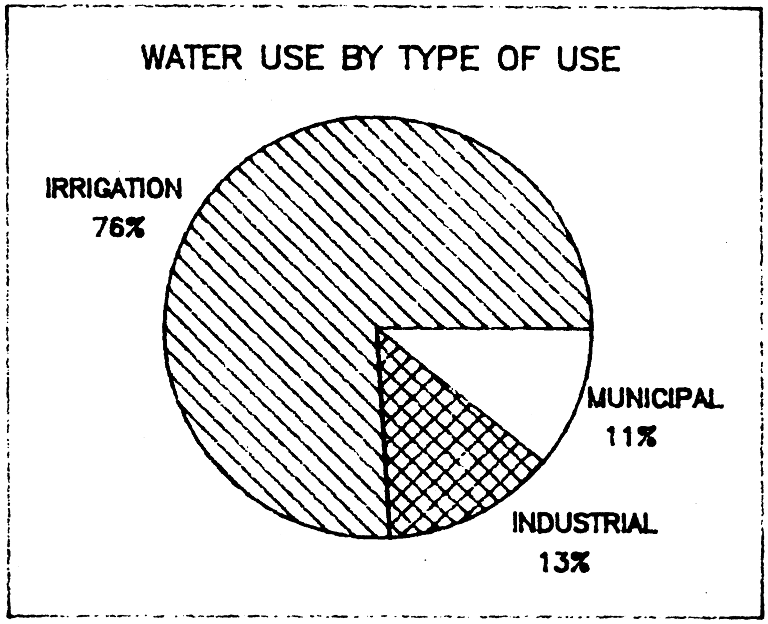
Figure 6: Surface Water Use in Washington State, 1980
(Exclusive of Hydropower)



Total use = 2,738.4 billion gallons/year
= 8.4 million acre-feet/year

Figure 7 is a composite of ground and surface water use by the three major types of use (not including hydropower) in the state. Irrigation accounts for 76 percent of all water use in the state; industrial, 13 percent; and municipal, 11 percent.

Figure 7: Water Use in Washington State, 1985
(Exclusive of Hydropower)



Water use in the state falls into a pattern of three regions each with a dominant use. Figure 8 shows the three regions on a map of the state, and Figure 9 provides more detail on each region's specific use. In the east Puget Sound region (Region 1), municipal use is highest, with a significant industrial component. In southwestern Washington, and including the Olympic Peninsula (Region 2), industrial use predominates, and in eastern Washington (Region 3), irrigation far exceeds all other use.

FIGURE 8: WATER USE REGIONS

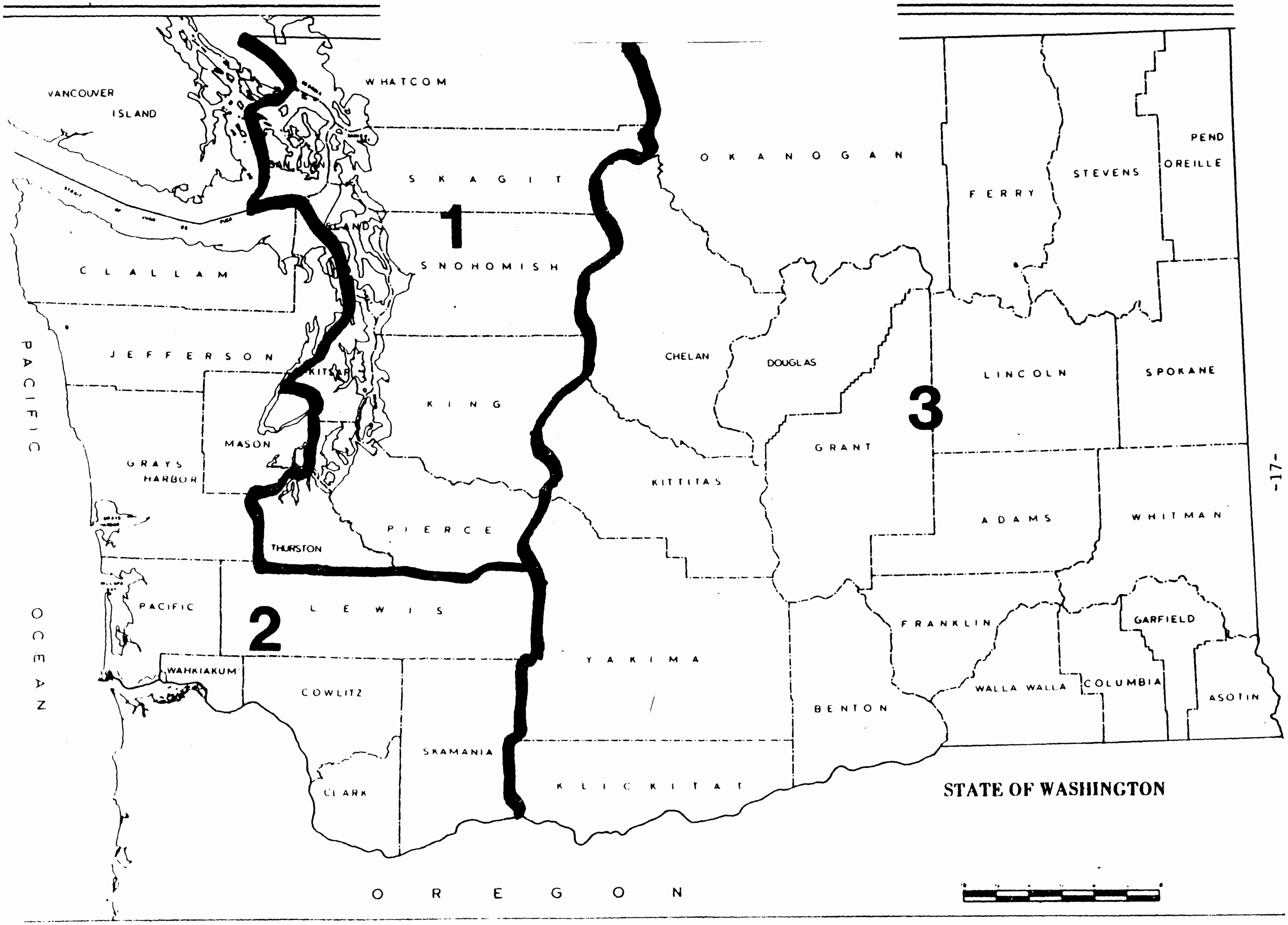
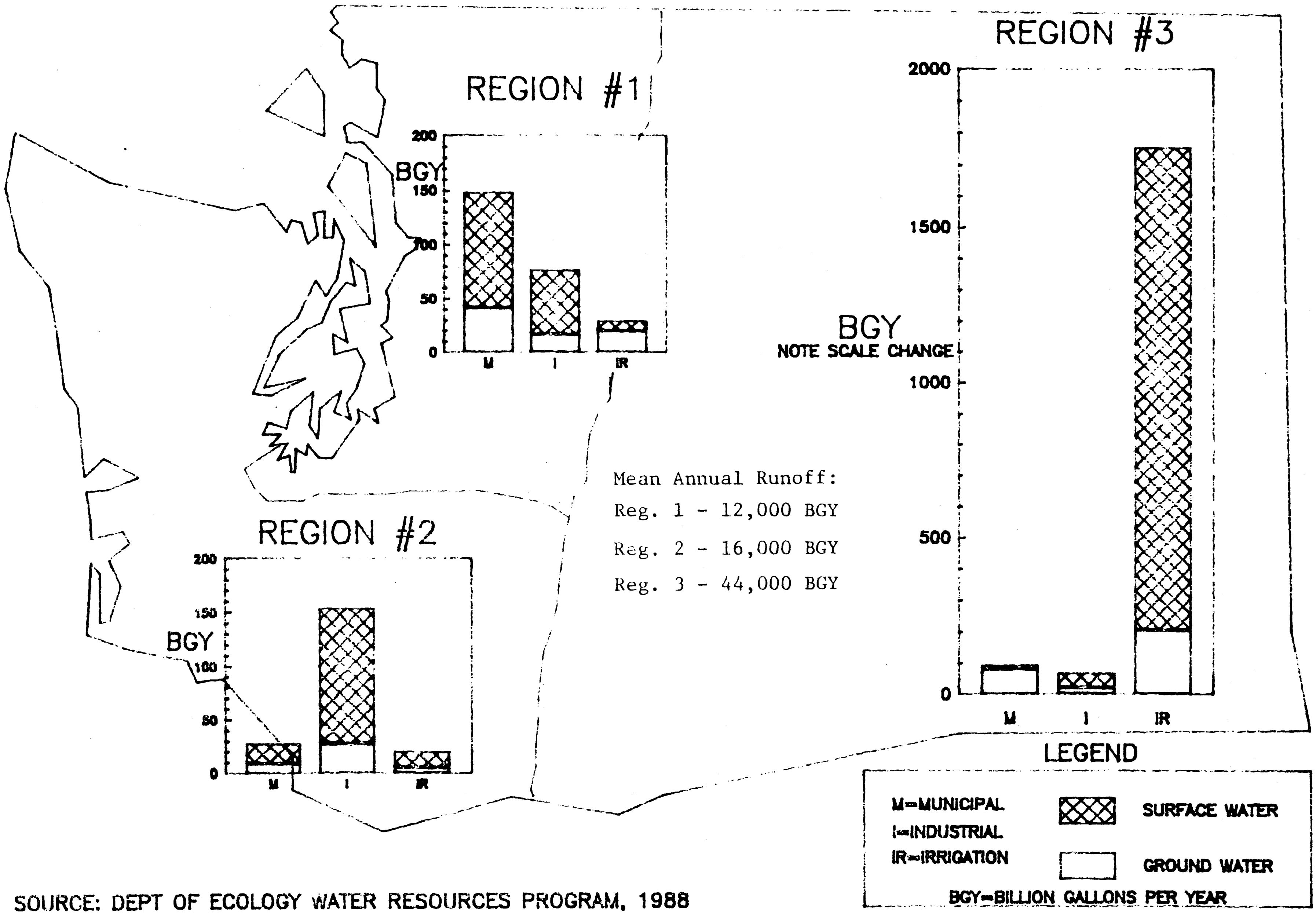


FIGURE 9

1985 REGIONAL MUNICIPAL, INDUSTRIAL, AND IRRIGATION WATER USE



SOURCE: DEPT OF ECOLOGY WATER RESOURCES PROGRAM, 1988

II.A.2.a. Municipal and Domestic.

Municipal and domestic water uses include residential use for drinking and for outdoor maintenance, as well as local government use for irrigation of public spaces. The major municipal systems across the state are summarized in an Ecology study as follows:

The cities of Seattle, Tacoma, and Everett operate municipal water supply projects on the Cedar and Tolt Rivers, the Green River, and the Sultan River respectively. These systems provide the majority of the domestic water supply for the central Puget Sound metropolitan region, although these systems are supplemented significantly with ground water, particularly Tacoma. Other large surface water municipal systems in western Washington include Bellingham (Middle Fork Nooksack River and Whatcom Creek), Olympia (McAllister Creek), Bremerton (Union River), Port Angeles (Elwha River and Morse Creek), Aberdeen (Wishkah and Wynoochee Rivers), and Hoquiam (Hoquiam River). Large surface water municipal systems in eastern Washington include the Tri-Cities (Columbia River), Yakima (Naches River), and Wenatchee (Columbia River). Other major municipalities rely principally on ground water sources. New surface water diversions are being considered by Seattle (North Fork Tolt River), Bellevue (North Fork Snoqualmie River), Tacoma (Green River), Jefferson County (Dosewallips River), Kitsap County (Hamma Hamma River), Yakima (Rattlesnake Creek), and Walla Walla (Mill Creek). (Ecology 1987a)

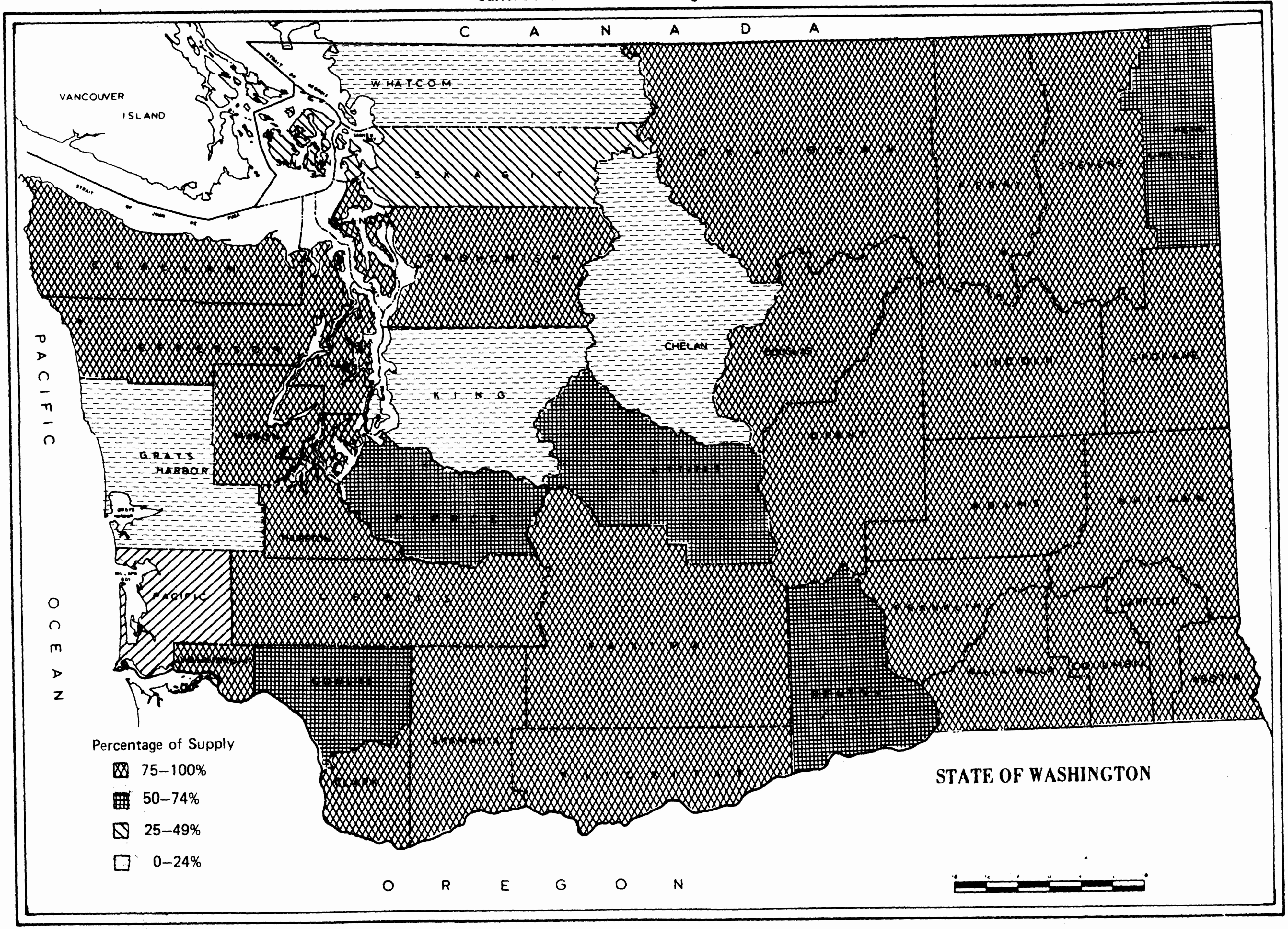
In addition to these larger municipal systems, there are many other public and private domestic water systems throughout the state. Those systems that are self-supplied typically rely on ground water. Figure 10 is a map of the state, and shows the extent of reliance on ground water for drinking water for each county. Twenty-seven counties rely on ground water for 75-100 percent of their drinking water supply, and according to Ecology's Water Quality Program, "Nearly two-thirds of the state's population relies on ground water for drinking water. Of approximately 10,000 public water systems in the State of Washington, 9,500 rely on ground water" (Ecology 1987b). This assessment of ground water reliance may understate the actual reliance by a significant amount because it does not include the domestic supply wells producing less than 5,000 gallons per day.

II.A.2.b. Industrial.

Industrial water use includes the processing and cooling water used by manufacturers, and the cooling water used by thermal power plants. (It does not include water for hydropower generation.) Approximately 63 percent of the water used for industrial purposes is self-supplied. Seventy-five percent comes from surface water sources, and 25 percent from ground water. The pulp and paper and food processing industries are heavy water users, and the high technology and metal production firms are somewhat less water-intensive. The high costs associated with developing new water supplies and with disposing of used water are encouraging many industries to develop water conservation measures, including water recycling.

Figure 10. RELIANCE ON GROUND WATER FOR DRINKING WATER SUPPLIES

Current and Reserved Water Rights



II.A.2.c. Irrigation.

Irrigation is the application of water to lands for agricultural purposes. In 1985, irrigation use represented 76 percent of total water use in the state (not including hydropower), with 87 percent of the irrigation water coming from surface water sources and 13 percent coming from ground water. Ecology's instream resources study describes irrigation in the state as follows:

Irrigation occurs mainly in eastern Washington. It is concentrated within the Yakima basin (one-half million acres), Okanogan basin (32,000 acres), and Columbia basin (600,000 acres) where federal projects have been built to supply irrigation water. Extensive private irrigation development has occurred in the Horse Heaven Hills using direct pumping of Columbia River water (about 42,000 acres), in the Wenatchee basin using water supplied by gravity from the Wenatchee River and tributaries (about 15,000 acres) and in areas near the Snake River using water pumped from the Snake River (about 60,000 acres). Smaller irrigation developments using surface water occur throughout eastern Washington, especially along river and stream valley bottoms. Smaller irrigation systems typically do not involve storage facilities, and must rely on natural stream flows.

Scattered surface water irrigation occurs throughout lowland areas of western Washington. Concentrated areas of surface water irrigation are in the Dungeness basin (48,000 acres), the Nooksack basin (11,000 acres) and the Chehalis basin (16,000 acres)...

Given current technology, the areas of the state with the most potential for future irrigation development using surface water are in the eastern undeveloped portion of the Columbia Basin Project area (about 450,000 acres), the Horse Heaven Hills (about 270,000 acres), and the lower Snake River area (about 165,000 acres). (Ecology 1987a)

II. B. WATER AVAILABILITY AND WATER RIGHTS

The issue of water availability is as complex as the hydrologic cycle itself, and it is further complicated by the set of laws and doctrines that govern water rights in the west.

The riparian doctrine and the prior appropriation doctrine provide the bases for establishing water use rights in Washington. The riparian doctrine acknowledges that owners of land bordering water bodies have, as part of their land, rights to use water from those water bodies. The prior appropriation doctrine establishes rights based on the principles of beneficial use and "first in time, first in right." (Ecology 1988) Under the prior appropriation doctrine, users can remove water from a water body and transport it to nonriparian land for use. (Ecology 1987a)

In 1917 Washington passed the State Water Code, which establishes appropriation as the exclusive means for establishing new rights to surface water. The State Ground Water Code was passed in 1945, and extended this appropriation system to ground water. The fundamental nature of water rights comprises five basic elements established in statute and case law. An Ecology water use efficiency study summarizes these elements as follows:

i) Amount. The measure and limit of a water right is the amount of water actually diverted and put to beneficial use....Water use is measured both in instantaneous quantity terms, usually cubic feet per second, and absolute quantity terms, usually acre feet per year.

ii) Place of Use. The right to appropriate water is appurtenant to the land or place where it is used....A water right may, however, be transferred from the original place of use, under certain circumstances, and become appurtenant to other lands or places of use.

iii) Purpose of Use. An appropriative right is established for a particular beneficial use. However, the right may be changed to another use under certain circumstances.

iv) Point of Diversion. Similarly, an appropriative right is established with a definite point and method of diversion; however, that too may be changed from one point or method to another.

v) Priority. The priority date of the right is probably the most important element of an appropriative right. When the supply of water is limited, those with the earliest priority date are entitled to have their needs met to the exclusion of junior right holders. (Ecology 1988)

The waste doctrine developed out of the beneficial use requirement of the prior appropriation doctrine. The waste doctrine recognizes that water resources are limited, that wasting water is not in the public interest, and that such waste would preclude putting the water resource to its maximum beneficial use. Both the surface and ground water codes prohibit the waste of water, and water that is wasted (i.e., not put to beneficial use) is not considered part of a person's vested water right. One problem arising out of this doctrine is that it can inadvertently serve as a disincentive for conservation: a user who could improve his water use efficiency would not necessarily benefit from his water savings because that amount saved is regarded as wasted water and not available for the user's alternative purposes.

Ecology has generally applied a "reasonably efficient" test to water users to reduce wasteful practices. This test permits a user to divert only that amount of water required for a given purpose using reasonably efficient methods of conveyance and application. To this end, Ecology has developed "Quantity Allocation Guidelines" to achieve consistency and equity in the water rights process. These guidelines, or "duties," cover agricultural and nonagricultural irrigation, domestic, municipal, and stock watering uses. The allocation guidelines take into account the site-specific physical characteristics that may affect the quantities recommended for a permit, and include such factors as soil type, slope, and micro-climate.

II.B. 1. Appropriation of New Water Rights

As the state agency responsible for the appropriation of new water rights, Ecology follows a permitting process that the efficiency study summarizes as follows:

The Water Code requires Ecology, prior to issuing a water use permit, to answer four basic questions: (a) Is there water available for appropriation? (b) Will the proposed appropriation impair existing rights? (c) Will the water be put to beneficial use? (d) Will the appropriation be detrimental to the public welfare? (Ecology 1988)

On the question of availability, the study states that, "Determining whether water is available for appropriation is usually a 'judgement call' on the part of the administrator. This determination is generally based upon whether water is physically available that is not, for the most part, subject to call by existing rights."

The judgement call on the availability of water is complicated by a set of factors for which Ecology may not have adequate information. The department maintains good records on rights allocated since 1917, but does not have a reliable record of claims filed before 1917. Such claims to water use must be confirmed by adjudication before they are recorded as valid water rights. In the case of valid rights, Ecology may not know the actual amount of a water right that is being exercised. The state follows a "use it or lose it" principle on water rights, so if a right-holder is not using his full allocation, Ecology can reallocate that portion of the right, but the agency needs to have the knowledge before it can act. In addition, where Ecology does not know of illegal uses of water, the agency cannot factor such use into its appropriation judgement.

The final factor in this judgement call, as it applies to rivers and streams, is the instream flow requirement. Ecology's Water Resources Program sets instream flow requirements to meet flow levels necessary to preserve instream values. Where those flow levels are established by administrative rule, the instream flow requirement has the same status as a water right in the hierarchy of rights on the stream. Where the instream flow has not been established, Ecology works with the Department of Fisheries on a case-by-case basis to take into account fisheries habitat before granting a new water right. A fuller discussion of the instream flow requirement issue follows.

Ecology's appropriation of new water rights depends on this "judgement call" regarding water availability in part because the department does not have enough information to sustain an objective, purely scientific, determination. Ideally, the agency would know how much water is available in a stream (or other water body or aquifer) on an annual basis, would also know how much water is already appropriated from that source to senior rights holders, and could therefore calculate how much more water is available for future appropriation. The methodology for such an analysis is well-known, but the data requirements are vast, the effort is time-consuming, and the sheer number of water bodies and aquifers in the state make the overall application of this approach a daunting task. Ecology has applied this methodology to some extent in its instream resources and water allocation program and in some groundwater management areas.

Another complication in the water allocation issue is the fact that the state does not regulate private supply wells under 5,000 gallons per day. Lacking the information about these small systems, the state cannot evaluate the effects of proposed permits on existing small systems and users. Larger, permitted systems can affect water levels thereby increasing pumping costs for the smaller users even though the smaller systems predate the larger ones.

II.B.2. Instream Flow Requirements

The "Instream Resources Protection Study Report," prepared by the departments of Ecology, Fisheries, and Game (now Wildlife), provides this background on the instream flow issue:

In 1949, the Legislature declared it to be the policy of the state "...that a flow of water sufficient to support game fish and food fish populations be maintained at all times in the streams of this state."

Under this legislation, approximately 250 streams (nearly all very small) have been closed to further appropriation, and low flow provisions have been applied to individual permits on approximately 250 other streams.

The Minimum Water Flows and Levels Act was enacted in 1967 and amended in 1969 to provide a more formal process to protect instream flows. Under this act, the Department of Ecology shall, when requested by the department of Fisheries or the Game Commission, establish minimum streamflows and lake levels to protect fish, game, birds, or other wildlife resources or recreational or aesthetic values or to preserve water quality.

The Water Resources Act of 1971 provides that, "Perennial rivers and streams of the state shall be retained with base flows necessary to provide for the preservation of wildlife, fish, scenic, aesthetic, and other environmental values, and navigation values (RCW 90.54)." The act further provides that lakes and ponds shall be retained substantially in their natural condition. Under this and the authorities discussed above, Ecology has established instream flows on 172 major streams or stream reaches of the state and has closed over 300 streams and lakes to further consumptive appropriation (including many of the streams noted above). (Ecology, Fisheries, and Game)

The Water Resources Program regulations, adopted by Ecology in 1976 to provide guidelines for the instream flow and water allocation activities authorized by the Water Resources Act, establish the 62 Water Resource Inventory Areas (WRIAs) as planning units. These regulations state that, "As sufficient data are obtained for each WRIA and/or grouping thereof in the state to enable the department to formulate a water resource planning and management program for such area, the department shall by regulation establish policies for the beneficial use of public waters...(WAC 173-500)"

The "Instream Resources Protection Study Report" summarizes the effort:

Ecology is vested with exclusive authority under state law to set instream flows and levels on state waters. In establishing such flows, Ecology is required to consult with and carefully consider the recommendations of the departments of Fisheries and Agriculture, the Game Commission, and the Energy Office as well as affected Indian Tribes....

...During the early 1970s, Ecology initiated a basin planning process to address basin specific water allocation policies, including instream flows. Between 1974 and 1978, Ecology adopted eight basin management programs for some of the more serious water problem areas of the state. These programs addressed instream water needs and analyzed the level of existing demand in order to define the quantity of water remaining available for further appropriation.

To meet changing priorities, in 1979 Ecology began development of modified basin planning programs. This new effort, the Washington Instream Resources Protection Program (WIRPP), established a high priority for protecting instream resources (primarily fish and wildlife) through the establishment of instream flows. Because of their importance for fish and wildlife and growing demand for out-of-stream water use, western Washington streams and the main stem of the Columbia River have been treated as high priority waters in this program...

The WIRPP is a water resources planning effort that focuses principally on the development and adoption of regulations into the Washington Administrative Code intended to preserve and protect instream resource values. These measures include minimum instream flows and closure of streams and lakes to further consumptive water rights appropriation.

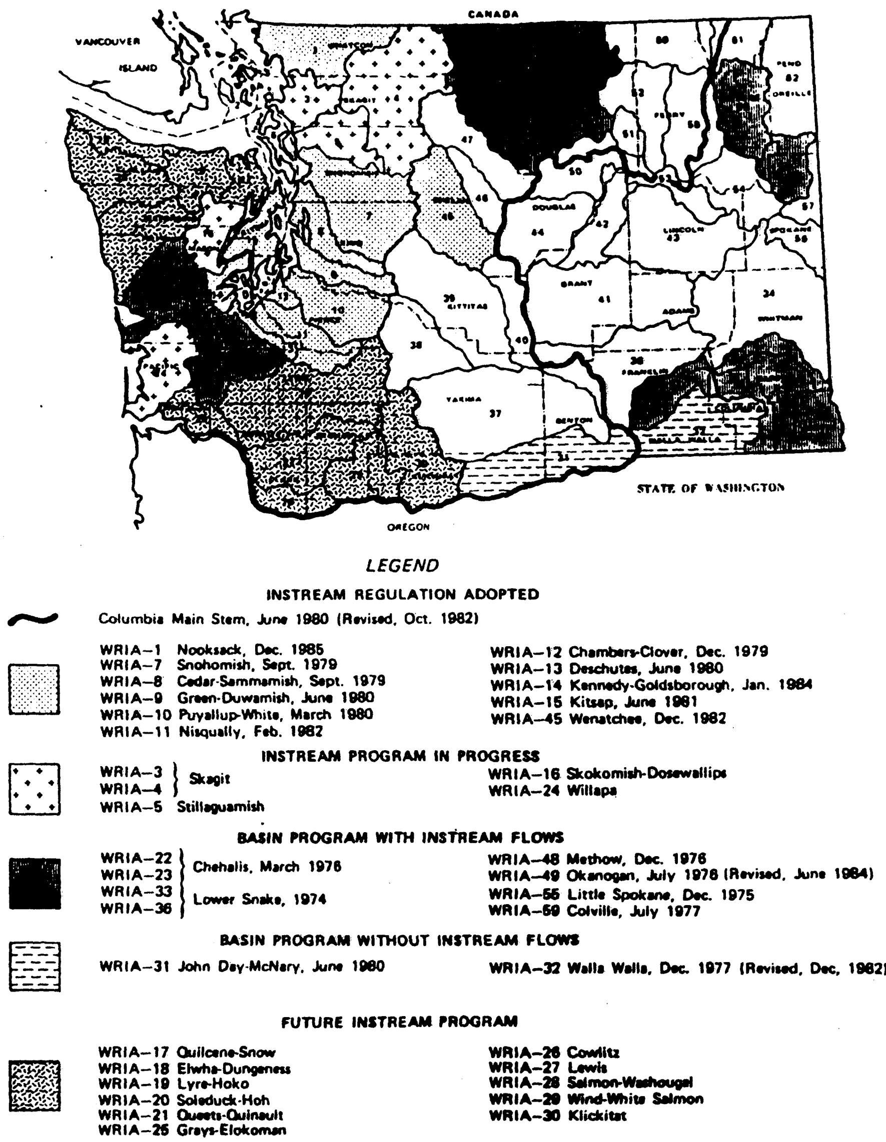
Instreams flows protect streams only from consumptive use appropriations approved after the adoption of the flows. When the flow of a stream falls below a specified instream flow level, those water rights provisioned with those flows must cease or reduce diversion until the instream flow is met or exceeded. Water rights issued prior to the establishment of instream flows are not affected. Streams which have already been fully appropriated are not affected by this program until existing water rights are abandoned and re-linquished.

When a stream is closed to further consumptive appropriation, no further rights will be issued for consumptive water diversion during the period of closure. Closures are normally necessary only for the low flow period of the year (generally midsummer to early fall in Washington streams) but may cover the entire year depending on the situation in a specific stream.

Whenever possible, Ecology prefers to establish instream flows on streams rather than closing them to future uses. However, where it is determined that the level of existing diversions seriously affects the welfare of instream uses, or where any new diversions would irreparably harm instream values, the stream may be closed to further consumptive appropriation. Many small streams have been closed for this reason, even where few if any consumptive diversions exist. (Ecology, Fisheries, and Game)

Figure 11 shows the status of basin planning, including instream regulations adopted, as of January 1, 1986. The instream program is currently under review, and no new instream regulations have been adopted since the publication of this figure.

Figure 11: Status of Basin Planning--January 1, 1986



Source: Ecology, Fisheries, Game; 1986

Public controversies surrounding instream flow statutes, policies, and procedures led to the instream resources and water allocation program review. The report of this program review captures the importance of the issue succinctly: "How instream flows are defined, and the level at which they are established constitute major state water policy. Instream flows are critical for the maintenance, preservation, restoration, and enhancement of Washington's fisheries resources as well as for preservation of other instream values such as aesthetics, recreation, and water quality. The level at which they are established also has significant implications for future water resources development opportunities. Future projects can be made economically infeasible or very costly depending upon the level of the instream flow to which they are conditioned." (Ecology 1987a)

The state laws that guide Ecology in setting the levels of instream flow do not define several key terms, and the result is a continuing difference of opinion in the interpretation of these terms. According to the program review report, "...the terms 'base flows', 'minimum flows', 'protect', 'enhance' and 'preservation of...values' imply to some a high, optimum streamflow level for instream values and to others a low survival level." Ecology has used its own interpretation in developing procedures for setting instream flow requirements.

Of the methods available for analyzing instream flow needs, the more sophisticated ones, according to the "Instream Resources Protection" report, "...focus on fisheries needs and involve complex models of open channel hydraulics and the behavior of fish under varying natural conditions." The report identifies the Instream Flow Incremental Method (IFIM), developed by the U.S. Fish and Wildlife Service, as the leading method in widespread use, and briefly describes the method as follows:

Use of this method involves the collection of field data on hydraulic parameters (depth and velocity) that vary with streamflow and other characteristics of the aquatic environment such as cover (items used by fish for holding and hiding) and channel substrate. Data are also collected that describe the stream-specific preferences for these parameters by fish species and lifestages to be analyzed. From the data collected, a site-specific hydraulic model is developed that evaluates the changes in depth and velocity that occur as flow is varied. Once calibrated, this model is interfaced with the fish species and lifestage preferences for the various parameters. The result of this analysis is a table showing the predicted incremental relationship between flow and available habitat for each fish species and lifestage of interest.

...Earlier methods were based heavily on the analysis of hydrology without much regard for biological needs, because those needs were undefined or undocumented. Studies using IFIM indicate that to achieve maximum potential production, fish residing in small and medium sized streams may need much or all of the water naturally available, particularly during the normal summer-fall low flow period. This information has also influenced Ecology's decisions to close significant numbers of small streams to further consumptive appropriation to protect fisheries resources.

IFIM studies on some large Northwest rivers seem to indicate that for large rivers, relatively low instream flows may provide full fish habitat protection. The effects of such low flows is less clear for rearing than for spawning, because the habitat parameters for rearing are not as well understood and are less adaptable to existing modeling techniques...(Ecology, Fisheries, and Game 1986)

Regardless of the method used to analyze instream flow needs, the analysis relies on some standard for the final determination of instream flow level. There is a broad range of potential instream values to protect, and an instream flow analysis must necessarily relate flow levels to some criteria for protecting some specific values. In Washington the debate over what constitutes adequate protection has centered on the needs of fisheries habitat, with other values such as recreation, aesthetics, water quality, and navigation taking a secondary importance. But the debate does not end with the the decision to focus on fisheries. Other key questions remain: At what level should the flow be set to protect fisheries--survival, sustaining, optimum, or some other? And what fisheries, and which life stages, should guide the analysis? Nor is the focus on fisheries necessarily a fixed decision. Proponents of the other instream values are likely to assert an increasing influence over time.

The review of the instream resources and water allocation program is considering these and other water issues. Any further discussion is beyond the scope of this resource characterization. The important points for the purposes of this report are that these issues are scientifically, economically, and politically complex, and that Ecology is working with the appropriate interest groups and authorities to resolve the differences.

Instream flow requirements affect water availability by making some streams less reliable as sources of water supply than they would be otherwise. The combination of existing rights, instream flow requirements, and future water needs may be greater than a stream's capacity to provide water.

II. B. 3. Hydrology and Climate

The hierarchy of water rights for each water body comprises a set of constraints on water availability, and represents a major human factor in the issue of water availability. Other human activities also affect water quality and quantity, and the interaction of these human factors with natural conditions--especially hydrology and climate--determines the amount of water available for human and other uses. The instream resources program review report provides the following discussion on this topic:

Water availability to meet new demands is a problem in many areas of eastern and western Washington. A major factor affecting water availability is the climate of the Pacific Northwest. Although much of our state receives adequate precipitation on an annual basis, the pattern in which it is received creates some problems. Most of our precipitation is received during winter, whereas summer and early fall tend to be rather dry. Nearly all streams in the state reach their lowest flows during this period. Water demand for many uses, including irrigation and municipal use, peaks during this dry period. The low flow period is also a critical period for instream uses including recreation, aesthetic values, water quality, and fish and wildlife. In many cases the level of fish production is determined by flows during this low flow period...

Areas of eastern Washington where water availability is critical include the Walla Walla basin, the Okanogan basin, and the Yakima basin. Many small streams in eastern Washington have been fully appropriated for many years. Shortages of available ground water occur in many areas of eastern Washington. Aquifers are being depleted in some areas where withdrawals exceed recharge rates. In western Washington, availability is most critical in the San Juan Islands, Whidbey Island, eastern Jefferson County, southwestern Pacific County and parts of the Kitsap Peninsula due to poor surface and/or ground water availability or quality. In the rapidly growing central Puget Sound metropolitan region, surface water sources are abundant, but instream uses are also highly valued. New dams and diversions conflict with growing recreational and fish and wildlife demands. Some existing ground water supplies have been threatened by toxic pollutants, and seawater intrusion has become a problem in some aquifers. (Ecology 1987a)

II. B. 4. Federal and Indian Reserved Water Rights

The issue of federal and Indian reserved water rights is complicated and contentious, and adds yet another dimension to the complexities of the overall water availability question in Washington. The instream resources report provides the following background on the issue:

Federal and Indian reserved rights are derived from the federal reserved rights doctrine as formulated by a historical sequence of court interpretations of treaties between tribes and the United States. The federal reserved rights doctrine holds that when the federal government reserves land for federal purposes, by implication a reservation of then unappropriated water is also made to accomplish the principal purposes of the reservation. The priority date of a reserved right is the date on which the reservation was created. This applies to Indian reservations and national parks and forests, for example. Reserved rights are not invalidated through non-use. Unexercised reserved rights may become exercised at any time.

In Washington state, most federal lands other than Indian reservations are generally in upper basin areas where water availability and unquantified claims do not presently raise much concern. However, because tribal reservations are not limited to mountainous uplands and contain approximately 2,500,000 acres in this state, unquantified Indian reserved rights are of great concern to holders of appropriative water rights.

For Indian nations, primary purposes of the reservation requiring water for fulfillment may include domestic, agricultural and industrial purposes and fisheries propagation. Methods of calculating amounts of water necessary to meet the purposes of Indian reservations have varied. Whatever the method, it is apparent that many tribes may have unquantified and thus far unexercised reserved water rights, with priority dates dating back to creation of the reservation (the 1850's for most reservations in Washington). The right of tribes to water for instream uses on the reservation is also being established by courts. In Colville Confederated Tribes v. Walton, the 9th circuit court recognized the existence of a treaty right to instream flows to support a fishery and maintain spawning grounds.

In addition to reserved water rights, treaties and subsequent court decisions support many Indian Tribes' rights to take fish in usual and accustomed areas. These fishing rights are distinct from land reservation-related rights. In U.S. v. Washington, Phase II, the tribes have argued that the right to take fish implies the right to have fish and their habitat protected. The tribes view the taking of fish as a property right; property rights imply such means as necessary to protect the exercise of the right. The tribes' view is that instream flows to preserve fisheries are among their reserved rights. The first decision regarding the protection of habitat said that an implied legal right to protection of fisheries habitat existed, that the state has a duty to refrain from degrading habitat to an extent that would deprive tribes of their moderate living needs, and further, that the state could not subordinate the fishing right to any other objectives or purposes it preferred. (Ecology 1987a)

The validity and extent of the environmental protection right remains unresolved, and the courts have not mandated the state to protect fisheries habitat. But, as the instream resources report states, "...if the environmental right is eventually defined and the rights are treated as reserved rights to instream flows with treaty priority dates, existing (water) rights could be subordinated to instream fisheries needs." The report describes the implications for the state's water appropriation program as follows:

The implications for the instream planning process derive from two concerns: that quantification of the reservation-related irrigation rights could preempt state-issued water rights for out-of-stream use or instream flows, and that the tribes' reserved fishing rights could require that high instream flows be protected against future and existing water rights to afford optimal habitat protection. Based on the extent of existing appropriation, it appears that resolution of these issues could have a significant impact on the state's water appropriation program. (Ecology 1987a)

II. C. WATER QUALITY

Section 305(b) of the federal Clean Water Act (CWA) requires states to report on a biennial basis on the quality of their waters. Ecology's 1988 Statewide Water Quality Assessment is the most recent 305(b) report for Washington, and it includes, "...the assessment of CWA goal attainment, designated use support, causes and sources of impaired water quality, impairment by toxic pollutants, and other determinations for 374 surface waterbodies within the state." (Ecology 1988) The report offers this overview of the scope of the assessments:

...Individual assessments have been prepared for 52 estuaries (2,114 square miles or 71.8 percent of the state total), 4 coastal segments (163 shoreline miles or 100 percent of the state total), 49 lakes (156,518 surface acres or 25.5 percent of the state total), and 269 river and stream segments (4,621 miles or 11.4 percent of the state total)....Ground water contamination has been assessed for 23 of the 39 counties in the state. (Ecology 1988)

The surface water assessments rely on a computerized information management system developed by the Environmental Protection Agency (EPA), and referred to as the Section 305(b) Waterbody System (WBS). The ground water assessments were based on a less comprehensive data base "...designed for compilation of summary information on the types, causes, and sources of water quality impairment for various ground water areas." (Ecology 1988)

II. C. 1. Ground Water Quality

An examination of the regulatory history in the area of water pollution reveals an early pattern of emphasis on point source control and on the protection of surface waters. In recent years the regulatory scope has expanded to include more attention to nonpoint sources and to the protection of ground water resources. At present, however, one consequence of this historical emphasis is that the data base on ground water is relatively less comprehensive than the data base on surface water. The 305(b) report, for example, does not specify the number or size of the ground water sources assessed, nor does it provide a full ground water inventory comparable to its surface water data. The 305(b) ground water assessment covers 23 of the 39 counties in the state, but the data sources cannot provide comprehensive information on the magnitude or the specific areas of ground water quality problems.

In consideration of the ground water data deficiencies, the 305(b) report notes that, "Ecology is currently developing a computerized data management system for assessing ground water quality conditions and setting ground water program priorities. The data base will include summary information from hazardous waste site reports, past monitoring studies, regional office files, etc." (Ecology 1988)

Compounding the problems associated with the limitations of the ground water data is the urgency of prevention of ground water contamination. One Ecology ground water study reports that, "Ground water contamination is exceedingly difficult to clean up," (Ecology 1987b); and another notes that, "Contaminant identification and cleanup is often difficult and prohibitively expensive, and can require years to complete," (King County/Ecology). By the nature of its confinement, ground water does not share surface water's ability to cleanse itself through dilution and evaporation. Rather, ground water contamination tends to form plumes that move slowly and, for the most part, unpredictably throughout an aquifer. The joint King County and Ecology study, Ground Water Resource Protection, offers the following brief description:

Plumes of contaminated ground water have been traced from a few feet to several miles from the pollution source. The shape and size of a plume depends on a number of factors including the geologic framework, ground water flow patterns, the type and concentration of contaminants, and the rate of contaminant leaching.

The mobility of ground water contaminants in a plume is determined by a number of factors including the physical and chemical characteristics of the aquifer, the velocity of the ground water, and the solubility of the contaminant. Some compounds such as nitrates are extremely soluble and, depending on aquifer conditions and ground water movement, can be very mobile. Others, such as PCB's, are very insoluble and not very mobile. (King County/Ecology)

The related problem of ground water depletion--when withdrawals and discharge exceed recharge--can exacerbate, and even cause, ground water contamination. The concentration of contaminants is higher when the volume of water is lower. And when water levels fall low enough, aquifers can experience unusual inflows from surface waters, which, if contaminated, can contaminate the ground water. In coastal areas when ground water levels drop too far, seawater can flow into a freshwater aquifers. This saltwater intrusion can render the ground water source useless for many human purposes. According to the ground water protection report, "Seawater intrusion is a potential problem in all coastal areas of the state. It is already a particularly serious problem in Island and San Juan counties, where residents depend almost entirely on ground water for public water supplies," (King County/Ecology).

The 305(b) report, basing its findings on incomplete data for 23 counties, lists the following 10 concerns, explicitly not in priority order:

Increasing incidence of nitrates in ground water, especially in the irrigated regions of the Columbia Basin and in areas with high densities of on-site wastewater systems.

Potential leaching of pesticides into ground water, particularly in areas with irrigated agriculture.

Possibility of transport of radioactivity from materials stored at Hanford Nuclear Reservation into ground water within and outside the reservation.

Leachate from municipal landfills and hazardous waste sites.

Leaks from industrial and domestic underground storage tanks.

Chemical spill contamination.

Contamination by industrial waste through land disposal or discharge to ground water.

Saltwater intrusion.

Arsenic contamination from apparently natural sources along the western foothills of the Cascade Mountains.

Transport of pollutants by stormwater discharges to ground water via dry wells and other recharge devices. (Ecology 1988)

The 305(b) report also includes a county-by-county table of ground water contamination in the state. The table lists known contaminants for 28 of the 39 counties.

The King County/Ecology study reports that, "Ground water quality in Washington is still very good," and the Ecology water quality study, You Drink What You Pour Out, adds that, "The quality of the state's ground water appears--in general--to be good..." But both reports warn that human activities are causing problems, and the findings of the 305(b) report are consistent with those warnings.

II. C. 2. Surface Water Quality

The 305(b) report provides a much more comprehensive assessment of surface water than of ground water. Table 1 summarizes the surface water assessments. The waterbodies are categorized by the degree to which their level of water quality supports their designated uses. The 305(b) report uses the following categories: 1) fully supported--all designated uses are supported; 2) fully supported but threatened --ambient pollutant levels are approaching the applicable criteria, and sources that could further degrade water quality are present; 3) partially supported--water quality levels fully support all designated uses but one; and 4) not supported--water quality levels do not support two or more designated uses. In addition to the designated use support assessment, Table 1 shows how the state's surface waters meet the Clean Water Act (CWA) "fishable" and "swimmable" goals.

Table 1: Summary of Surface Water Assessments
(in percentage of waterbodies assessed)

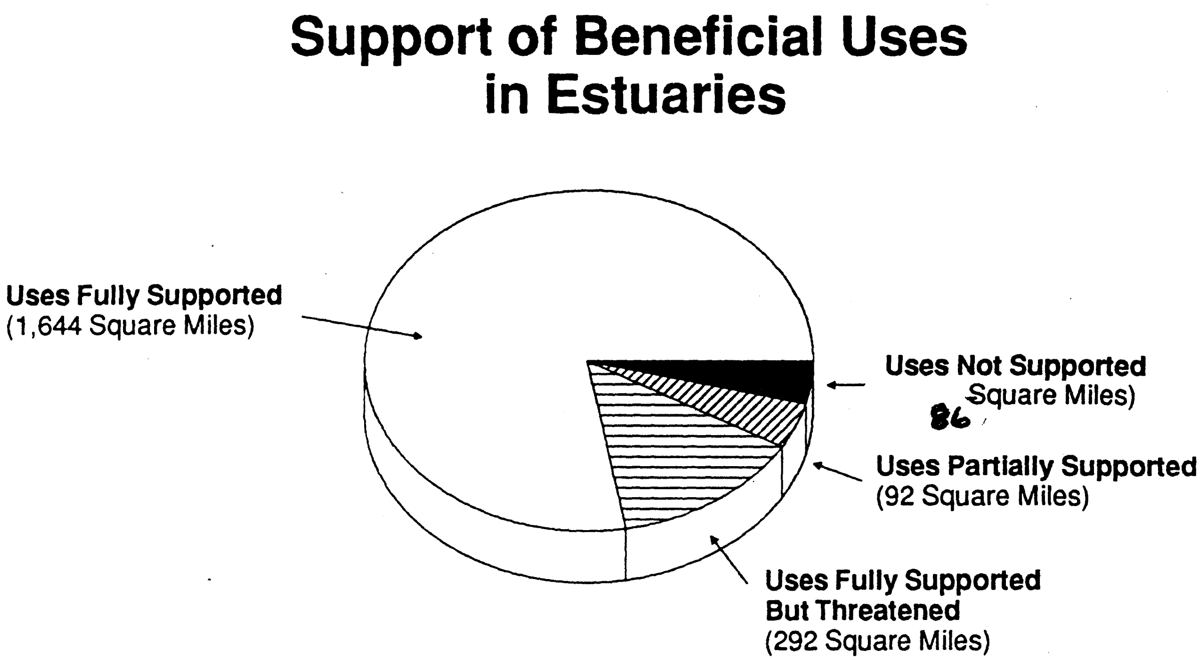
DESIGNATED USE SUPPORT STATUS	COASTAL WATERS	ESTUARY WATERS	RIVER WATERS	LAKE WATERS
Fully Supported	100%	78%	22%	4%
Fully Supported but Threatened	0%	14%	28%	74%
Partially Supported	0%	4%	35%	21%
Not Supported	0%	4%	15%	1%
CWA GOAL ATTAINMENT				
Meets Swimmable Goal	100%	93%	63%	99%
Meets Fishable Goal	100%	95%	69%	79%

Source: Department of Ecology

The 305(b) report has the inherent bias that most of the water bodies assessed for the report are in developed areas--either urban or agricultural. The water quality monitoring efforts tend to focus on these areas because they are more likely to have problems. The proportion of waters supporting their beneficial uses, as identified in the 305(b) report, may not be representative of all waters in the state. Remote stretches of streams, for example, are not included in the assessments, and are likely to be fully supporting their beneficial uses.

Of Washington's marine waters, the 305(b) report assessed all 163 shoreline miles in the state. As Table 1 shows, all of these coastal waters--which include the Pacific Ocean and the Strait of Juan de Fuca--are fully supporting their beneficial uses. The state has 2,943 square miles of estuaries; the 305(b) report assessed 2,100 square miles. Of these estuaries, 78 percent are fully supporting their beneficial uses. The Figure 12 pie chart provides the details.

Figure 12: Support of Beneficial Uses in Estuaries



Source: Department of Ecology

The 305(b) report states that, "The primary causes of water quality impairment in the state's estuaries are bacteria, primarily from agricultural runoff, on-site waste water disposal, and municipal wastewater treatment plants, and organic enrichment/dissolved oxygen problems due to natural causes. Metals and priority organics from urban and industrial sources are a serious, although far less extensive, problem in certain embayments." Table 2 lists the water quality problems affecting estuaries, shows the size of the waterbodies not fully supporting their beneficial uses affected by those problems, and assesses whether the effects from the problems are major or moderate/minor.

Table 2: Summary of Problems Affecting Estuaries

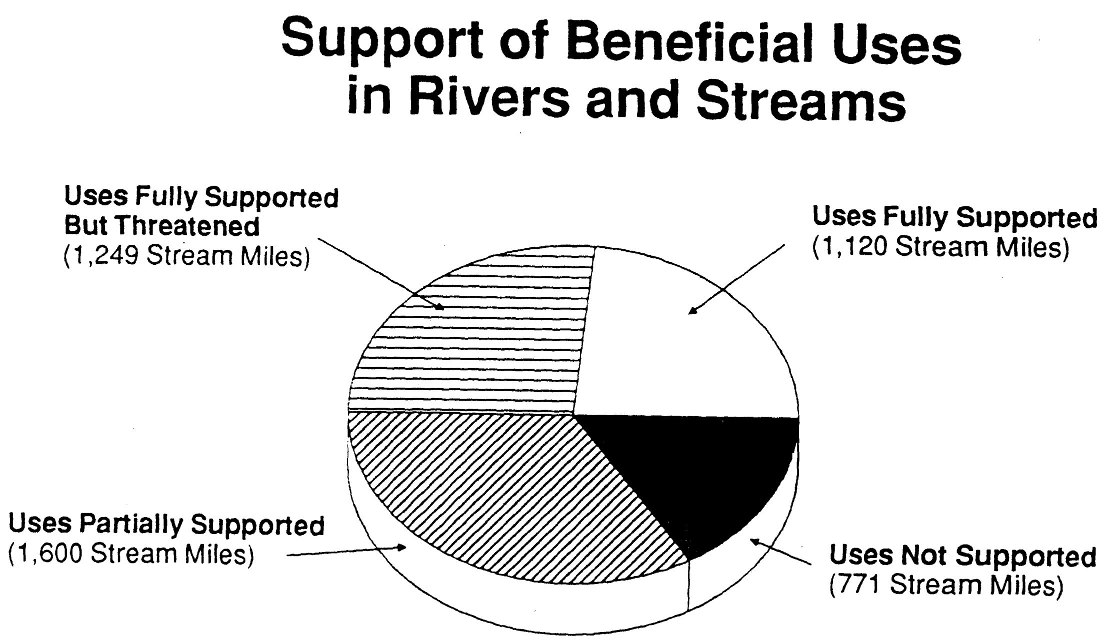
TOTAL SIZE (IN SQUARE MILES) OF WATERBODIES NOT FULLY SUPPORTING USES AFFECTED BY VARIOUS CAUSE CATEGORIES

Cause Categories	Major Impact	Moderate/Minor Impact
Pesticides	0.0	2.0
Priority Organics	21.4	13.8
Non-Priority Organics	3.7	1.1
Metals	40.2	14.6
Ammonia	0.0	5.1
Chlorine	0.0	0.5
Siltation	0.8	6.9
Organic Enrichment/DO	0.0	25.1
Thermal Modification	0.0	5.6
Other Habitat Alterations	1.4	0.0
Bacteria	66.9	93.4
Oil and Grease	0.8	5.1
Taste and Odor	0.0	6.0
Suspended Solids	0.0	4.2
Cause Unknown	20.6	0.0

Source: Department of Ecology

There are more than 40,000 miles of rivers and streams in the state, plus 346 miles of border rivers (the Snake and the Columbia). The 305(b) report assessed 4,621 of these stream miles. The pie chart in Figure 13 shows the extent to which these rivers and streams are supporting their beneficial uses. Fully half of the stream miles assessed are not supporting, or only partially supporting, their beneficial uses.

Figure 13: Support of Beneficial Uses in Rivers and Streams



Source: Department of Ecology

Table 3 shows the wide range of problems affecting water quality in Washington's rivers and streams. The table follows the same format as Table 2. Bacteria, thermal modification, siltation, metals, and suspended solids lead the long list of river and stream water quality problems.

Table 3: Summary of Problems Affecting Rivers and Streams

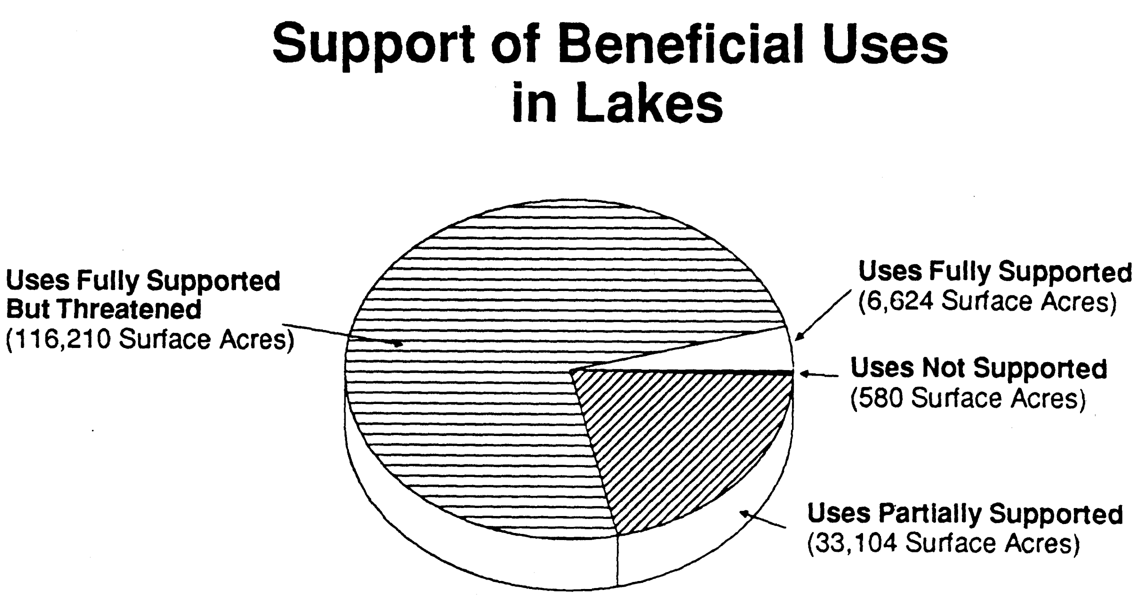
TOTAL SIZE (IN STREAM MILES) OF WATERBODIES
NOT FULLY SUPPORTING USES AFFECTED BY
VARIOUS CAUSE CATEGORIES

Cause Categories	Major Impact	Moderate/Minor Impact
Unknown Toxicity	9.4	0.0
Pesticides	120.0	43.2
Priority Organics	112.9	164.7
Non-Priority Organics	65.0	30.6
Metals	186.8	631.6
Ammonia	57.8	68.2
Chlorine	0.0	33.1
Nutrients	237.9	251.3
pH	135.3	136.2
Siltation	425.4	376.7
Organic Enrichment/DO	184.0	363.5
Salinity/TDS/Chloride	0.0	58.3
Thermal Modification	248.1	874.2
Flow Alteration	192.7	65.2
Other Habitat Alterations	288.6	25.8
Bacteria	804.6	864.7
Oil and Grease	90.3	7.0
Taste & Odor	1.5	17.8
Suspended Solids	224.4	469.3
Noxious Aquatic Plants	20.3	0.0
Filling and Draining	8.4	0.0

Source: Department of Ecology

Washington has over 8,000 lakes, ponds, and reservoirs for a total surface area of 613,582 acres. The 305(b) report assessed 157,000 of those surface acres; Figure 14 displays the findings.

Figure 14: Support of Beneficial Uses in Lakes



Source: Department of Ecology

A large proportion (74% or 116,210 surface acres) of the surface acres of lakes assessed for the 305(b) report fall into the "fully supported but threatened" category. These are waters that are currently fully supporting their beneficial uses, but where ambient pollution levels are approaching levels that would exceed the criteria for supporting beneficial uses, and where sources that can further degrade water quality are present. This finding is somewhat misleading, however, because it obscures the effect of one very large lake: Lake FDR (79,000 surface acres) accounts for 68 percent of the surface area of lakes in the threatened category. (See Appendix A for further details.) Table 4 lists the water quality problems for lakes. It follows the same format as Table 2 and 3, but adds a list of problem categories affecting lakes in the fully supported but threatened group.

Table 4: Summary of Causes Affecting Lakes

TOTAL SIZE (IN ACRES) OF WATERBODIES AFFECTED BY
VARIOUS CAUSE CATEGORIES

USES FULLY SUPPORTED BUT THREATENED:

Cause Categories	Size Affected
Priority Organics	22,138.0
Non-Priority Organics	22,138.0
Metals	101,138.0
Nutrients	28,189.0
Siltation	25,285.0
Organic Enrichment/DO	30.0
Thermal Modifications	22,138.0
Flow Alteration	2,919.0
Other Habitat Alterations	88.0
Bacteria	23,121.0
Suspended Solids	62.0
Noxious Aquatic Plants	558.0

USES IMPAIRED

Cause Categories	Major Impact	Moderate/Minor Impact
Pesticides	0.0	33104.0
Priority Organics	580.0	0.0
Non-priority Organics	0.0	580.0
Metals	580.0	33104.0
Ammonia	0.0	33104.0
Nutrients	0.0	33104.0
Organic Enrichment/DO	0.0	580.0
Salinity/TDS/Chloride	0.0	580.0
Thermal Modification	0.0	580.0
Flow Alteration	580.0	0.0
Bacteria	580.0	33104.0

Source: Department of Ecology

The 305(b) report summarizes the information on lakes as follows: In general, lakes in Washington have water quality which supports CWA goals. Several lakes in urban areas are considered threatened and/or water quality limited due to nonpoint sources associated with urbanization. For most of these lakes the primary threat is from excessive nutrient loading. Franklin D. Roosevelt Lake (79,000 acres) is impacted by metals primarily from mineral extraction and processing sources in Canada. Lake Union (580 acres) is impaired due to fecal coliform and toxics contamination from urban runoff and industrial discharges. Chelan Lake (33,104 acres) is impacted by historic pesticide usage within its drainage basin, as well as nutrients and bacteria from various local sources.

II. D. SUMMARY OF RISKS TO THE WATER RESOURCE

Several of the Environment 2010 risk assessments identify risks to the waters of the state. This section summarizes those findings that relate specifically to the water resource. The section is organized by risks to surface water and to ground water, and within those categories follows the Environment 2010 risk reports. Each relevant risk report is identified and its findings with respect to water are summarized.

II. D. 1. Summary of Risks to Surface Water

Nonpoint discharges, defined as those discharges not from a single source such as a pipe or specific outlet, are the most widespread sources of discharge pollution. The constituents of pollution carried by nonpoint discharge vary by source. The sources considered here include agricultural practices, silvicultural practices, dredging, septic systems, mining, and urban runoff.

Agricultural practices can have a significant adverse effect on surface water. According to the nonpoint pollution risk assessment, "Crop production (irrigated, non-irrigated, and specialty crops) introduces pollutants by disturbing the soil and increasing runoff, removing vegetative cover, and increasing nutrients and other chemicals through the application of fertilizers, pesticides, and herbicides. Major water quality concerns related to crop production are pesticides/herbicides, sedimentation and turbidity, and increased nutrients."

Manure management practices can introduce bacteria to waterbodies, contaminating drinking water supplies. Nutrients (nitrogen and phosphorus) can cause algal blooms, promote unwanted aquatic plant growth, and produce lower dissolved oxygen levels.

Sedimentation causes siltation of waterbodies, decreasing light penetration which decreases primary productivity. Sedimentation destroys aquatic habitat, including feeding grounds, and spawning grounds. Sediments also carry chemicals to waterbodies. These chemicals hinder aquatic plant photosynthesis and lower the resistance of aquatic organisms to other environmental stresses, among other effects.

Another source of nonpoint water pollution from agricultural practices is inorganic salts leached from soils. These enter surface waters usually via irrigation system return flows. Increased ionic strength may cause a species shift in the affected waterbody, and make the water itself undesirable for further use either for irrigation of drinking.

Silvicultural practices include such activities as road construction; maintenance and abandonment; site preparation; clear cut and partial cut practices; removal of streamside vegetation; herbicide application; and logging debris management. These activities can be major sources of nonpoint degradation of waterbodies. Effects include altered stream sedimentation rates and processes, mass wasting of slopes, alteration of fish spawning beds, and physical damage to fish. Additionally, perturbations associated with logging and slash burning increase nutrient release from watersheds, and may cause enrichment in sensitive waters. Removal of streamside vegetation causes water temperature increases. Runoff from roads and equipment used in road construction can contaminate waterbodies with metals, hydrocarbons, and other substances toxic in the aquatic environment. The use of pesticides in silviculture is associated with short-term toxicity in streams.

Dredging and channelization, including open water disposal of dredged material, can temporarily block sunlight, kill benthic organisms, and resuspend and spread contaminated sediments.

Runoff from septic tanks and drain fields can cause contamination with pathogenic organisms, nutrient enrichment, and organic enrichment, thus lowering dissolved oxygen concentrations. In addition, eutrophication can result from an influx of nitrogen and phosphorus.

Mining can cause sedimentation and, in limited instances, can contaminate surface waters with radionuclides, sulphur, and zinc.

Urban runoff from highways, parking lots, and other impervious surfaces can carry solids, metals, and organic compounds into surface waters.

Point source discharges are those discharges from a single source, usually a pipe. The ecological effects of point source discharges vary by type, and the following discussion is organized by type of discharge.

Pulp and paper: Pulp and paper manufacture results in the discharge of microbial pathogens, suspended solids, and nutrients. These cause sediment buildup, organic enrichment and anoxia, reductions in populations of benthic communities, and algal blooms. Pulp and paper manufacture also results in the release of toxic organics into the surface waters of the state. Principal toxics include dioxins, furans, and chlorination products. These accumulate in sediments and bioaccumulate in the flesh of fish and shellfish.

Primary metals production: The iron, steel, and casting industries discharge metals, cyanide, and priority organics (primarily polyaromatic hydrocarbons--PAHs). These cause sediment contamination, benthic community depression, and tissue bioaccumulations.

Aluminum production: Major pollutants resulting from aluminum production are toxic organics (primarily PAHs and PCBs), and toxic inorganics including metals and fluoride. These can cause bioaccumulation in tissue and contamination of benthic sediments.

Food processors: Food processors discharge suspended solids and nutrients that increase biochemical oxygen demand and cause a decrease in dissolved oxygen, sediment buildup, nutrient enrichment, and siltation.

Oil refineries: Major pollutants from oil refineries are ammonia, oil and grease PAHs, phenols, sulfide, and metals. These increase chemical oxygen demand in receiving waters. Pollutants from oil refineries cause contamination of water, sediments, and aquatic organisms.

Inorganic and organic chemical manufacture: Contaminants vary but generally cause changes in biochemical oxygen demand, chemical oxygen demand, and pH. Oil and grease, thermal pollution, and inorganic and organic chemical discharge are also associated with these point sources. Contaminants cause bioaccumulation of toxics and chronic toxicity in receiving waters.

Electric power plants: Cooling water discharges from electric power plants contain thermal pollution, oil and grease, and organics. These cause acute and chronic effects on receiving water biota and threaten aquatic life in localized areas.

Municipal wastewater treatment plants: Contaminants include microbial pathogens, metals, organics and nutrients, and chlorine. These cause organic enrichment, depressed dissolved oxygen content in waters, algal blooms, acute and chronic toxicity of benthic and aquatic organisms, and bioaccumulation of organics and metals.

Combined sewer overflows (CSOs): These sources discharge a mixture of stormwater and sanitary sewerage, particularly during major storms. CSO effluent contains metals, bacteria, organic compounds, sediment, oxygen demanding compounds, and debris.

Hydrologic modifications threaten surface waters in a variety of ways. Disruptions analyzed for Environment 2010 include dam construction and operation; surface water withdrawal; construction and flood control within streams, lakes, riparian areas, and flood-plains; forest practices; irrigation distribution works and on-farm practices; dryland agricultural practices; livestock grazing; urban development; and groundwater withdrawal. Only those threats not covered in the nonpoint section are included here.

Dam construction and operation: Dam construction and operation can severely damage aquatic and riparian ecosystems, and can alter stream bank erosion, sedimentation, and bed load transport characteristics. The creation of reservoirs reduces water velocity. Thermal and chemical stratification develops in reservoirs.

Surface water withdrawal: When diversions take a significant percentage of natural flows from streams, changes occur in the availability of dissolved oxygen and in biological oxygen demand. There are also alterations of water chemistry, and reductions in the ability of waterbodies to dilute permitted waste discharges.

Construction and flood control in streams, lakes, riparian areas, and flood plains: Some flood control measures eventually lead to worse flooding, decreased stream length and higher stream gradient, decreased pool to riffle ratio, and induced continuous bed load movement.

Urban development: Aquatic and riparian habitats are destroyed or degraded in urban settings. Sources of degradation include increased runoff from impervious surfaces causing increased flooding, decreased low flows, and transport of pollutants to waterbodies. Typical pollutants include sediment, fertilizer, salts, and oil. Even large streams may disappear forever into tunnels or concrete channels in urban areas.

Global warming, ozone depletion, and the consequential rise in sea level pose a complex interactive set of problems for the environment of Washington. Global warming, due in large part to the effect of greenhouse gases on the atmosphere, is a matter of some dispute in the scientific community. The position of the Washington Environment 2010 Technical Advisory Committee is as follows.

We know that the chemistry of the atmosphere is changing rapidly. Scientific theory predicts that these changes will result in global warming due to the greenhouse effect of certain gases, particularly carbon dioxide, methane, nitrous oxide, and chloroflourocarbons, among others. This warming will include other climatic changes that are expected to have profound effects on sea level and water resources, as well as a host of other natural and man-made systems.

The implications of ozone depletion are less well researched than those of climate change. It is known that the effects will be related mostly to human health.

While the committee recognized that there is some credible scientific dispute regarding the state of global warming, they believe that the phenomenon is certain to occur. Additionally, the committee believes that the consequences of ignoring the phenomenon and being wrong are too serious to risk.

Ecological effects on the water resource from global warming, ozone depletion, and sea level rise have been characterized as uncertain due to the paucity of current data and the lack of geographic precision in current forecasting methods.

Precipitation patterns in the Pacific Northwest are projected to change as a result of the anticipated 3-5 degree Celsius increase in temperature. Different models predict precipitation increases of between 1.7 percent and 29 percent.

While there has been no analysis of seasonal variation, it is generally agreed that more precipitation will fall as rain than does now. This will reduce the winter snow pack. Peak streamflows would occur earlier in the season, possibly shifting from a spring snow-melt runoff peak to a winter precipitation runoff peak.

Sea level rise by the year 2100 is predicted to reach 1.8-11.3 feet. The rise will occur as a result of expansion of the oceans due to warming of ocean water, as well as melting snow and ice. Land subsidence in the Puget Sound region will aggravate sea level rise; uplift along the ocean coast will moderate sea level rise.

Coastal flooding, inundation of estuaries, and saltwater intrusion in coastal aquifers are anticipated as a result of sea level rise. Inundation of estuaries will alter salinity and cause changes in the number and diversity of species supported in these sensitive aquatic ecosystems.

Global warming is anticipated to alter the need for and the amount of water available for agricultural irrigation. Irrigated acreage may increase or decrease by about six percent, and total agricultural acreage is expected to increase 8-13 percent. This shift raises the question of water availability during the growing season since the winter snow pack is expected to decline. Additionally, competition for instream and out-of-stream uses will intensify as summer low flows become even lower.

Similarly, the winter snow pack has been the traditional primary source of water for approximately 60 percent of the state's hydropower generation. With increased average temperatures and reduced snowfall, large water volumes could be available only during short winter periods, forcing hydropower operators to serve winter demand and fill reservoirs at the same time.

Air pollution threatens water because air provides a pathway through which contaminants are transported to water. Airborne heavy metals are deposited in waterbodies, and once there, they sink to the bottom and contaminate the benthos--the plant and animal life at the bottom of a sea, lake, or river.

In addition, there is a potential for an indirect effect from air pollution. Ozone may cause damage to some of the most sensitive tree species in a forest. As the damage progresses, the mix of species shifts to domination by more ozone-tolerant species. This shift in turn alters the hydrology of drainage basins and degrades water quality in those affected basins.

Radioactive releases, as defined for the purposes of Environment 2010, are largely a controlled risk in the state. The single exception is radioactive releases from waste disposal practices at the Hanford Nuclear Reservation where liquid waste releases affect surface waters at low levels.

Accidental chemical releases, defined as the unintentional release of chemicals during transport, production, storage, and use, represent a risk to surface waters. Explosions, spills, and vehicular accidents are common sources. Chemicals of concern include pentachlorophenol, PCBs, ammonia, sodium hydroxide, and petroleum products.

The ecological effects of accidental releases occur primarily in surface waters. On average, one large scale spill will occur every 1-3 years in marine waters in Washington. Three to six releases with the potential for ecological damage occur every year. Fifteen to thirty releases with obvious significant environmental impacts occur per year, and about 750 smaller, one-time releases of petroleum products occur per year.

Acid deposition is the deposition of acid oxide air pollutants onto land and water. Washington's sensitive aquatic resources (alpine lakes, for example) have the potential, but have not yet been severely affected by acid deposition. Effects that have been noted, however, are seasonal variations in the pH and acid neutralizing capacity of the alpine lakes. These effects are associated with the release of acids during snowmelt. Additionally, changes in sulfate levels in the lakes have been linked to changes in emissions of sulphur dioxide in the Puget Sound lowlands. Research on these issues is incomplete, and these findings are tentative.

Litter degrades water quality, and is a particular concern in marine waters. Marine mammals and birds are strangled in six-pack rings after becoming entangled. Ingestion of plastic by marine birds and fish results in death by starvation or infection. Abandoned commercial fishing nets entangle marine mammals, birds, and fish. All die.

II. D. 2. Summary of Risks to Ground Water

Ground water is currently at risk from a number of sources. The relevant Environment 2010 risk reports include point source discharges; nonpoint discharges; active, inactive, and nonhazardous waste sites; materials storage; pesticides; radioactive releases; hydrologic disruptions; and accidental releases. The following discussion relies on the "Threats Related to Point and Nonpoint Source Discharges" report, as well as on the hydrologic disruptions report.

Nonpoint sources considered here include agricultural pesticides, agricultural nutrients, domestic septic systems, municipal sludge, saltwater intrusion, and underground injection wells.

Agricultural pesticides: Pesticide contamination of ground water can result from misuse, poor storage practices, improper mixing and container disposal, and even, in the case of certain chemicals, from proper application to field crops. The highest risks exist where there are unconfined aquifers, permeable soils, shallow water table, irrigation, or other factors that contribute to vulnerability. Any chemical pesticide can contaminate ground water if handled improperly. The chemicals of most concern under normal field application conditions are those with leacher characteristics. These chemicals or their metabolites tend not to bind readily to soil particles, tend to be soluble in water, and tend to be more or less stable in the soil, particularly below the root zone. The EPA has compiled a list of about 60 known or suspected leachers. This list includes chemicals that are known to leach and have been found in ground water, and those with similar characteristics.

A 1984 Department of Social and Health Services (DSHS) study found 13 wells in Skagit, Whatcom, and Thurston counties with levels of ethyl dibromide (EDB) above the health advisory. Ten of the wells were public water supplies serving a total of about 550 persons.

Ecology's 1988-89 Pesticide Pilot Study tested 81 wells in three agricultural counties. Twenty-three of the wells showed indications of at least one pesticide; seven detections were above recommended standards. A United States Geologic Survey (USGS) study in Benton and Franklin counties found five of 24 tested wells with traces of one or two pesticides.

Agricultural nutrients: There are two major sources of nitrates associated with agricultural nutrients--agricultural fertilizers and animal manures. The Pesticide Pilot Study found nitrates in 61 of 81 wells sampled. A current USGS ground water study in Franklin and Benton counties has taken a total of 700 samples from 420 wells. About 20 percent of the wells tested showed nitrate levels above the drinking water standard. In Franklin County, 32.5 percent of the wells tested showed nitrates above the standard. In Benton County, 10.1 percent of the wells exceeded the standard.

Domestic septic systems: Contaminants of concern from domestic (private and community) septic systems include nitrates, chlorides, phosphorus, pathogenic bacteria, organic compounds, metals, and solvents. Ground water contamination has been documented in 24 counties across the state for elevated nitrates, chlorides, and/or coliform bacteria.

Municipal sludge: Sludge is the solid material remaining after municipal wastewater treatment. It is usually disposed of through land application. Contaminants of concern include nitrates and chlorides. No data are available for ground water monitoring at sludge disposal sites.

Saltwater intrusion: In coastal areas of the state, the increased use of ground water has resulted in increased incidences of saltwater intrusion as evidenced by elevated chloride levels in well water. Contaminants of concern include chlorides and TDS.

Underground injection wells: Stormwater runoff from urban, industrial, and commercial areas is directed into stormwater collection systems and then delivered to dry wells from which it enters ground water. Contaminants of concern include heavy metals, volatile organic compounds, organic solvents, and petroleum products. Contamination has been documented in all 39 counties.

Point sources considered here include aluminum production, concentrated animal feeding operations, general industry, municipal waste water treatment facilities, oil refineries, pulp and paper processing, resource extraction, and mining.

Aluminum production: Aluminum production results in the discharge of cyanide, fluoride, PCBs, and PAHs. There are 16 aluminum plants in the state, all posing the risk of ground water contamination. The ecological risks of aluminum production are illustrated by the fact that cyanide levels of 100 ppb and fluoride contamination have been documented in the ground water. Ground water contamination at aluminum production facilities has been very extensive and is considered impossible to fully clean up.

Concentrated animal feeding operations: Concentrated animal feeding operations include dairies, feedlots, chicken farms, and other operations where large numbers of animals are kept in a restricted area. Contaminants posing a risk to ground water include nitrates, and coliform bacteria from manure handling practices.

Food processors: Washington has four major categories of food processors that discharge part of their processing waste stream into the ground. These are fruit; potato; other vegetables; and a collection of meat, fish and poultry processors. The waste material is discharged to land by spray application, or it is discharged into a waste lagoon. Ground water threats from food processors include nitrates, BOD, pH, all TDSs, sugar, diphenol amine, sulfates, cyanide, and chlorides.

The practice of land application is based on the premise that the agronomic rate of nutrient uptake will prevent contaminants from reaching ground water. Application rates, however, as the Eastern region discovered, frequently exceed uptake rates by as much as 10 times.

General industry: General industry activities include machine shops, electroplating, gas and oil users, painters, contractors, cleaners, print shops, agricultural waste disposal, fertilizer and pesticide applicators, auto wreckers, electrical utilities, gravel pits, landfills, and fish farms. Contaminants posing a risk to ground water include chrome and heavy metals, organic solvents, gasoline and oil, fertilizers, and pesticides. Additionally, general industry sometimes disposes of unwanted products or chemicals through drainfields and lagoons, or incurs spills and leaks in product or chemical handling. These additions expand the universe of potential contaminants in ground water.

Municipal wastewater treatment facilities: Treated effluent from eastern and central Washington municipal wastewater treatment facilities generally has access to ground water in one of three ways--land application and spray irrigation; bentonite lined lagoons for evaporation and anaerobic degradation of waste; and infiltration basins and drainfields. In western Washington, the majority of outfalls discharge to surface waters.

Ecological risk is posed by nutrients, pathogenic bacteria and viruses, high BOD, and an assortment of organic contaminants, petroleum products, and solvents. Ecology's Eastern Regional Office has documented several instances of ground water contamination associated with municipal wastewater treatment systems.

Oil refineries: There are three potential routes to ground water contamination from the state's six oil refineries--land treatment fields for waste, surge ponds for wastewater treatment, and accidental product spills. All refineries are now permitted under the Resource Conservation and Recovery Act (RCRA), and the major potential for contamination comes from spills.

Pulp and paper processing: Ground water is vulnerable to leaching from storage yards for logs and chips, wastewater treatment lagoons, and in-plant treatment processes. Contaminants posing a risk include priority organics, cyanide, copper, and zinc.

Resource extraction, exploration, and development: This threat to ground water includes surface and hard rock mining, sand and gravel pits, and coal mines. Ground water may be contaminated either by the mining itself or operating plant practices at mines.

Ecological damage may result from disturbance of the ore body if that disturbance results in contact between ore and ground water. Additionally, chemicals used in heap leaching as well as wastewater produced n ore processing may enter the ground water if not properly managed. Contaminants posing a risk to ground water include cyanide, sulfuric acid, mercury, and any mineral in the ore body itself.

Sand and gravel mining: The threat to ground water quality from sand and gravel extraction is limited. Ground water may be adversely affected when excavation pits expose the aquifer, when leaching through porous overburden occurs, or when allied industries near pits discharge waters.

Ecological damage to the ground water occurs when contaminants reach exposed ponds on extraction sites. Water quality issues include dust, turbidity, petroleum products, solvents, and other chemicals associated with related industry.

Hydrologic modifications affect ground water in many ways. Ground water quantity and quality are affected by urbanization. The creation of impervious surfaces deprives underlying aquifers of recharge. Additionally, urban storm water, when transmitted to the ground through injection wells, carries contaminants into the aquifer.

Irrigation creates artificial aquifer recharge in the more arid regions of the state. The most dramatic evidence of this can be found in the creation of wetlands.

Ground water withdrawal can become a threat to ground water quality when the rate of withdrawal from an aquifer exceeds the rate of recharge. This practice is known as ground water mining, and it creates the potential for saltwater intrusion and the unintended migration of contaminants.

II. E. CONCLUSIONS: AN ILLUSION OF ABUNDANCE

Surface water use exceeds ground water use in Washington by a significant amount. In 1985, surface waters accounted for 82 percent of all water use in the state (not including hydropower), while ground waters contributed the remaining 18 percent. Of all consumptive uses, regardless of source, irrigation dominates. In 1985, irrigation accounted for 76 percent of water use; industrial uses, 13 percent; and municipal uses, 11 percent. There is a regional pattern to this use. Each of three regions has a particular dominant use--municipal use in east Puget Sound, industrial use in southwestern Washington, and irrigation in the eastern part of the state.

Ground water use is increasing in the state, and nearly two-thirds of the state's population now rely on ground water for drinking water. And while the overall assessment of ground water quality is still good, concerns are growing about protecting the resource. There is ground water contamination in 28 counties, and the potential for more contamination from past practices--contaminants that are already in the soil and that may eventually leach to ground water. Less is known about ground water because the regulatory history has emphasized pollution controls affecting surface water.

Contamination is the most important issue concerning ground water. By its very nature, ground water is difficult or impossible to clean up after it is contaminated. This fact underscores the urgency of preventing contamination in the first place.

Surface water quality is measured against a waterbody's support of its designated beneficial uses. At present a large proportion of marine waters and lakes are supporting their beneficial uses, but half of the state's rivers and streams are not supporting, or only partially supporting, their beneficial uses.

Point and nonpoint source discharges, and the potential effects of global warming are posing the most serious threats to Washington's water resources. Both point and nonpoint sources are currently causing water quality problems throughout the state. Nonpoint sources may pose the greater threat because they are more difficult to regulate and control, and because there is a longer regulatory history with respect to point sources.

The resolution of Indian reserved water rights issues may have wide-ranging effects on state water policy. If full protection of fisheries habitat is required as a matter of first priority, then instream flow requirements may displace existing rights. Reservation-related irrigation rights could also preempt other state-issued rights. In any case, the state's water appropriation program will have to adjust and respond to whatever new conditions prevail.

The abundance of water in Washington State is at once reality and illusion. The reality is that Washington has 163 miles of coastal shoreline, over 2,900 square miles of estuaries, over 40,000 miles of rivers and streams, over 8,000 lakes (total surface area of over 613,000 acres), aquifers with a total storage of about 80 million acre-feet, annual ground water recharge of 7.5 million acre-feet, and annual runoff of 72 trillion gallons. If this sounds like a lot of water, it is.

The illusory aspect of this inventory, however, is that the water is not always available when and where it is needed. Low streamflows occur in both eastern and western Washington during mid to late summer and early fall. This corresponds to the period of highest water demand--for agricultural irrigation as well as for municipal uses. Instream uses, including habitat protection, compete with out-of-stream uses during this critical time. Conversely, high stream flows occur in winter and spring when demand is lower.

The location of the water is an equally important factor in its availability. The source must be reasonably proximate to the demand or it is for all practical purposes unavailable. Storage can solve the water availability problems associated with time, and transportation can solve the problems associated with place. But reservoirs and pipelines or other technological solutions may be infeasible because of high financial and environmental costs. In any case, the hydrology of the state sets the basic parameters of water availability.

III. POSITIVE ASPECTS OF THE WATER RESOURCE

Aside from sustaining life on the planet, water has other important positive aspects. Washington's waters support a particular way of life. The vast and varied surface waterbodies create a natural setting that helps define the character of the state. Residents and visitors alike benefit from the scenery and from the recreational and economic opportunities that the water resource provides.

A review of water uses in the state can serve as a guide to the positive aspects of the resource.

Irrigation: The single largest water use in the state, irrigation contributes significantly to Washington's agricultural production. There are over 1,600,000 acres of irrigated cropland in the state, an amount that represents over 20 percent of our total cropland. Most of this irrigated land is east of the Cascades and supports local farm economies. A detailed breakdown of production by irrigated and dryland cropland is not available, but some figures from Yakima County can demonstrate the importance of irrigated agriculture in the eastern part of the state. Of Yakima County's 417,000 acres of cropland, 360,100 acres are irrigated. Yakima County's net farm income ranks first among all counties in the state and represents over 18 percent of the state total. No other county matches this production, but many counties that rely on irrigation make substantial contributions to the state's total agricultural output, and perhaps more importantly, many of these counties rely on agriculture as the mainstay of their local economies. (Christensen, et. al.)

Municipal uses: Water supports the full range of domestic and commercial activities. Daily life in our households and businesses depends on a reliable supply of clean water. Likewise, domestic and municipal water availability is a prerequisite for growth and development.

Industrial uses: Water used in processing and cooling enables several important industries to operate in Washington. Pulp mills, semiconductor chip manufacturers, and food processors are among the industries that rely heavily on water. These industries and other water-dependent industrial users provide employment opportunities and contribute to the tax base.

Hydropower: Washington relies heavily on electric power produced by hydropower facilities, not only for households but also for industry and commerce. Inexpensive hydroelectric power has historically supported the state's economic development, and continues to provide a strong base for the state's economy. Of the total hydropower production in the state, industry uses about 39 percent; residences, 36 percent; commercial enterprises, 20 percent; and agriculture, about 5 percent.

Navigation: Several Washington rivers support commercial navigation, and several estuaries are used for port facilities.

Recreation/Aesthetics: The value of the water resource's aesthetic contribution to life in Washington is difficult to quantify but easy to recognize. Water is an essential element of the state's natural beauty, a complement to our mountains, deserts, and islands.

On a more practical basis, residents and visitors enjoy the wide array of recreational opportunities created by our diverse water resources. These recreation outlets in turn contribute substantially to the state's economy. Tourism as well as small commercial and industrial enterprises associated with recreation provide employment and, in some communities, establish the base of the local economy.

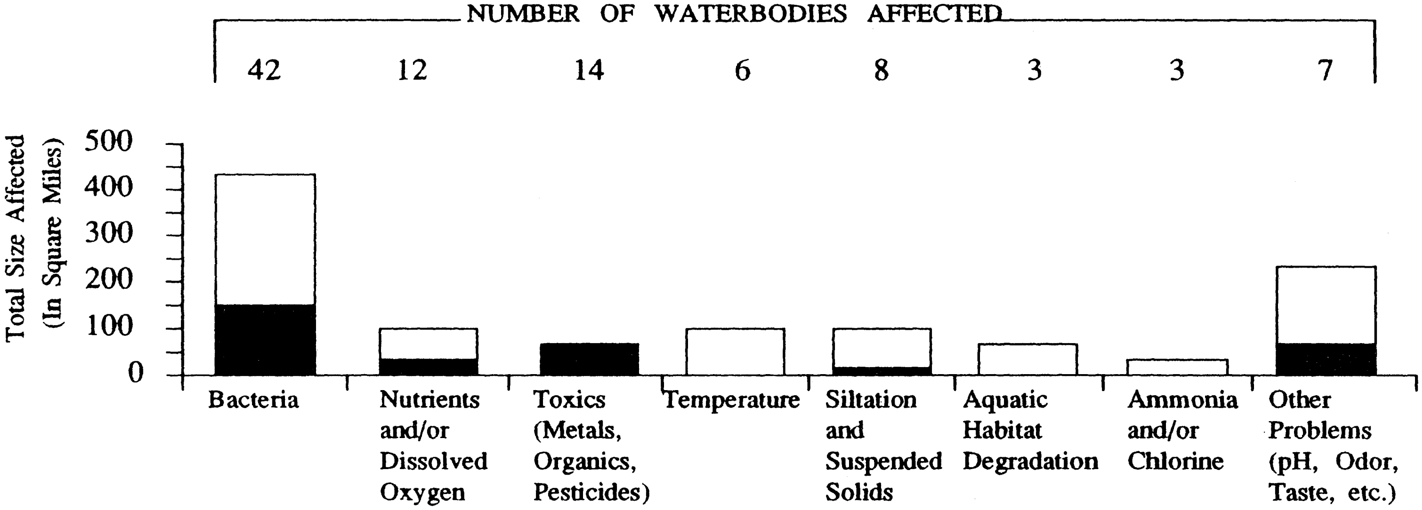
Support of fisheries and other wildlife habitat: Among the many positive aspects of the water resource are those that are strictly ecological. Water's support of fisheries and other wildlife habitat falls into this category. Washington's diverse waters create varied habitats that support a wide range of wildlife. This diversity has its own intrinsic value, and it also supports a variety of human uses. Commercial and sport fishing are multi-million dollar industries in the state. Other human benefits include the opportunities for bird watching, hunting, and related outdoor activities.

APPENDIX A

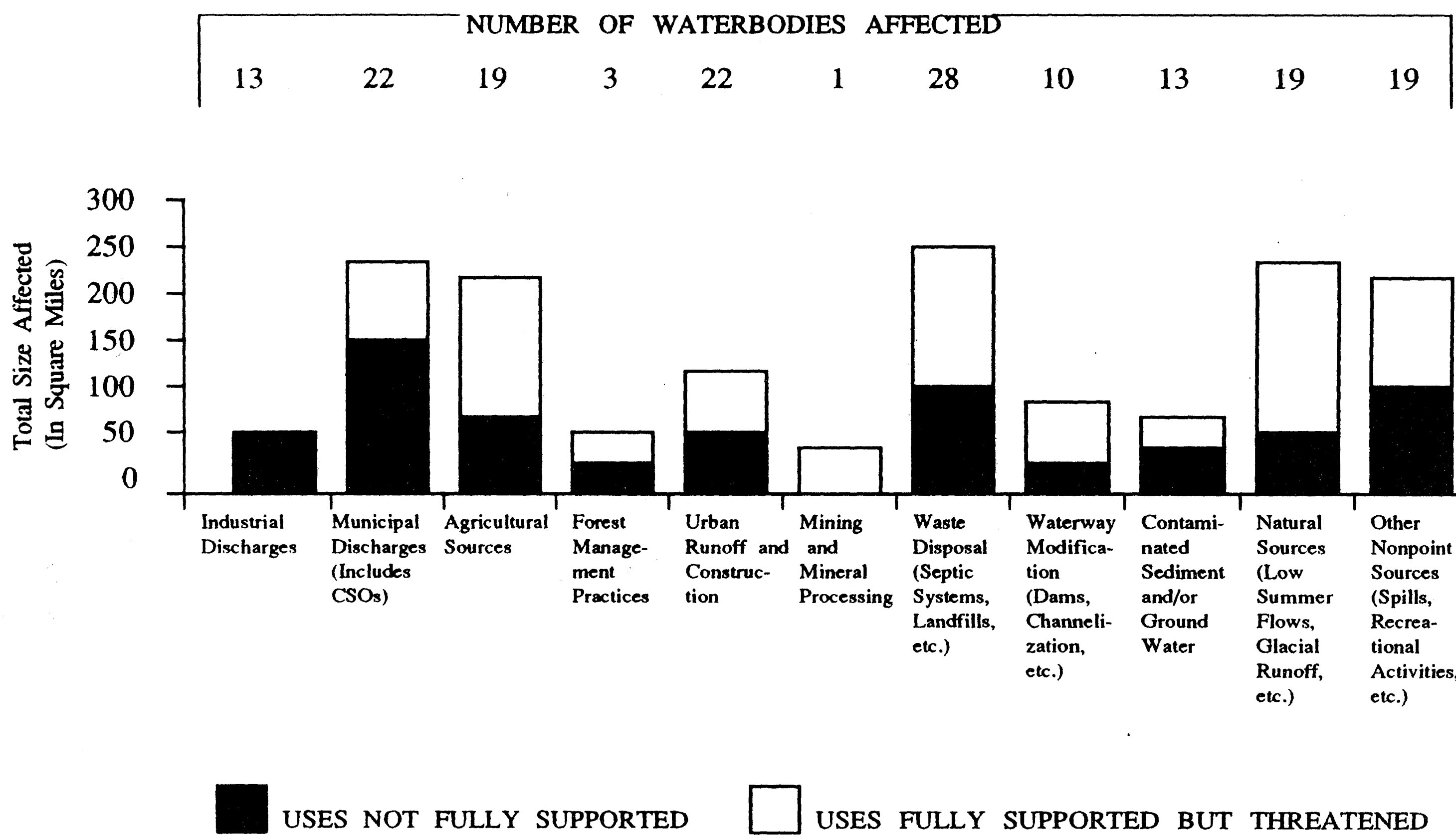
SUMMARY GRAPHS OF WATER QUALITY PROBLEMS

BY TYPE OF WATER BODY

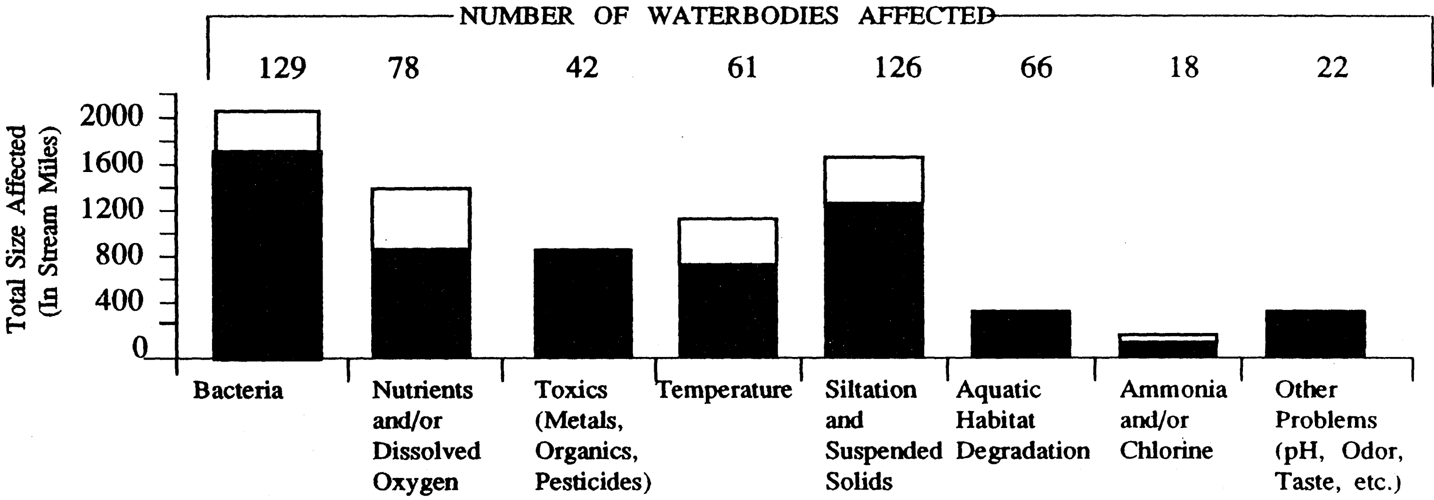
WATER QUALITY PROBLEMS AFFECTING ESTUARIES



SOURCES OF PROBLEMS AFFECTING ESTUARIES



WATER QUALITY PROBLEMS AFFECTING RIVERS AND STREAMS



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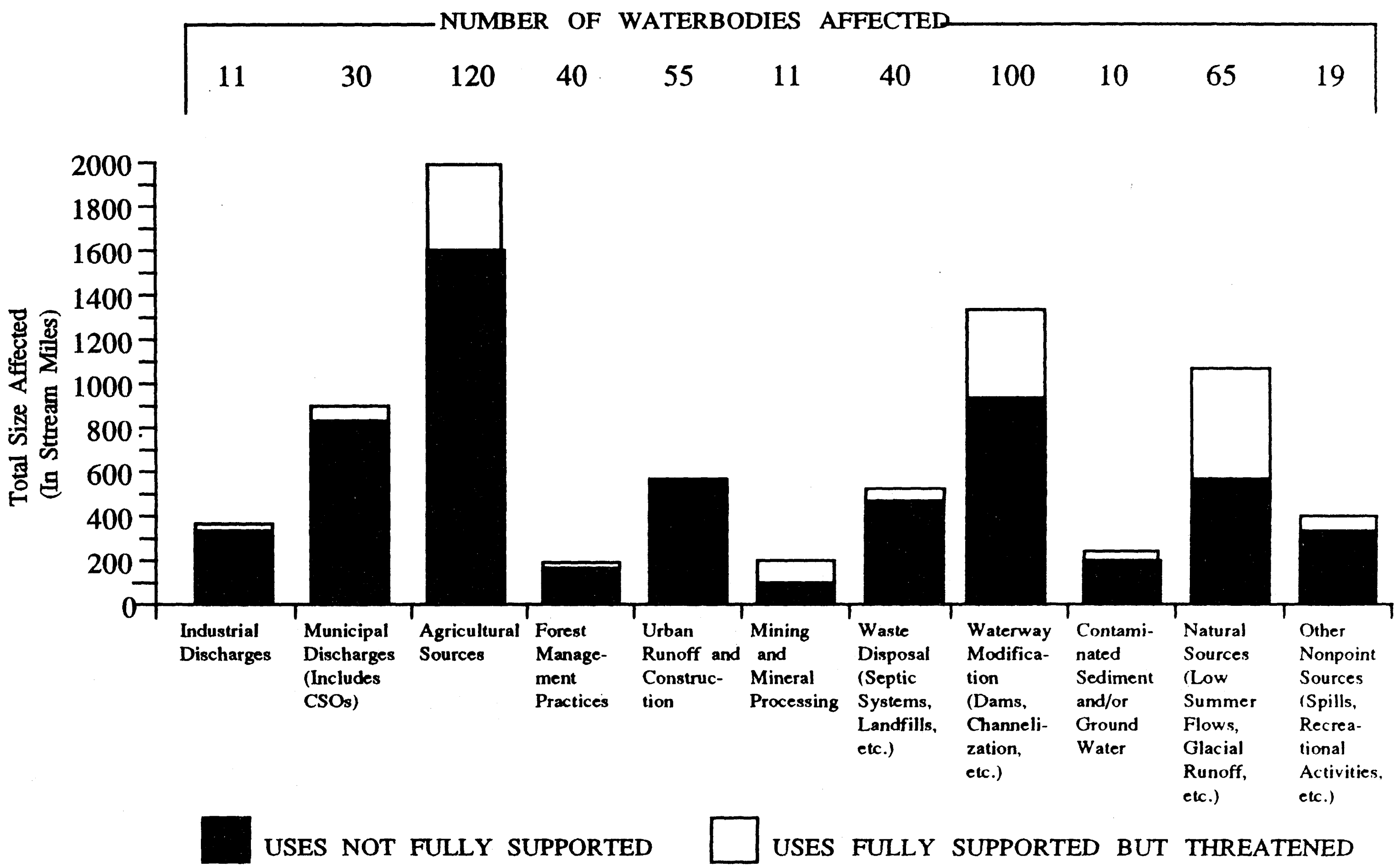
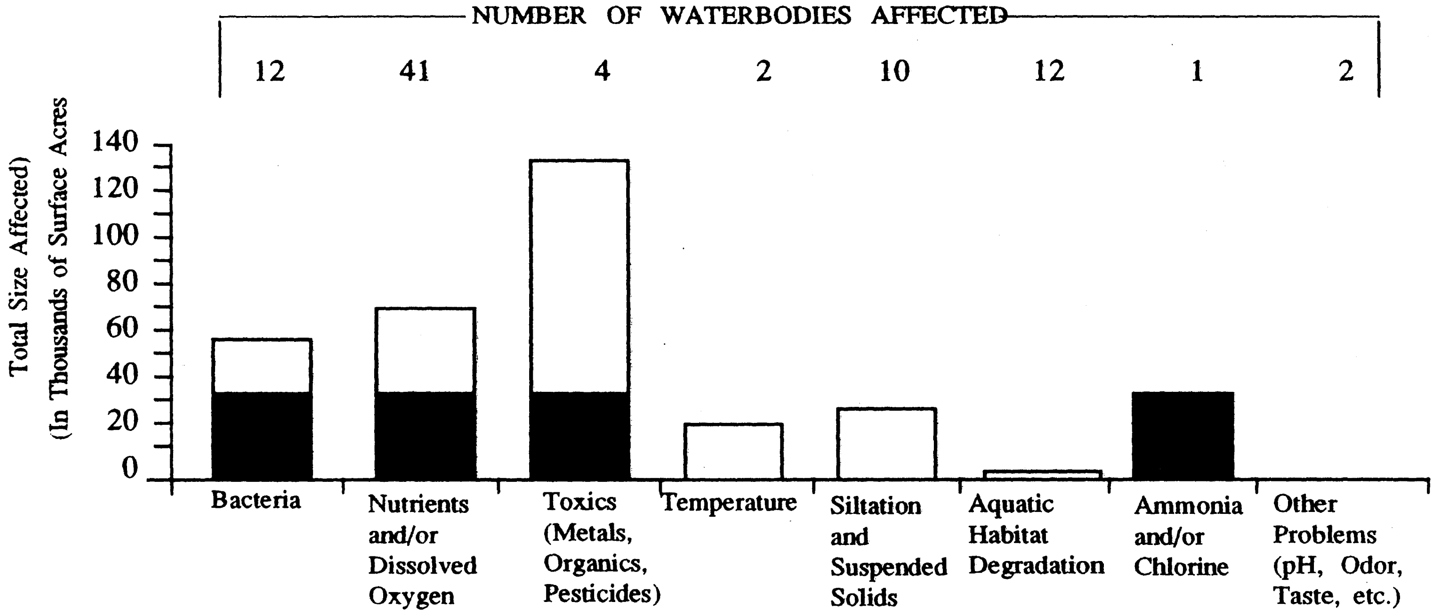
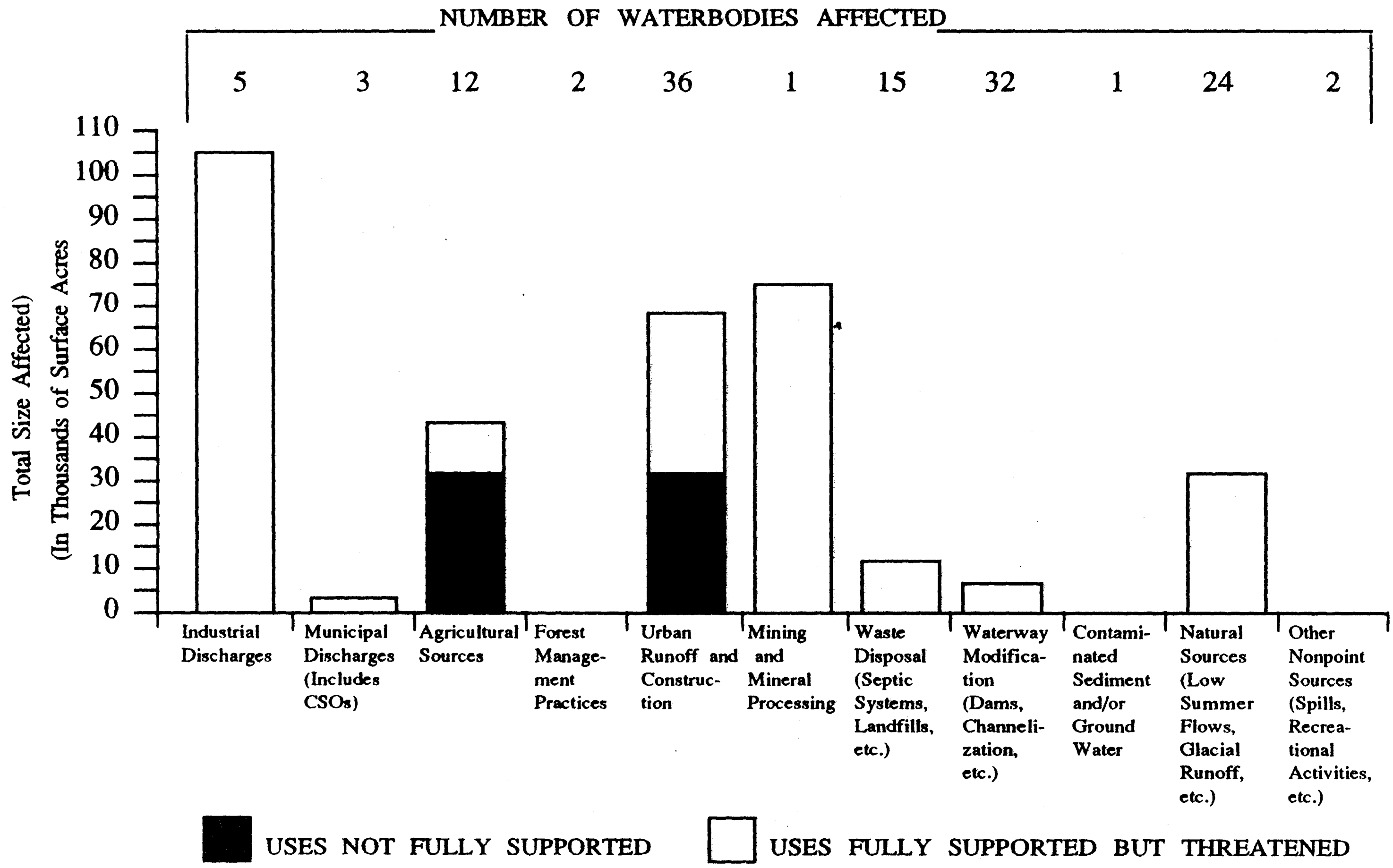


WATER QUALITY PROBLEMS AFFECTING LAKES



SOURCES OF PROBLEMS AFFECTING LAKES



THE STATE OF THE ENVIRONMENT REPORT

VOLUME II
Part 3

Land Resource Characterization Report

ENVIRONMENT 2010

State of Washington
October, 1989

Washington Environment 2010
State of the Environment Report
Volume II/Part 3

Land Resource Characterization Report

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INTRODUCTION TO LAND RESOURCE CHARACTERIZATIONS

Environment 2010 breaks the Washington state land resource into five separate categories--agricultural, forest, range, recreation, and urban lands. These categories provide a fairly comprehensive basis for an assessment of the land resource, but they are by no means mutually exclusive nor are they all-inclusive. Recreation land, for example, overlaps with some urban land as well as some forest land. Lands that fall outside these five basic categories include some that fall outside these five basic categories include some roads and highways, and some federal Defense and Energy Departments land. Each report identifies the land it considers; this section provides an overview of the entire land resource.

Land ownership is useful way of examining the state's land resource, and Table 1 provides a summary.

TABLE 1: SUMMARY OF WASHINGTON STATE LAND BY OWNERSHIP

Ownership	Acres
Private	26,107,704
Public	
Federal	12,681,885
State	3,461,850
Local	343,561
Total	42,595,000

Source: Adapted from Soil Conservation Service and Washington Rangeland Committees and Washington Conservation Commission

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Table 2 breaks out the Table 1 figures into land types by ownership, and Table 3 summarizes the land by type. Recreation land does not appear in these tables as a separate category, but recreational activities occur on all of the various land types. The recreation land resource characterization is explicit about what land is included in the recreation land analysis.

TABLE 2: WASHINGTON STATE LAND BY LAND TYPE AND OWNERSHIP

Ownership	Land Type	Acres
Private	Forest	9,396,758
	Cropland	7,795,776
	Range	6,830,264
	Urban/Other	2,084,906
	Subtotal	26,107,704
Federal	Forest	11,799,475
	Range	462,736
	Other	419,674
	Subtotal	12,681,885
State	Forest	2,959,796
	Other	502,054
	Subtotal	3,461,850
Local	Forest	26,443
	Other	317,118
	Subtotal	343,561
	Total	42,595,000

Source: Same as Table 1

The figures in Tables 1 and 2 do not include the 1,039,000 acres of water in the state. Table 3 includes these acres as bedlands. The bedlands together with the other lands add up to a total of 43,634,000 acres of area in the state.

TABLE 3: WASHINGTON STATE LAND BY TYPE

Land Type	Acres
Forest	24,182,472
Cropland	7,795,776
Range	7,293,000
Urban/Other	3,323,752
Subtotal	42,595,000
Bedlands	1,039,000
Total	43,634,000

Source: Same as Table 1

The set of Environment 2010 resource characterizations does not include a characterization of urban lands. Urban lands, by definition, are already built up for residential, commercial, industrial, and community services purposes. Urban development has drastically altered the original ecosystems of these lands but this fact does not mean that environmental issues no longer pertain to urban areas. On the contrary, the human health risks posed by the various threats examined by the Environment 2010 risk assessments apply without exception in urban areas.

In addition, many ecological risks affect urban areas, especially those areas with significant bodies of water. The cities on Puget Sound, for example, have experienced a degradation of the Sound's water, and according to several of the Environment 2010 risk assessments, the threat of continuing degradation remains. These ecological threats, however, are threats to urban areas, not to urban lands. This distinction is important in the Environment 2010 approach, an approach that intends to be as comprehensive as possible while avoiding duplication.

There is no risk report on impacts to urban lands equivalent to the reports on impacts to agricultural, forest, range, and recreation lands because urban lands are not subject to any comparable risks. Similarly, there is no resource characterization of urban lands because these lands have been changed by their urbanization to built-up uses. Urban parks and greenbelts, however, are exceptions to this description. The park lands are considered in the recreation land resource characterization and risk assessment. Greenbelts are not specifically covered elsewhere.

In urban communities experiencing rapid or sustained growth, greenbelts are emerging as an important community concern. Greenbelts are stips of land in natural or relatively underdeveloped states, and serve to break up the continuous patter of urban development. As urban areas use their greenbelts for roads, houses, or other built-up uses, the environmental character of the community changes. A recent Seattle survey found that the preservation of greenbelts is the key concern of neighborhood groups. The nature of the greenbelt issue is local, and the resolution of disputes over greenbelt development or preservation is likely to remain in the local domain.

THE STATE OF THE ENVIRONMENT REPORT

VOLUME II
Part 3
Section A

Land Resource Characterization Report for Forest Lands

State of Washington
October, 1989

FORESTED LANDS

I.A. General Description of the Forest Resource

The forested region of Washington encompasses a number of very complex vegetation and animal communities. These lands are not only contributors to Washington's timber industry, but they also provide benefits to Washington's residents and tourists, including habitat for wildlife populations, outdoor recreation, and opportunities to experience the natural world.

The quantity and quality of the resources provided by the forest lands are threatened by increases in competitive demand for these resources. The quantity and quality of the resources provided by forest land may be impacted by four major threats:

1. Conversion of commercial forest lands to nonforest uses.
2. Conversion of old growth to second growth forests.
3. Nontimber uses of forest lands.
4. Silvicultural uses of forest land.

Other secondary but potentially significant risks are presented by air pollution, global warming, and acid deposition.

I.B. General Description of the Quantity and Distribution Pattern of the Forest Resource

21.5 million acres, or 50% of the state, is classified as forested land which supports recreation, wildlife and timber resources. 17.4 million acres of those lands are described as commercial timber lands.

Tables I and 2 combine and summarize data obtained from a series of U.S. Forest Service Resource Bulletins (PNW-91, PNW-93, PNW-96, and PNW-104) produced by the Pacific Northwest Forest and Range Experiment Station. Each Resource Bulletin presents timber resource statistics for a portion of Washington. The first of these Resource Bulletins, PNW-91, is based on 1977 and 1978 data. The most recent, PNW-104, is based on 1980 data.

Table I lists the acreage of each of the forest land classes by county in Washington. Forest land is defined as land which is at least 10 percent stocked by live trees or land formerly having such tree cover and not currently developed for nonforest use. Timberland is defined as forest land capable of producing 20 cubic feet per acre per year of industrial wood. Deferred or reserved timberland is defined as forest land which meets the productivity requirements of timberland, but is withdrawn from timber utilization through statute, ordinance, or administrative order. Other forest land is defined as forest land which is incapable of producing 20 cubic feet per acre per year of industrial wood because of adverse site conditions. Table 2 lists the acreage of timberland in each ownership class by county in Washington.

TABLE 1 AREA BY COUNTY AND FOREST LAND CLASS
(Thousands of Acres)

	Timberland	Timberland Deferred & Reserved	Other Forest	Total
ADAMS	--	--	--	--
ASOTIN	61	--	18	79
BENTON	--	--	--	--
CHELAN	674	120	238	1032
CLALLAM	707	179	104	990
CLARK	225	2	5	232
COLUMBIA	90	26	30	146
COWLITZ	630	--	4	634
DOUGLAS	6	--	1	7
FERRY	1022	4	172	1198
FRANKLIN	--	--	--	--
GARFIELD	57	6	11	73
GRANT	--	--	--	--
GRAYS HARBOR	1070	20	10	1100
ISLAND	76	1	2	78
JEFFERSON	520	343	156	1018
KING	812	56	80	948
KITSAP	162	1	2	165
KITTITAS	530	24	117	670
KLICKITAT	356	--	134	490
LEWIS	1199	65	51	1315
LINCOLN	49	2	11	63
MASON	483	28	19	530
OKANOGAN	1286	177	484	1948
PACIFIC	500	2	13	515
PEND OREILLE	733	17	42	792
PIERCE	589	91	91	771
SAN JUAN	66	3	4	73
SKAGIT	606	66	78	751
SKAMANIA	915	27	40	982
NOHOMISH	701	143	96	940
SPOKANE	293	24	43	359
STEVENS	1102	5	121	1228
THURSTON	311	1	3	315
WAHKIAKUM	142	--	2	144
WALLA WALLA	19	--	5	24
WHATCOM	451	128	175	755
WHITMAN	9	--	2	11
YAKIMA	826	44	128	999
TOTALS	17,278	1,605	2,492	21,375

Totals may not agree due to rounding.

TABLE 2 AREA OF TIMBERLAND BY COUNTY AND OWNERSHIP CLASS
(Thousands of Acres)

	National Forest	Other Public	Private	Total
ADAMS		--	--	--
ASOTIN	22	9	29	61
BENTON	--	--	--	--
CHELAN	514	35	124	674
CLALLAM	184	176	347	707
CLARK	1	49	175	225
COLUMBIA	48	6	36	90
COWLITZ	20	75	535	630
DOUGLAS	--	--	6	6
FERRY	407	453	162	1022
FRANKLIN	--	--	--	--
GARFIELD	43	3	11	57
GRANT	--	--	--	--
GRAYS HARBOR	131	254	686	1070
ISLAND	--	9	66	76
JEFFERSON	116	188	216	520
KING	153	143	517	812
KITSAP	--	39	124	162
KITTITAS	231	69	230	530
KLICKITAT	--	112	244	356
LEWIS	326	114	759	1199
LINCOLN	--	4	45	49
MASON	107	64	312	483
OKANOGAN	649	448	189	1286
PACIFIC	--	73	427	500
PEND OREILLE	464	36	233	733
PIERCE	99	82	408	589
SAN JUAN	--	4	62	66
SKAGIT	166	129	310	606
SKAMANIA	693	81	141	915
SNOHOMISH	235	143	322	701
SPOKANE	--	32	261	293
STEVENS	211	297	593	1102
THURSTON	--	76	236	311
WAHKIAKUM	--	34	107	142
WALLA WALLA	--	3	17	19
WHATCOM	182	80	189	451
WHITMAN	--	1	8	9
YAKIMA	286	471	69	826
TOTALS	5,288	3,792	8,186	17,276

Totals may not agree due to rounding.

I.C. Soils and Forest Ecosystems of the Forest Land Base

The soils and forests are the fundamental resources to be considered in an evaluation of the forest land base. Soil is defined as the earth material at or near the surface of the earth which supports or is capable of supporting growth. The soil is the basic medium for forest growth and rooting, and the storehouse of mineral nutrients and water required by the forest community. A soil is the product of the interaction of: 1) climate; 2) organisms; 3) parent material; 4) topography; and 5) time. A variation in any one of these factors can produce significant differences in soil properties and behavior. The wide range of climate, vegetation, geological materials, topography and soil ages across the forest land base of the State of Washington has created a great deal of diversity in the properties and behavior of the forest soils.

The forest land base of Washington also covers a wide range of forest ecosystems. Franklin and Dyrness (1973) have identified several major forest zones in Washington: the *Picea sitchensis* Zone; the *Tsuga heterophylla* Zone; the *Tsuga heterophylla* Zone (Puget Sound area); the Subalpine forests; the *Abies grandis* and *Pseudotsuga menziesii* Zones; and the *Pinus ponderosa* Zone. These zones reflect the responses of forest communities to strong macroclimatic gradients in temperature and moisture and are named after the dominant tree species in the climax community.

Traditional plant succession concepts depict an orderly progression of plant communities, each modifying existing conditions to a degree that facilitates their replacement by later successional stages until a stable climax community results. The character of the successional stages and the rates at which successional stages are replaced on a site is strongly influenced by soil-related ecosystem factors. Therefore, diversity of forest communities within each of the macroclimatic zones is influenced by two major factors; the time elapsed since the last disturbance of each site and the differences between the soils.

In order to discuss the diversity of the forest soils and forest ecosystems in Washington, it is convenient to divide the state into the seven physiographic provinces shown in Figure 1: 1) the Olympic Peninsula Province; 2) the Willapa Hills Province, 3) the Glaciated Puget Sound Lowland Province; 4) the Cascade Mountain Range Province; 5) the Okanogan Highlands Province; 6) the Blue Mountains Province; and 7) the Columbia Basin Province. Each of these physiographic provinces has its own unique combination of soil, climatic, and other environmental characteristics which determine the potential composition, structure, and sensitivity of the forest communities found within it. The boundaries between the physiographic provinces tend to be gradual, often with a mix of various characteristics at the boundaries.

Soils and Forest Zones of the Olympic Peninsula Province

The Olympic Peninsula Province is characterized high mean by annual precipitation and soils with generally shallow to moderate depth. The shallow to moderate soil depths have been greatly influenced by a combination of glacial activity, the character of the geologic parent material and recent geomorphologic processes.

The central core of the Olympic Range was the source of several glacial events during the Pleistocene period. Glaciers extended out beyond the mountain front, scouring and depositing as they went. Within the mountain range, U-shaped valleys with steep sideslopes are a typical result of this glacial activity. Rapid stream downcutting has also contributed to oversteepening of slopes in certain areas. The steep sideslopes, high precipitation rates and character of the primary sedimentary bedrock within the Olympic Range interior have contributed to a relatively high potential for surface erosion and mass wasting. These processes have resulted in relatively shallow soils on the sideslopes. Soils of greater depth are generally found on alluvial and glacially derived deposits along the larger stream bottoms and beyond the mountain front.

Soil textures within the mountain front tend to be generally coarser, due to the relative youth of the soil surfaces. Gravel contents tend to be relatively high, particularly on the steep sideslopes. Beyond the mountain front, textures become generally moderate to fine, due to the somewhat finer character of the geologic parent material and the greater age of most of the soil surfaces.

Organic matter content and distribution within the soils of the Olympic Peninsula is primarily a function of elevation. At lower elevations the organic matter in the duff layer is more rapidly converted into humus and incorporated into the mineral soil than at higher elevations. At the higher elevations, where temperatures are colder, soil biological activity tends to be significantly reduced. Thus, at higher elevations forested soils tend to have thicker duff layers and lower humus production and incorporation. Lower humus incorporation in the soils at higher elevations tends to limit their structural development and their forest productivity.

Forest productivity is lower at the higher elevations in the Olympic Peninsula because of the shallower soil depths, the lower levels of humus production and incorporation, and the shorter, cooler growing seasons. Available soil nutrient levels in the Olympic Peninsula Province, as in other forested regions, are directly influenced by the levels of humus production and incorporation. Higher levels of humus production and incorporation are reflected in higher available soil nutrient levels. Moving out through the Olympic foothills toward the coastal areas. Forest productivity becomes significantly greater because of deeper soils with more incorporated humus. Higher temperatures, and a longer growing season.

The *Picea sitchensis* Zone occurs within the fog zone of coastal areas along the Pacific Ocean and the western portion of the Straits of Juan de Fuca at elevations up to 500 feet. The *Tsuga heterophylla* Zone occurs at intermediate elevations up to 3,250 feet. The Subalpine forests occupy the highest forested terrain on the Olympic Peninsula at elevations ranging between 2,000 and 7,500 feet.

Soils and Forest Zones of the Willapa Hills Province

The Willapa Hills Province has much less topographic relief than the Olympic Peninsula Province to the north. This province was not subjected to scouring by glaciation during the Pleistocene period and the absence of this scouring has produced an area largely covered by relatively mature surfaces and soils. The long period over which soil forming processes have been active and the intensity of these processes due to the high mean annual precipitation and moderate temperatures have produced an area characterized by deep, medium to fine textured soils.

Drainage characteristics of most soils in the Willapa Hills Province are favored by their depth, good structural development and relatively high organic matter. In undisturbed situations, most soils in this province can absorb and transport all water supplied during peak precipitation with minimum surface flow or other negative effects. Soil disturbance, particularly compaction, can reduce the infiltration rates of these soils, and can significantly increase the potential for surface flow and surface erosion.

Although surface flow is minimal and general drainage characteristics favorable on most undisturbed soils in this province, mass wasting is a problem in certain areas. Deeply weathered sedimentary materials, particularly those with strata that concentrate subsurface water and those on steep sideslopes, tend to increase the potential for mass wasting.

Organic matter and available nutrient levels in most soils of the Willapa Hills Province are high in comparison to other forested areas of Washington. This is because the high precipitation and moderate temperatures of this province favor the production of large amounts of forest litter which is rapidly converted into humus and incorporated into the soil.

The soils of the Willapa Hills Province are among the most productive in the State of Washington. The generally greater depths, finer textures, better structural development, higher humus and nutrient contents and better drainage of these soils in comparison to other areas of the state contribute to this greater productivity.

The *Picea sitchensis* Zone occupies the area of the Willapa Hills Province which is heavily influenced by coastal fog. The remainder of this province is occupied by the *Tsuga heterophylla* Zone.

Soils and Forest Zones of the Glaciated Puget Sound Lowland Province

The soils of the Glaciated Puget Sound Lowland vary widely because of the variety of glacial and post-glacial parent materials which are present. Differences in parent materials are of primary importance in determining the differences in soil properties and soil behavior in this province because of the relative youth of these parent materials. The parent materials from which these soils have formed have been altered very little by soil forming processes due to the fact that they have all been deposited within the last 13,000 years. Forest communities are found on three major types of glacial deposits in the Glaciated Puget Sound Lowland Province; glacial till, glacial outwash, and glacial lacustrine deposits.

Glacial till is deposited directly by glacial ice and lacks the particle size sorting which is characteristic of water-deposited parent materials. Glacial till soils often contain a wide range of particles sizes, from large stones to clay, within the same soil profile. For this reason glacial tills are commonly called "boulder-clays". Glacial till soils commonly have an extremely resistant layer of compacted till material, the lodgement till, at a depth averaging between 20 and 40 inches. Thin layers of glacial till have been deposited directly on the underlying bedrock in certain situations. These glacial till soils behave in much the same way as the other glacial till soils, because both the underlying bedrock and lodgement till restrict penetration of roots and water.

The behavior of glacial till soils and the character of the forest communities growing on them are strongly influenced by the depth of the impenetrable layer, either bedrock or lodgement till. As the depth to the impermeable layer becomes shallower, drainage and root penetration both tend to be restricted. Restrictions on drainage and root penetration are most evident on glacial till soils found within low-lying topographic depressions.

The soils formed on glacial outwash deposits consist primarily of sand and/or gravel-sized particles which have been stratified and sorted by rapidly moving glacial meltwater. Drainage tends to be relatively rapid in these glacial outwash soils because of the generally coarse textures of the parent material and the lack of restrictive layers.

The textures of the soils formed in glacial lacustrine deposits are the finest in the province. The textures are dominated by silts and clays which were deposited at the bottoms of glacial lakes. These lacustrine deposits often display layering, with alternating bands of contrasting texture. Subsurface saturation is common within these lacustrine deposits because drainage is restricted by the fine textures and the textural banding. "Blue clays" is a term which has been applied to glacial lacustrine deposits because of the anaerobic conditions resulting from subsurface saturation. The drainage restrictions in glacial lacustrine deposits have a significant effect on soil behavior and the forest communities found on these soils.

Problems associated with surface erosion and mass wasting activity within the Glaciated Puget Sound Lowland tend to be concentrated on a relatively small portion of the area because of the relatively subdued topography of this province. Soil types with limited drainage rates located on steeply sloping terrain present the highest potential for surface erosion and mass wasting here, just as they do in other forested areas. Shallow glacial till deposits overlying steeply sloping bedrock surfaces present a very high potential for surface erosion and mass wasting in this province as do glacial lacustrine deposits on steeply sloping terrain.

Humus production and incorporation occur at average rates throughout the Glaciated Puget Sound Lowland Province because of the moderate climatic conditions. The relative youth of soil types in this province has resulted in "A" horizon (topsoil) thicknesses and total accumulations of humus and available nutrients which are generally less than comparable soils in adjacent provinces. Humus production and incorporation tend to be limited in those soils with low water holding capacity (i.e., very coarse textured outwash soils) and those with excessive moisture (i.e., glacial till or lacustrine soils in topographic depressions). The highest productivity in this province is generally found on deep, well-drained soils of medium texture. Coarse-textured outwash soils with high gravel contents have below-average potential productivity because of their excessive drainage rates and low available nutrient levels. The poorly-drained conditions commonly associated with the fine-textured lacustrine soils tend to limit their potential productivity. The <u>Tsuga heterophulla</u> Zone (Puget Sound area) occupies the entire province.

Soils and Forest Zones of the Cascade Mountain Range Province

The Cascade Mountain Range Province is perhaps the most diverse, both in terms of soils and forest zones, of any of the physiographic provinces in the State of Washington. Variations in elevation, precipitation, parent materials, topography, and plant communities contribute to a wide range of soils in this province. Soil depths generally vary with elevation and slope. Soils at higher elevations and those on precipitous slopes tend to be shallow, while deep and moderately deep soils occur commonly on moderate slopes and at lower elevations. In many areas of the province, especially in the northern portions, glaciation and natural erosion have left large areas of exposed bedrock and shallow soils. In the southern parts of the province are large areas of deep and moderately deep soils formed on a variety or parent materials, including volcanic ash deposits and deeply weathered bedrock.

Topography and depth to an impermeable layer are major factors influencing soil drainage in the Cascades. Concave topographic features tend to concentrate surface and subsurface drainage waters, resulting in properties and behavior associated with wet soil conditions. Moisture levels are also likely to be higher in soils with shallow impermeable layers.

Surface erosion and mass wasting processes in the Cascade Mountain Range Province, as in other provinces, tend to be more common on steep concave topography on which surface and/or subsurface drainage waters are concentrated.

Organic matter character and distribution in forest soils of the Cascade Mountain Range Province follow the patterns common to other forested mountain regions. Organic matter is converted to humus and incorporated into the soil more slowly under the low temperatures of the higher-elevation Cascade Mountain Range forests. Duff layers generally get thicker and humus production and incorporation is reduced as one moves higher in these forested areas. As in other soils, available nutrient levels tend to be strongly correlated with the levels of humus incorporation. Those soils with the higher levels of humus incorporation are likely to have higher levels of available nutrients.

The rain-shadow effect of the Cascades has created a drier forested environment on the eastern slopes, complete with a different set of forested communities and soil-forming processes. The drier conditions affecting the forests on the eastern slopes of the Cascade Range generally result in less organic litter and less moisture available for leaching and other soil-forming processes. Compared to soils on the western Cascade slopes at similar elevations in similar parent material, soils on the eastern slopes are generally less weathered and less acid, and have less organic matter.

Forest productivity varies widely. Areas of deep, medium-textured soils and favorable climate in the southwest corner of the Province provide above-average conditions for forest growth. Forest productivity is limited by shallow, coarse-textured soils occurring throughout the province, the short growing season of the higher elevations and the low precipitation levels of the eastern forested flanks of the Cascades.

The Tsuga heterophylla Zone is found at elevations up to 3,250 feet along the western slopes of the Cascade Range. The Subalpine Forest Zone includes the forest communities at the highest elevations along the center of the Cascade Range. The Pinus ponderosa Zone is found at the lowest forested elevations and lowest precipitation levels along the eastern foothills of the Cascade Range.

The Okanogan Highlands Province

The Okanogan Highlands Province, like the Cascades to the west, includes a wide range of forest ecosystems and soil types. In the rain shadow of the Cascades, its mean annual precipitation varies from 15 inches at the lower elevations along the western and southern boundaries to over 50 inches in the mountainous terrain of Pend Oreille County. Increases in elevation within the Okanogan Highlands Province are closely correlated with increases in mean annual precipitation levels. As elevations and mean annual precipitation levels increase in the Okanogan Highlands province, the higher soil moisture levels are generally reflected in higher levels of forest productivity and soil forming processes which proceed at a somewhat more rapid rate.

Glaciation has played a major role in determining the terrain and soil types of the Okanogan Highlands Province. Glacial outwash and glacial till are major soil parent material types, although glacial lacustrine materials may be common in some locations. Glacial erosion left portions of the Okanogan Highlands with exposed bedrock or shallow layers of soil material overlying bedrock. Post-glacial wind-deposited silts and volcanic ash materials have covered much of the Okanogan Highlands Province and have played a major role in determining the properties of the surface soils in many areas.

Coarse-and medium-textured soils are typical because of the common occurrence of glacial till, glacial outwash, and shallow bedrock soils in the province. Soil textures have not been significantly modified by soil forming processes in the Okanogan Highlands Province because these soils are relatively young and the soil forming processes tend to be limited by the low soils moisture levels in much of the province.

Soil organic matter is relatively low in the Okanogan Highlands Province, as it is in other portions of eastern Washington, because of the low mean annual precipitation. Low mean annual precipitation levels limit both the production of organic litter in the forest communities and the conversion of this organic latter into soil humus. The rates of organic litter production and conversion of organic litter into soil humus tend to increase as mean annual precipitation and available soil moisture levels increase in the Okanogan Highlands Province.

Aspect plays a major role in differentiating plant communities as well as soil characteristics and behavior in eastern Washington. Southerly aspects are exposed to higher levels of solar insolation and are characterized by warmer temperatures, higher evapotranspiration rates, and lower soil moisture levels than northerlv aspects. At the lowest elevations within the province, where mean annual precipitation levels are lowest, only the northerly aspects will have adequate soil moisture levels to support forest communities. At intermediate elevations, the productivity levels of forest communities on the northerly aspects will generally be higher than those on the southerly aspects because of the higher available soil moisture and soil nutrient levels. Forest communities at the highest elevations in the Okanogan Highlands Province, as in other areas, can be more productive on southerly aspects if soil moisture levels are not a limiting factor and the southerly aspects provide for warmer temperatures and longer growing seasons.

Soils tend to be more highly developed on the northerly aspects throughout the Okanogan Highlands Province because the higher soil moisture levels tend to increase the rate of soil forming processes. The soils on the northerly aspects also tend to have greater resistance to both surface erosion and mass wasting because they generally have more dense vegetative coverage and root support and they tend to have thicker organic litter layers and higher amounts of incorporated humus.

Eastern Washington, including the eastern portions of the Cascade Mountain Range Province, is characterized by a climatic regime in which much of the mean annual precipitation occurs as snowfall. The spring thaw presents special problems regarding soil management in eastern Washington. Rain or warm temperatures can produce rapid snow melting while the soil below is still frozen, limiting infiltration. Such situations increase the potential for surface flow and surface erosion. The soil saturation which commonly occurs during spring thaws increases the potential for compaction and rutting associated with logging activities.

The Pinus ponderosa Zone is found on the driest forested sites at lower elevations along the southern and southwestern edges of the Okanogan Highlands Province. The Abies grandis and Psuedotsuga menziesii Zones cover the majority of the forested acreage at intermediate elevations within the Okanogan Highlands Province. The Tsuga heterophylla Zone is found on favorable sites at intermediate elevations in the northeast portion of the Okanogan Highlands Province, that portion of the province with the highest mean annual precipitation. Subalpine forests occupy the highest forested elevations in the Okanogan Highlands Province.

The Blue Mountains Province

The Blue Mountains Province has climatic characteristics which are similar to those of the Okanogan Highlands Province, but with slightly lower maximum mean annual precipitation at the higher elevations. The Blue Mountains Province is basically a dissected basalt plateau with steep sided erosional valleys and rolling uplands. Glacial deposits of basaltic material are found at higher elevations, while wind-deposited primarily silt-size loess materials become common at the lower elevations. Most soil types of the Blue Mountains Province show evidence of volcanic ash depositions.

Because of similarities in climatic characteristics, soil forming processes and soil management concerns in the Blue Mountains Province are similar to those in the Okanogan Highlands Province. Forest productivity is relatively low throughout the province and tends to be limited at lower elevations by low mean annual precipitation and at higher elevations by low temperatures and short growing seasons. Aspect, as in other forested areas of eastern Washington, plays a major role in determining the rates of soil forming processes and characteristics of the forest communities through its effects on soil moisture levels.

The Pinus ponderosa Zone is found at the lowest forested elevations within the Blue Mountains Province. The Pseudotsuga menziesii and Abies grandis Zones are found at somewhat higher elevations and mean annual precipitation levels. The Subalpine Zone occupies the highest forested terrain in the Blue Mountains Province.

II.B. Summary of Risks to the Forest Resource

II.B.1. Risks to the Forest Resource from the Conversion of Forest Lands to Nonforest Uses

Conversion of forest lands (approximately 50,000 acres/year) to uses other than forest dependent uses represents a significant threat to the long term maintenance of the forest land base. Presently, a number of forest dependent uses are actively competing for a share of that resource. The forest resource supply and demand scenario has already identified that there is not enough of the resource to go around. Population increases projected by future growth scenarios can only increase the demand and competition for these resources. The magnitude of population growth will largely determine the rate of conversion over time.

Ecological Risks

Conversion of forest lands to nonforest lands creates the potential for increased flooding, reduction in ground water recharge, increased pollution of round and surface water, supply reductions of forest dependent commodities, and loss of carbon dioxide fixing potential.

Human Health Risks

The human health risks were not analyzed.

Economic Damages

The economic damages were not analyzed.

II.B.2. Risks From the Conversion of Old Growth to Second Growth Forests

Conversion of old growth to second growth forest in Washington has reduced the inventory of old growth and mature forests to between 3 and 4 million acres in 1989. Recently, a great deal of attention has been focused on the future of the old growth ecosystem in the Pacific Northwest. That focus has revolved around the designation of old growth habitat for spotted owls. In reality, however, the old growth issue is far more complex. The old growth forest provides a wide variety of valuable commodities ranging from timber supply to the maximum wildlife diversity. Uses of old growth forests are frequently considered incompatible with each other and have consequently created the competitive situation which exists today.

Ecological Risks

The impacts associated with old growth to second growth conversion include a reduction in the acreage of old growth forests, a reduction in attendant species diversity, loss of ecosystem function and structure and fragmentation of the remaining old growth stands. Old growth forests are the most diverse ecosystems with respect to species, structure and function. Consequently, conversion of these forests will cause a greater loss in diversity than harvest in second growth stands. The effects of old growth fragmentation may be approaching a critical level for the viability of wildlife associated with these late successional (Lehmkuhl and Ruggiero, 1989).

Human Health

No human health consequences associated with the conversion of old growth to second growth were examined in the 2010 report.

Economic Damages

Economic damages were not analyzed.

II.B.3. Silvicultural Uses of Forest Lands

The amount of timber harvested in the state varies between 4 and 7 billion board feet annually. Between 150,000 and 200,000 acres of forest land are clearcut each year and another 400,000 to 500,000 receive a thinning or partial cut. The activities are accompanied by other forest management activities, such as road building and reforestation.

Ecological Risks

The impact associated with silvicultural uses of forest lands include; increased erosion and mass wasting, increases soil compaction, changes in soil chemical properties, and a reduction in species diversity. These effects are greatest in old growth forests and least in second growth forests. In general, sedimentation from silvicultural activities in forested drainages is well below the standards established for agricultural land. Problems exist, but tend to be localized in particular harvest units or drainages.

Human Health

No human health risks associated with silvicultural uses of forest land were examined in the 2010 report.

Economic Damages

Economic damages were not analyzed.

II.B.4. Nontimber Uses of Forest Lands

Nontimber uses of forest land have increased substantially in the past decade. If these trends continue, overcrowding at parks and recreation areas will become more common.

Ecological Risks

Ecological risks will include increased erosion and soil compaction. These risks will be localized at specific high-use parks and recreation areas.

Human Health

No human health risks associated with nontimber uses of forest land were examined in the 2010 report.

Economic Damages

Economic damages were not analyzed.

II.B.5. Risks to the Forest Resource Delivered Through the Air

Air provides a pathway through which contaminants may be transported to the forest lands. Once contaminants have entered the forest ecosystem they can cause ecological and economic risks to the forest resource.

Ecological Risks

There is a dearth of information regarding forest lands impacts from air pollution. Elevated levels of ozone throughout the state may be damaging sensitive plants. An evaluation of the potential effects on hardwoods indicates that there may be impacts to the softwood timber industry and other vegetative components of the forest ecosystem.

Impacts from toxic air pollutants are most likely localized in areas adjacent to the point sources.

Human Health Risks

There are no specific health risks identified in the Washington Environment 2010 Air report.

Economic Damages

This topic was not analyzed.

II.B.6 Risks to the Forest Resource from Global Warming and Stratospheric Ozone Depletion

The phenomenon of global warming, ozone depletion and related climatic changes can have dramatic effects on the forest resource. The potential effects have only been addressed in a generalized manner by ecologists. Unique plants will be most affected by the climatic change.

Ecological Risks

Temperatures are projected to increase and precipitation patterns are forecast to change throughout the Pacific Northwest. However, within the range of projected temperature increases, elevated levels of carbon dioxide will compensate for higher temperatures without stressing the plants. For most species the upper elevation limit of their range is projected to rise. Plant response to decreasing site water balance is mitigated by doubling the available carbon dioxide. Secondary and tertiary effects of doubled carbon dioxide and global warming are not well understood.

Human Health Risks

No human health hazards are identified from global warming and ozone depletion influences on forest lands.

Economic Damages

This topic was not analyzed.

II.B.7 Risks to the Forest Resource from Acid Deposition

Acid deposition does not seem to be affecting forest ecosystems in Washington although there is some evidence in the eastern United States that it may be affecting forest ecosystems in areas that receive high levels of hydrogen ion deposition.

Ecological Risks

There are a number of hypotheses concerning acid deposition, although measurable growth effects or foliar injury have not been reported in Washington. Theoretically, it is possible that subtle ecosystem effects have or may occur at present acid deposition rates and fog levels in the state.

Human Health Risks

No human health consequences associated with acid deposition were examined in the 2010 report.

Economic Damages

This topic was not analyzed.

II.C. Conclusions About the Status of the Forest Land Resources

There are about 22 million acres of forest land in the State of Washington. Commercial forests constitute over 17 million acres while slightly over 4 million acres are reserved from timber harvest and used for parks, wilderness area and other administrative areas. These reserved lands are mostly managed by federal agencies. Commercial forest lands are managed by federal and state agencies, large corporations and about 20,000 non-industrial private woodland owners.

Historically, the forest land base and the amount of commercial forest land in the state continues to decline. In the period between 1930 and 1980 about 4 million acres of commercial forest lands were converted to nonforestry uses, such as cities, and roads. This trend is continuing today.

The character of our forests has also changed during the past six decades. One of the most visible changes is the reduction in the acreage of old forests. Between 1930 and the present, the amount of old forests declined from 11 million acres to slightly over 4 million acres. Many of the remaining stands, not already preserved are fragmented into areas too small to be functionally beneficial. Fragmentation of these stands is increasing and will continue to increase in the future. Historically, the rate of change in the amount of old forests is declining. In the 60 years prior to 1930, over nine million acres of old forest in the state were harvested. This declining trend in the rate of conversion will continue and eventually the amount of old growth will become stable.

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[1] Commercial forest land is forest land capable of producing more than twenty cubic feet per acre per year of usable wood volume.

The amount of timber harvested in the state has varied between 4 and 7 billion board feet for nearly 90 years. Between 150,000 and 200,000 thousand acres are clearcut each year and another 400,000 to 500,000 acres receive a thinning or partial cut. These activities are accompanied by other forest management activities, such as road building and reforestation.

Erosion rates are commonly used for assessing the status of agricultural land and are useful guides for our forest lands. Monitoring of erosion on forest lands in Washington is not extensive. However, the studies which have been conducted indicate that erosion from managed watersheds ranges from about .15 to .5 ton/acre/year (Ryan, personal communication). These estimates agree reasonably well with regional estimates (Patric, 1984). They are about one-tenth of the maximum standard of 2 to 5 ton/acre/year established for agricultural lands. Problem areas do exist, but they tend to be isolated occurrences within specific harvest units or drainages that can be dealt with under existing regulations.

Historically, the erosion from forest land is probably decreasing. Much of the reduction is the result of increasing regulation of the industry over the past 50 years. Today, areas which present potential problems for forest management receive review by interdisciplinary teams. Management practices such as slash burning have declined significantly during the past decade. These trends are likely to continue.

II.D. Positive Aspects of the Forest That Exist Regardless of Government Actions

Forest lands contain numerous and diverse values for this state. The actual use patterns on these lands are determined in large part by the landowner. Multiple use recreation is largely relegated to public lands, with the national forests the primary public supplier of recreations, timber, hunting, wilderness, and nature study. Twenty-one percent (9 million acres) of the state's land base is managed by the Forest Service for this variety of resource values. Thirty-one percent (5.4 million acres) of the state's commercial timber lands are managed by the national forests with 38% of the unharvested timber inventory (Larson, 1989).

Pursuit of fishing and wildlife recreation greatly benefit state and local economies. Eight percent of the hunter and fishermen days, or WFUDS, (one Wildlife and Fish User Day consists of 12 hours of recreation that is the result of fish or wildlife use) occur on the national forest lands. For example, in the 1986-87 hunting season, 10,500 elk tags were sold for the Washington portion of the Umatilla NF. Hunters spent 42,820 WFUDs in the pursuit of elk, spending an average of $75 per day on food, lodging, transportation, equipment, licenses and tags.

Forest lands support a diverse mosaic of year-round and seasonal habitats for 450 species of animals, including several threatened and endangered species. including the spotted owl, bald eagle, grizzly bear and wolf. The Olympic's Roosevelt elk population is the largest of its kind. The Umatilla's elk population is one of the largest concentrated herds in the U.S. The majority of contiguous unaltered habitat areas for these animals is owned by the National Park Service and the National Forests.

National parks and forests provide a major drawing card for tourists and recreationists. The Wenatchee and Mt. Baker National Forests are both in the top 10 most visited recreational forests in the U.S. Mt. Baker alone had 4.2 million visitor days in 1983. Additionally, significant American Indian religious and cultural values are associated with these forests.

The national forests and parks contain this state's largest inventory of old growth forests. The current inventory of old growth and mature forests is about 4 million acres, about half of which are preserved for future generations.

The forests constitute a significant source of water supplies for municipal, domestic and agrcultural uses. A major inventory of potential federal and state wild and scenic rivers lie within the national forests. The forests also contain numerous locatable and leasable mineral resources.

III. Current Government Programs for Control of Impacts to Forest Resources

Four significant programs in the state of Washington are designed to control the degradation of the forest resource:

1. The Timber/Fish/Wildlife agreement made significant advances in the regulation of the impacts of timber harvest on other resources by all regulatory agencies and landowners. The agreement represented a historic shift in the way Washington manages natural resources. It provided a framework, procedures and requirement for managing our state's forests so as to meet the needs of a viable timber industry and at the same time provide for protection for our public resources (TFW Agreement). The agreement did not, however, address the major problem of timber supply but rather developed a regulatory mechanism to evaluate existing timber harvest practices.

2. The United States Forest Service developed draft management plans designed to address regulatory protection of their lands and the issue of allocation of scarce resources to competitive user groups. The plans are presently in the draft stage to be completed over the next year. These plans are required by law to maintain scarce resources in such a fashion as to provide for minimum viable populations of all animal species in addition to providing a land base to support a viable timber industry. Standards, guidelines

and best management practices are the regulatory mechanisms used by the plans to protect resources on lands managed for timber harvest. Land set-asides are the other administrative vehicle to protect values such as roadless areas, primitive recreation and specific wildlife values.

3. The Governor's office initiated a series of task forces to deal with the declining timber supply that was becoming the major constraint on maintaining the production and employment in Washington's timber industry. The Governor's four point timber plan is designed to increase the supply of timber available for harvest, which is essential for the economic health of timber communities, while protecting the state's long term interests in resource management, recreation, and environmental protection. The elements of the plan are:

    1. State timber for state jobs by setting aside a portion of state timberlands for in-state processors.

    2. The timber community stability plan to modernize our state industry, improve marketing of Washington products and increase timber supply in the future.

    3. Develop a Washington solution to a Washington problem by bringing together industry, environmentalists, labor and communities to try to solve the problem.

    4. Increase the harvest level in the short term to soften the impacts of projected harvest reduction on U.S. Forest Service and private lands.

4. Commission of Old Growth Alternatives

    The Commission on Old Growth Alternatives was created in June, 1988 by Commissioner of Public Lands, Brian Boyle. It consisted of 32 citizens broadly representative of the timber industry, conservation and wildlife groups, school and other trust beneficiaries, Indian tribes, local Olympic Peninsula community leaders as well as legislators, and financial, legal and forestry experts. Its goal was to advise the Commissioner on the future management of old growth forests on state trust lands on the western Olympic Peninsula. In June of 1989, the Commission released their recommendations.

    1. The state should provide sources of revenue for school and university construction that go beyond revenues derived from the harvest of state owned timber. The creation of supplemental revenue sources would not only stabilize school construction needs, it would provide ecological benefits by relieving the pressure on state lands to be managed solely for timber harvest.

2. An experimental forest should be created on the 200,000 plus acres of state owned land on the westerm Olympic Peninsula. The intent of the experimental forest would be to investigate ways that commercial forest land could be harvested to better protect wildlife and other eco-systems values.

3. The experimental forest should be supplemented by an Olympic Natural Resources Center. This research and educational facility would support the state's efforts in the experimental forest as well as provide additional research and education on forest ecology and commodities.

4. State lands on the Olympic Peninsula should be managed as a separate sustained yield unit. This not only stabilizes the timber supply for the local economy but would also slow the loss of old growth habitat over the next decade.

5. Harvest should be deferred on 15,000 acres of state owned Peninsula old growth for 15 years. Deferred areas should be identified as those most critical to spotted owls and emphasize unfragmented stands of old growth contiguous to old growth in other ownerships, i.e., Forest Service and National Parks.

6. Up to 3,000 acres of western Olympic Peninsula state lands that have special ecological, aesthetic, and interpretive values should be permanently acquired and removed from the harvest base.

7. A comprehensive economic study on the unique needs of the Peninsula's timber communities should be undertaken to provide improved economic development for the area.

Legislation in the 1989 legislative session has provided authority and funding to begin implementation of these recommendations.

IV. Impacts That Population Growth, Energy Demand and Shifts in the Labor Market have on the Forest Land Resource

The competitive demand on the forest's natural resources will increase as the population of the state increases. This demand will rise in a somewhat proportional relationship with the population increase. The population pressure will be most acute where forest lands are used for recreation.

V. Plausible Status of the Forest Land Resource in 2010

It is estimated that there will be about 20 million acres of forest land in Washington State in 2010. Approximately 16 million acres will be in the commercial harvest base and 4 million acres will be reserved. These reserved lands will mostly be managed by the federal government. Commercial lands will continue to be managed by federal and state agencies, large industrial landowners and nonindustrial private landowners.

The amount of old forest will decline to a little over 3 million acres. Fragementation of commercial stands will continue and will be at a higher level than it is today. Recreation use of all forest lands will be much higher than it is today.

Harvest levels will continue to range between 4 and 7 billion board feet. National and global fiscal and monetary policies will continue to influence annual harvest levels. Forest management activities will continue to be tightly regulated. This regulation and continued improvements in harvesting and road building techniques and equipment will reduce the impacts of forest management on second growth forest ecosystems.

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THE STATE OF THE ENVIRONMENT REPORT

VOLUME II
Part 3
Section B

Land Resource
Characterization Report
for
Recreation

ENVIRONMENT 2010

State of Washington
October, 1989

Recreation Land

Resource Characterization

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Washington Environment 2010

Resource Characterization: Recreation Lands

C.1.d. General Description of Recreation Resource

From the urban parks of Seattle or Spokane to the primitive backcountry of our national parks, lands designated and managed for outdoor recreation in Washington are found in a variety of settings that are as diverse as the geography of the state itself.

Recreation in many forms will take place wherever there is open space and people who want to use that space. Land does not have to be designated for recreation in order to be used for recreation. Recreation lands discussed here, however, are those designated and managed primarily or exclusively for recreation. So-called multiple-use lands, on which resource extraction (e.g., timber harvest; as usually emphasized, are not included in this discussion, even though significant recreation occurs in these settings. The experience of the Washington State Interagency Committee for Outdoor Recreation indicates that including multiple-use lands in recreation inventories tends to overestimate actual recreation opportunity.

C.2.d. General Description of Quantity and Distribution of Recreation Land

One tool for better understanding the extent of recreational lands is the Recreation Opportunity Spectrum (ROS) as described by the United States Forest Service (Clark and Stankey, 1979). The ROS recognizes the variety of settings for recreation and attempts to define these settings in qualifiable terms. The range of the ROS is from the developed to the undeveloped, "Urban" through "Primitive."

The ROS descriptions that follow are based on a table developed by Buist and Hoots.

1. The Urban Rural setting is usually substantially modified, although the background may have natural appearing elements. Sights and sounds of humans predominate and moderate to high social interaction takes place. Facilities are provided for intensified motorized access or use, including parking. Public transportation to the through the site is often available.

   Generally, Urban/Rural sites are managed by local agencies including cities, counties, school districts, park and recreation districts, utility districts, and Indian tribes. These sits typically include ball fields, city parks, picnic areas, boat launch areas, and so on. This also includes so-called "open spaces" and greenbelts.

2. Roaded settings are predominantly natural appearing with moderate evidence and sights and sounds of humans. Evidences usually harmonize with the natural environment. Resource modification and

utilization practices, such as timber harvest, clear cuts, and dams are present or evident but harmonize with the natural environment. Conventional motorized use (passenger cars) is provided for in construction standards and facility design. The Paradise Visitor Center and recreation trails in Capitol Forest at Mt. Rainier are examples of the roaded setting.

3. State agencies managing recreation in these settings include the departments of Fisheries, Wildlife, Natural Resources, Washington State Parks and Recreation Commission. Federal agencies include the U.S. Forest Service and National Park Service. Typical sites are developed front country facilities such as visitor centers, campgrounds, picnic areas.

4. The semi-primitive setting is predominantly natural or natural appearing areas of moderate to large size, typically backcountry type areas. Interaction between users is low, but there is often evidence of other users. Minimum on-site restrictions and controls may be present but are subtle (fire rings, hardened camp sites, signing). The semi-primitive setting can be managed for motorized (e.g. trail bike) or nonmotorized (hiker, horse) uses.

   The largest land manager in this category is the U.S. Forest Service. Multiple uses incompatible with recreation (i.e., timer harvest, grazing, mineral extraction) are not precluded by management prescriptions. These acres may at some point in the future be redesignated to allow for resource utilization/extraction.

5. The primitive recreation setting is an essentially unmodified environment of fairly large site. Interaction between users is usually low and evidence of others is (or should be) minimal. The area is essentially free from evidence of human induced restrictions and controls. Motorized use is not permitted.

   Almost 100 percent of primitive recreation in Washington State takes place on federal land managed by the Forest Service, Bureau of Land Management, and the National Park Service.

   Much of this primitive setting is found in congressionally designated wilderness. However, it is important to keep in mind that wilderness is managed for preservation first. Recreation is one allowable activity to take place in wilderness, but in any conflict between preservation and recreation, preservation will take precedence. Permit systems to limit recreation access to wilderness are in place now in areas including the North Cascades National Park, Mt. Rainier National Park, and the Alpine Lakes Wilderness managed by the Wenatchee National Forest. Most draft forest plans issued over the past two years have indicated the likelihood of increased regulation via permit system.

   The over four million acres of primitive land overstates the amount of recreation land available to most users. The season of use for Wilderness areas is July-October (due to snow). In addition, in most of the wilderness areas only 4-5 percent of the land is a grade less than 35 degrees--too steep for most people to use.

Quantities of recreation lands are best described in acres. The following table summarizes the quantity of recreation land by ROS category.

Table 1. Inventory of Recreation Lands

Land Category	Acreage	Percentage	Management
Urban/Rural	82,093	1.06%	Local
Roaded	984,815	12.70%	State
	1,268,330	16.35%	Federal
Semi-Primitive*			
Motorized	250,563	3.23%	Federal
Nonmotorized	918,275	11.84%	Federal
Primitive**	4,252,344	54.82%	Federal
Total	7,756,420	100.00%	

* Semi-primitive land managed by U.S. Forest Service is multiple-use land; this acreage may overstate the actual amount of land dedicated to recreation use in the future.

** The primitive acreage overstates the available land for recreation--much is inaccessible for part of the year because of weather conditions, and some of it is so steep that few people can use it for recreation.

The distribution of urban/rural recreation acres generally follows the distribution of major population centers. The larger cities will own the most recreation acres, followed by more populous counties.

Roaded natural and roaded modified acres are distributed throughout the state. These acres will often be found in forested, mountainous sites, especially in the foothills or low elevations of the Cascade, Olympic, Kettle, Selkirk, and Blue Mountains, in state and national forests and state and national parks.

Significant semi-primitive areas are located in the Gifford Pinchot, Mt. Baker-Snoqualmie, Wenatchee, Okanogan, and Colville National Forests.

Primitive areas are found in the same national forests listed above, as well as in North Cascades, Mt. Rainier, and Olympic National Parks.

C.3.d. History of Land Use/Degradation in Washington State

The natural history of outdoor recreation in Washington State is directly linked to the unique story behind each designated site.

In the more developed recreation settings, natural history has been greatly altered by the influence of human development. Discovery Park in Seattle, for example, was in pioneer times a primeval forest of classic ancient, old growth trees. With the growth of the population, the forest was used as a source of timber and firewood. Years later, the site became a federal military reservation before it finally passed to the City of Seattle and became a city park.

Many state-owned recreation sites were at one time in private hands, often for resource extraction purposes. Seaquest State Park was an orchard before the land was bequeathed to the state.

Primitive and semi-primitive settings are often those that have not yet felt the influence of human development. The remoteness and difficult access of such sites have protected them from development so far.

Natural history and the progression of natural events can actually add to the recreational land inventory. A well known and dramatic example is the eruption of Mt. St. Helens. Those 1980 volcanic eruptions transformed the natural landscape and disrupted human development, resulting in a shift of management emphasis from extractive use to preservation and semi-primitive recreation. The National Volcanic Monument has become a major tourist attraction, with 623,480 visitors to the monument during 1987.

C.4.d.1.

A. Key indicators

Major stress agents, or threats to outdoor recreation, have been identified through 1) literature review, 2) interviews with key people in the recreation field, 3) IAC studies, including the Statewide Comprehensive Outdoor Recreation Plan (SCORP), and 4) the professional experience of TAC staff.

C. 5.j. Summary of Risk to the Recreation Resource

The major threat to the recreation resource is from the competitive uses of the land base--resource extraction (timber harvest and mineral recovery) and its associated road building, overuse, misuse, and urbanization and development. The potential effects are loss of habitat and environmental degradation which includes sanitation problems, water contamination, destruction of vegetation, and disruption of wildlife. Environmental settings impacted include forests, water resources, and open space. Other risks to the recreational resource include air pollution, acid deposition and global warming.

Land use activities may have known and predictable impacts on recreation, but those risks are often accepted in return for the value of the other activities (such as the economic value of timber harvest).

The discussion of the threats to recreation lands will distinguish the degree of the threats according to the recreation land type. Public recreation, for the purposes of this report, falls into four broad categories -- Urban/Rural, Roaded, Semi-Primitive, and Primitive (Wilderness). The lands not covered in this report include both private lands that support recreation, and those multiple-use public lands that are currently dedicated to resource extraction.

The analysis is further limited to the activities actually conducted on the various recreation lands. Timber harvesting on adjacent lands, for example, falls outside the boundaries of this study even though such activity could have an ecological impact on the recreation land.

The following sections detail the risks to the recreation resource. For further information on any one particular risk, refer to the full report on the applicable Environment 2010 risk assessment.

C. 5. j. 1. Risks to the Recreation Resource from Resource Extraction and Road Building

C. 5. j. 1. a. Ecological Risks

Resource extraction (timber harvest and mineral recovery) is prohibited on federally designated Wilderness (Primitive) lands. However, a clearcut on the border of a Wilderness area could disrupt wildlife within the Wilderness area, and could alter certain species' movements throughout their normal range. An evalulation of those effects would rely in part on the theories of island biogeography, and would be very complex. Such an analysis falls outside the scope of this report.

Resource extraction and the road building associated with it are the most significant future threats to Semi-Primitive lands. The US Forest Service manages the Semi-Primitive recreation lands under a multiple-use management prescription that allows both recreation (motorized and unmotorized in unroaded settings) and resource extraction.

Once harvesting is completed within a Semi-Primitive area, the smaller roads that lead to harvest areas are often abandoned until the next harvest 40-60 years later. But the main roads remain, and land that was Semi-Primitive converts to Roaded. The setting also changes from forested land to clearcut, and later, to second growth. Road building and resource extraction also eliminates access to trails. A significant number of trail miles have been lost on national forest land due to timber harvest.

The Semi-Primitive lands considered in this report represent half of the current amount of roadless acreage. (The other half is scheduled for timber harvest.) The remaining Semi-Primitive acreage is designated as unroaded through the Forest Service planning period, which ends in 2030. Throughout that period, the semi-primitive designation can be changed only with a public amendment process.

C. 5. j. 1. b. Human Health Risks to the Recreation Resource through Resource Extraction

Human health, both physical and mental health, appears to be enhanced by recreation and exercise. Outdoor recreation can provide an opportunity to enhance `wellness' (to breathe cleaner air, for instance) and exercise can cut absenteeism and medical costs. While it is difficult to quantify the relationship between recreation land and the health of the population, it does seem clear that resource extraction, as well as the other threats examined in this report, diminishes the ability of current and future generations to use a portion of the recreation resource.

C. 5. j. 1. c. Economic Damages to the Recreation Resource through Resource Extraction

The economic impact of neglecting our state's recreational resources is tremendous. Park and recreation facilities/programs can be effective measures in mitigating the cumulative costs associated with hospitalization, absenteeism, crime prevention, incarceration, and law administration. For example, taxpayers will spend over one million dollars for each prisoner they incarcerate over a 30-year period.

Further, research has shown that those who exercise regularly pay about half of what nonexercisers spend on medical bills. One prominent company estimates that it saves $2.00 for every dollar it spends on recreation, employee services, and lifestyle programs.

Property values ebb and flow with a site's proximity to greenbelts, parks, and open spaces. Specific studies show significant declines when such areas are located away from residences ($4.20 for each additional foot a house is located away from a greenbelt, according to one typical study - (Land Economics, May 1978).

This is a particularly important point, since our larger cities often expand into areas not served by park sites. This is unfortunate, as other infrastructure needs (roads, utilities, sewers, etc.) are usually addressed through municipal code requirements.

Often, our state's wildlands are worth more for their pristine values than for their commodities. For example, the Alpine Lakes Management Act condemned 24,400 acres of land owned by the Pack River Company for inclusion into the Alpine Lakes Wilderness. The Act required purchase in fee simple by the Forest Service. Based on the land's timber, the Service valued the property at $13.5 million. An out-of-court settlement, however, placed the real value at $25 million, based on wilderness significance and scenic beauty.

The U.S. Travel Data Center estimates that travel and tourism in America directly generated 5.5 million jobs in 1988. In that same year, the travel industry was responsible for more than 11 percent of all the additional jobs created in the entire U.S. economy. Outdoor recreation and use of our recreational lands accounts for a large portion of this tourism. Neglecting these lands can have a tremendous impact on the economy.

C. 5. 1. Trends in the Resource Extraction/Road Building Threat

Current semi-primitive (roadless) acreage will be reduced by half (for timber harvest) under the Forest Service's plan, thus reducing opportunities for use. Some of these users will have to shift to other types of recreation land. (See concentrated use.)

Roaded areas will grow in size, since most timber harvest practices require road building.

C. 5. j. 2. Risks to the Recreation Resource from from Overuse

Overuse is the result of more people trying to use a facility than the facility is designed to accommodate. The same concept applies to the land itself, that is, there is a capacity of the trails, fields, and other outdoor areas, and when use exceeds capacity the result is overuse.

C. 5. j. 2. a. Ecological Risks from Overuse

Overuse currently poses the most serious ecological threat to recreation lands, especially to Primitive lands. The most serious effect of concentrated use is degradation of habitat--sanitation problems, destruction of vegetation, soil hardening, disruption of wildlife, and loss of habitat.

Virtually all the Washington state recreation lands are currently approaching or exceeding capacity use, and the Primitive, Roaded and Rural/Urban lands show the ecological effects in habitat degradation. The accessible parts of the Primitive areas, however, are only 4-5 percent of the total Primitive acreage, and the overuse is confined to this smaller, accessible area. Likewise, the Semi-Primitive lands are at or near capacity use in their accessible areas (due, in part, to trail loss from timber harvest) but the addition of trails could expand their Semi-Primitive capacity.

When given the opportunity to recover, some degraded lands have rebounded fairly quickly--after two years of limited use at the Enchantments, for example, previously degraded land is stabilizing, vegetation is recovering, and wildlife is returning.

The alpine meadows at Paradise, on the other hand, have not recovered, despite the best efforts of the Park Service because park visitors continue to trample the delicate vegetation.

Other sensitive ecosystems at risk on recreation lands include rain forests, deserts, and ocean beaches.

C. 5. j. 2. b. Human Health Risks due to Overuse

Overuse can result in sanitation problems and water contamination. Overuse can also restrict access to a recreation area, which can prohibit some people's ability to recreate and exercise. (See the section on human health risk from resource extraction.)

C. 5. j. 2. c. Economic Risks due to Overuse

(See discussion under C.5.j.1.c. Economic Damages to the Recreation Resource through Resource Extraction

C. 5. 1. 2. Trends in the Overuse Threat

More primitive areas will be strictly regulated through a permit system, similar to the one currently in place in the Enchantments, which will force users to go to other types of recreation land.

Semi-primitive (roadless) areas will become more crowded, due to population growth and overflow use from the primitive areas, which will stress the capacity of the acreage.

Urban/rural areas will become increasingly crowded, due to population growth and overflow of users from other recreation areas.

C. 5. j. Threats to the Recreation Resource due to Misuse

Misuse can occur any time a recreation user fails to follow the rules of a recreation area. Misuse can include anything from littering to straying off marked trails to reckless fire-building.

C. 5. j. 1. a. Ecological Risks due to Misuse

The potential ecological effects of misuse run as wide a range as the misuse itself--anything from temporary degradation to a forest fire. There are no reliable data on misuse of recreation lands, and recreation professionals tend to view misuse as a minor threat compared to the others treated in this report.

C. 5. j. 1. b. Human Health Risks due to Misuse

Forest fires, and other misuses of the land, can threaten human health.

C. 5. j. 1. c. Economic Risks due to Misuse

Forest fires can diminish, especially in the short-term, the recreational value of a portion of land.

C. 5. j. Ecological Risks due to Urbanization and Development

The most significant consequences of urbanization and development are indirect--the increase in use of already overused areas.

The pressures of population growth and development are increasing the incidence of overuse. Assuming the same recreation use pattern that currently exists, we can expect more ecological damage resulting from concentrated use as the state population continues to grow.

Conversion of open space currently used for recreation for other uses is another risk of urbanization and development. Local and regional planners have difficulty anticipating the rapid expansion of urbanization and development and therefore may lose opportunities to purchase park land within or near developments. In the future, park land and other recreation opportunities may not be as close to neighborhoods as the population requires.

C. 5. Human Health Risks due to Urbanization and Development

Proximity of recreation areas is key to their access and the opportunity for people to recreate and exercise. (See the section on human health due to resource extraction.)

C. 5. Economic Risks due to Urbanization and Development

Property value and the proximity to parks, greenbelts, and other natural areas, clearly have an economic relationship. Future development made without parks and other areas can diminish the economic values of those areas. (See discussion under C.5.j.1.c. Economic Damages to the Recreation Resource through Resource Extraction).

C. 5. 1. Trends in Urbanization/Development Threat

All recreation land types will see more use, and overuse, leading to the same conditions expected under other issues.

C. 5. Ecological Risks due to Air Pollution, Acid Deposition and Global Warming

The impact of air pollution, acid deposition and global warming on recreational land is difficult to evaluate. These sources may pose a current or future threat to recreation lands, but at present there are no research findings on which to base an assessment.

The public may have an impression that recreation opportunities in the Primitive and Semi-Primitive areas should be pristine and free of the effects of air and water pollution. Therefore, the public may be less willing to accept the consequences of pollution in these areas.

C. 5. Effects on Water Quality

Overuse and misuse can result in water contamination and sanitation problems. See the reports on water quality for more information.

II. B. 7. Effects on Forest Lands

Impacts on forest lands affect recreation in that setting. See the forest land report for more information.

II. B. 8. Effects on Water Resources

Impacts on water resources affect recreation where there are wetlands. See other reports for more information.

C.7.d.1. Discussion of Opportunities

Outdoor recreation is important to the people of Washington State. Ranked among other states, Washington is: third in per capita visits to state park and recreation areas at 9.3 visits per person; sixth in the number of campers in national forests; seventh in fishing license revenues; fourteenth in the number of visits to national parks.

Washington State is blessed with an unusual blend of geography that allows a citizen to experience a broad spectrum of outdoor recreation. Within the state's borders, one can travel from a developed seaside resort or wilderness ocean beach across high mountains to golf or camp in a desert setting. In between are forests, parks, campgrounds, picnic areas, rivers, lakes, and more.

[II.E.2 a-b] Urban/rural recreation has benefitted greatly from the programs of the state Interagency Committee for Outdoor Recreation (IAC). Formed in 1964, the IAC has provided assistance to local agency projects in every county of the state. By 1989, the value of these projects was $174,123,314, of which the IAC committed $93,316,559 in state and federal funds.

Roaded natural and roaded modified recreation has been managed by state agencies including state parks and Recreation Commission and the Department of Natural Resources. From Deception Pass to Steptoe Butte, the state park system offers recreational settings easily accessible to nearly all state residents. According to the Department of Trade and Economic Development, in 1987 state parks attracted 1.2 million trailers, 680,000 tents, 46,000 boats, and 40 million visitor days, with state parks consistently outdrawing other outdoor attractions in the same regions.

The Department of Natural Resources manages 3 million acres of trust lands and 2 million acres of tidelands. Recreation is an important part of DNR management, which includes 138 camp, picnic, and trailhead facilities with more than 1,000 camp/picnic units and over 370 miles of horse, hiker, and off-road vehicle trail.

Semi-primitive recreation is available on federal land managed by the Forest Service. A statewide total of approximately 1,168,838 acres is available for primarily trail-based recreation. Semi-primitive experiences are available for both motorized (250,563 acres) and nonmotorized recreationists (918,275 acres) in settings that range from forested valleys to high mountain meadows and rocky peaks. Semi-primitive areas are recognized as an important recreational alternative to the primitive wilderness setting. As wilderness areas are used to capacity and more visitor restrictions come to bear, more and more recreationists will find themselves welcome in the semi-primitive setting, where visitor management can be more accommodating to recreational needs.

Primitive recreation is available on approximately 4,252,344 acres in wilderness areas scattered in seven national forests, and in our three national parks: North Cascades, Mt. Rainier, and Olympic. Each park offers its own unique recreational opportunities. The North Cascades is a premier destination for those seeking a true primitive experience in a dramatic setting of ice and rock alpine peaks: few roads enter the park, with primary access by foot. This rugged park drew 654,882 visitors in 1987. Mt. Rainier offers mountain grandeur on a more accessible scale: roads ease ones way to impressive views of our great mountain, roads which helped 1,325,629 visitors in 1987. Olympic National Parks offers majestic rain forests, a wilderness coastline worthy of World Heritage Site status, and a tumult of wildly-arranged alpine mountains. Olympic National Park hosted 3,362,535 visitors in 1987.

C.8.d. State Programs for Control of Resource Degradation

State agencies are taking many proactive steps to protect and enhance recreational resources for state citizens.

The Interagency Committee for Outdoor Recreation distributes funds from federal and state sources for recreation land acquisition. Since the creation of this agency in the mid 1960s, over $41 million has been distributed from a variety of sources, including the federal Land and Water Conservation Fund. Acquisition projects are a priority in IAC funding programs.

The State Parks and Recreation Commission has examined management of its properties based on carrying capacities adjusted to ecologic constraints. Further, the Commission endeavors to fund properties with the goal of adequately maintaining all properties, and there is continuing effort to identify unique resources that need to be protected.

The Department of Natural Resources received enabling legislation to establish Natural Resource Conservation Areas for protection of unique pieces of the Washington landscape. The Woodard Bay Natural Resource Conservation Area is a recent addition, which may provide excellent access to the water and other public uses. Management plans for each conservation area are being developed. The plans will address how each of the elements in need of protection will be managed and identify where and which public uses will be allowed.

C.11 Opportunities Created by Successful Control of Environmental Resource Degradation

Tourism is encouraged by a healthy recreational setting. Two important markets for tourism are served by the kinds of success discussed above.

First are the citizens of Washington State. Second are those visitors whose tourist dollars are important to the state's economy.

Washington State University recently completed a survey of the vacation patterns of Washington residents. While the study found that 66 percent of all citizens take an annual vacation of 12 or more days, only

14 percent of those 12+ day vacations are taken in-state. By maintaining high quality outdoor recreation land and facilities of all kinds, it may be possible to encourage Washington citizens to try in-state locations for vacation destinations.

At the same time, Washington can attract visitors from all over the world to its many areas of natural beauty and recreational significance. A case in point is the Cascade Pass trail in the North Cascades National Park: even on this relatively remote site, a magnificent setting for an easy day hike suitable for families, one can encounter an international array of visitors.

There is little doubt that the natural setting of the state and its abundant recreational opportunities attract many people to the area. There are few states in the country where one can enjoy the ocean, mountains, highlands, forests, desert, and more within a half day's drive.

C.12 The Impacts of Population Growth.

The impact of growing populations and increasing population densities was discussed above. American humorist Will Rogers, among others, commented about land: "They ain't making any more of it." The supply of people grows, but the supply of land remains the same. Unless dramatic changes are made, recreational acreage is not expected to become available at a rate even close to the rate of population growth.

Washington Environment 2010

Recreation Resource Characterization and Threats
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THE STATE OF THE ENVIRONMENT REPORT

VOLUME II
Part 3
Section C

Land Resource Characterization Report for Range Lands

ENVIRONMENT 2010

State of Washington
October, 1989

General Description of the Resource

Subcategories of Rangeland

Definitions

A distinction must be made between the terms "rangeland" and "grazingland." Grazingland is defined by the Washington State Grazing Land Assessment as "lands that produce forage and are suitable for livestock grazing, which include rangeland, native pasture, meadows, and many forest lands that support a herbaceous understory continuously or periodically" (Harris and Chaney, 1984). Rangeland is a subcategory of grazingland, as are pastureland and grazable forestland (also called grazable woodland).

In this document, the word "grazingland" (not rangeland) is used when referring, in general terms, to land used for grazing; "range" is used exclusively when referring to steppe vegetation (including natural grassland, savannas, and some wetlands, deserts, and tundra); "forestland" is used when referring to grazable forest land ("grazable woodland" and "grazable forestland" are interchangeable; the term woodland is used when taken directly from a source document); "pastureland" is used when referring to intensively managed (irrigated, planted, and fertilized) land with introduced forage species.

Now for the exceptions -- because various agencies define grazingland, rangeland, etc. differently, information provided by these agencies may not use terms consistent with definitions given above.

Different Types of Grazingland

According to the Grazing Land Assessment, "Rangeland is primarily covered with native vegetation and generally occurs on sites too isolated, too rough, or with soil too shallow, sandy, or alkaline, or rocky for agricultural development. Grazable woodland [grazable forestland] is open forest with understory vegetation suitable for use as forage. Pastures have better soils, are commonly seeded to introduce species (occasionally native), and are usually managed in conjunction with intensive agriculture."

Grazingland Ownership

Of the approximate 43 million acres of land in Washington State, approximately 12,500,000 acres can be classified as grazingland -- 7,000,000 acres of rangeland and 5,500,000 acres of grazable forest (Harris and Chaney, 1984). About 23 percent of the non-federal forest land is grazed by domestic livestock.

Much of this grazable land is privately owned, and is located in the southwestern Columbia Basin, the Channeled Scablands, major river valleys, and adjacent forested mountain and foothill areas. However, several federal and state agencies either own or have a major role in grazingland management, as explained below:

Federal Agencies

Bureau of Land Management (BLM):

In Washington State, grazingland managed by BLM is regulated under section 15 of the Taylor Grazing Act, which dictates leasing procedures. In BLM's Spokane Planning Area, which contains most if not all BLM-owned rangeland in Washington, 30,030 Animal Unit Months (*AUM, defined below) of livestock use are presently authorized on 232,809 acres of public land; 386 lessees graze livestock on 390 allotments, exclusively on the east side of the state. Due to the past pattern of land sales BLM-owned grazingland is very scattered: a small, isolated BLM parcel may be situated in the middle of a large parcel under private ownership.

By law, BLM grazing lands are leased only to those owning or in control of property adjoining BLM lands. The lease-fee is based on a formula set by executive order and varies depending on livestock prices and production costs, but cannot increase or decrease more than 25% from one year to the next, and cannot fall below a certain minimum fee. The current lease fee is $1.86 per AUM.

While leases are renewed every 10 years, they are commonly retained in perpetuity unless the lessee is found out of compliance with lease agreements or other regulations. BLM can sever the lease of any lessee found to be out of compliance (per telephone conversation with Mr. Richard Hubbard, BLM, (509) 456-2570).

Prior to making improvements on leased grazingland, lessees must receive approval from BLM; all improvements must be in accordance with BLM-approved practices. Improvements may be made by the lessee, by BLM, or as a cooperative effort involving the lessee, BLM, and/or other agencies.

Forest Service

In 1987, U. S. Forest Service land in Washington suitable for grazing totaled 1.1 million acres (this total includes 0.5 million acres of suitable transitory range available on timber management or other vegetative management areas). Current plans authorize grazing on U. S. Forest Service land in Washington at a level of 119,600 AUMs (animal unit months); actual use in 1987 was 104,800 AUMS. A total of 32,400 thousand animals graze this land: 22,400 cattle and 10,000 thousand sheep.

Actual grazing is 14,000 AUMs (or 12.4 percent) less than could be authorized in Washington on U.S. Forest Service land under current plans, or approximately 12.4 percent.

*AUM - Generally, the amount of forage consumed by one cow in one month. Specifically, the amount of forage consumed by one mature cow and calf under six months, for one month. The amount of forage consumed by one horse, or five sheep, or five deer, or six bighorn for one month is considered equal to one cow AUM; also a unit of measurement of grazing privilege that represents the privilege of grazing one animal for a period of one month.

The Forest Service leases grazingland under two different types of permits: 1) a long-term permit; and 2) a livestock use permit:

1. Long-Term Permits are long-term and renewed every 10 years.

2. Livestock-Use Permits are issued for grazing activities after it has been determined by Forest Service staff that forage manipulation will achieve desirable land-use goals, such as site preparation prior to reforestation, or to facilitate wildlife enhancement.

Soil Conservation Service (SCS) (Department of Agriculture):

The Soil Conservation Service (SCS), identified as the technical agency of the Department of Agriculture, does not either administer or have jurisdiction over land. Rather, the SCS provides technical, and sometimes financial help to individuals, groups, organizations, cities, towns, and county and state agencies. Soil and water conservation is the focus of technical assistance provided. While the majority of effort is with private land owners, SCS personnel also work with state and other federal agencies through coordinated resource management.

Assistance includes collecting data used by land managers to determine resource needs and developing plans designed to better manage grazing-land. Data collection includes surveys conducted to assess grazingland condition; much of the data used in this report originated from SCS surveys of grazingland.

Washington State Agencies

Wildlife

The Washington State Department of Wildlife does let leases for grazing on Department of Wildlife land, but only when grazing is designed to enhance the value of that land to wildlife. For example, if a Department of Wildlife Area Manager determines that livestock grazing during a certain time of year would improve the value of an area as deer-winter-range, a grazing management plan would be developed. If approved and land put-out for lease, the lease would contain specific conditions to accomplish wildlife objectives as specified in area manager's grazing management plan (per telephone conversation with Chuck Perry, Department of Wildlife - Moses Lake, (509) 765-6236).

As of April, 1989, Washington State Department of Wildlife had 139,999.9 acres under lease scattered throughout the state, with a vast majority in eastern Washington. Lease prices are set according to the number of AUMs per parcel; the current charge to lessees is $3.46 per AUM. Current leases encompass 11,101 AUMs.

Natural Resources

Of the five million acres of land managed by the Department of Natural Resources in 1988, three million acres was upland and generated income for various trust beneficiaries. Of these three million acres, 994,658 acres were managed as grazing lands: 283,654 acres under grazing permit (98 permits), and 711,004 under grazing lease (1,700 leases). In 1988, total revenue from grazing permits and leases was $582,120.

Historical Sources of Non-chemical Degradation/Loss of Rangelands

Since the last quarter of the 19th Century, Eastern Washington generally has been subjected to the alteration of native vegetation. Where rainfall, soils, and topography were suitable, large areas of dry land grain farming have replaced the native grass and sagebrush cover (BLM Range Management Plan, pg. 13). The Columbia Basin, which originally supported a semidesert-type plant association, is now the site of the Bureau of Reclamation's Columbia Basin Project.

In addition to conversion to other uses, rangeland has undergone prolonged periods of extensive overgrazing. Historical over-grazing caused damage so severe that land has yet to recover -- we are still striving to restore lands damaged prior to 1900.

Key indicators (Unit of Measure)

Identified ecological risks to grazed land in Washington State include:

1. Reduced forage due to over-grazing

2. Inundation by noxious weeds,

3. Conversion of grazing land to cropland, and

4. Destruction of forage vegetation resulting from recreational activities.

5. Soil Erosion

6. Drought

One "key indicator" with which to measure the amount of damage from each of these categories is the total number of acres of rangeland, grazable forest, and pastureland impacted by each stressor. The method most commonly used to rate grazingland condition is by "successional stage," explained below.

Successional Stages

As explained by BLM (___. 1984), ecological condition -- the present state of the vegetation of a site in relation to the climax plant community for that site -- is described as successional stages of plant communities. It is an expression of how closely the present plant community resembles the original community in its highest state of ecological development. The climax plant cover on Washington's rangeland is mostly native grasses, forbs, and shrubs valuable as forage for wild and domestic animals. There are four successional stages, climax, late seral, middle seral, and early seral, as defined below:

1. Climax state - a plant community in climax stage is a community that exhibits little change in species composition compared to the potential climax plant community for the site -- between 75% and 100% of the kinds and amounts of vegetation produced would be found in climax.

2) Late seral stage - these communities produce between 51% and 75% of the kinds and amounts of vegetation found in climax.

3) Middle seral stage - these communities produce between 26% and 50% of the kinds and amounts of vegetation found in climax.

4) Early seral stage - these communities produce between 0% and 25% of the kinds and amounts of vegetation found in climax.

CURRENT STATUS

This report assesses condition of grazingland more in terms of value as livestock forage than value as wildlife habitat/forage. However, because the assessment of grazingland condition for livestock forage is based on relative health of plant communities, this evaluation should also represent the status of grazingland with regard to wildlife.

To get an estimate of the condition of Washington rangeland, Soil Conservation Service employees surveyed approximately 0.05 to 2 percent of private and state rangeland. Approximately 2450 observation plots were surveyed, but because the 1981 surveys were limited to rangeland and pastureland, results do not provide information on the condition of grazable woodland. The condition of rangeland, as determined by analysis of survey data, is shown in Table 1, below.

Table 1
Non-federal Land Condition (1982, SCS)
Percentage and Acreage

Climax (Excellent)	11%	620,070
Late Seral (Good)	21%	1,183,770
Middle Seral (Fair)	32%	1,803,840
Early Seral (Poor)	34%	1,916,580
Other	2%	112,740

Based on this survey and other information, the SCS reports:

> More than 65 percent of the non-federal rangeland [5,637,000 acres] in Washington is producing 25 percent of its potential. This represents a minimal loss of 20 to 30 million pounds of red meat each year for Washington ranchers.
>
> As range condition deteriorates, grazing options are reduced. Therefore, managing the resource becomes more difficult.
>
> About 35 percent of the non-federal rangeland acreage has an overabundance of shrubs and lacks native grasses and forbs.

The SCS estimates that 27 percent of all rangeland (SCS), 40 percent of grazed forestland; and 39 percent of pastureland in Washington State require additional conservation treatment.

The Washington State Grazingland Assessment augments SCS data shown in Table 1 with information on the condition of pastureland and grazable-woodland. Information from the SCS surveys and a search of U.S. Forest Service files (for grazable woodland information) was compiled in the assessment as excerpted below:

Rangeland

Thirty-nine percent of the rangeland is estimated to be in poor condition, producing less than 25 percent of its potential livestock forage. In addition, 30 percent of the range is in fair condition, estimated to be producing between 25 and 50 percent of its potential and 11 percent is in excellent condition approximating full capacity. [see Table 2]

Grazed Woodland

This type makes up more than one third of the total grazable land in the state. Condition on grazed woodland is determined on the basis of the present production compared with what is expected under best forage species composition and growth. The four categories shown for woodland in Table [2] have a different meaning than the four range condition categories previously explained. If conventional range-site ratings were used, excellent condition in woodland, would imply maximum trees (climax association) and minimum forage in the understory. Best conditions for forest livestock grazing would be no trees (poor condition forest) and full understory coverage of forage plants.

In Table [2], the "not grazed" column lists the percent of woodland not grazed. The following comments refer to the condition of grazed portions, with specific references to the "low" and "moderate" fractions.

Overall, the forage value of grazed woodlands is poorer than that of range lands. Reference is made to the average line at the bottom of Table 2. Grazed woodlands, exclusive of the ungrazed areas were evaluated with 37 percent in low forage value and 28 percent in moderate forage value, totaling 65 percent with less than acceptable productive levels.

Data are not available for Columbia, Garfield, and Walla Walla counties, where there is woodland grazing, or Benton, Douglas, Franklin, Grant, or Whitman Counties, where there are no or few grazed woodlands.

Pasture

Estimates may be of questionable accuracy due to small numbers of plots sampled. Nevertheless, the data is presented because it is the only information available until a more comprehensive survey can be made. Therefore, caution should be used in drawing conclusions from data given in Table [3].

Seventy-two percent of pastures examined fell into the "poor" and "fair" condition. Only 28% were rated "good", and none excellent.

Table 2. Range Condition and Woodland Forage Value, by County, for the State and Private Grazing Lands of Washington, 1981.

	Range Conditions				Woodland Forage Value				
	Excellent	Good	Fair	Poor	Very High	High	Moderate	Low	Not Grazed
	%								
Adams	7	10	30	53	4/				
Asotin	11	33	34	22	11	5	19	65	
Benton	7	14	32	47	4/				
Chelan	2	18	41	39	1	5	19	34	41
Columbia	4	28	23	45	4/				
Douglas	13	42	33	12	4/				
Ferry	5	35	34	26	.3	15	40	44	1
Franklin	6	13	34	47	4/				
Garfield	5	21	35	39	3/				
Grant	3	16	22	59	4/				
Kittitas	17	31	34	18	3	7	21	32	37
Klickitat	19	11	25	45	2	14	20	48	16
Lincoln	12	19	29	40	6	34	24	24	12
Okanogan	1	7	58	34	4	13	52	24	7
Pend Oreille	1/				0.6	0.6	4	30	65
Spokane	3	32	21	44	1	17	50	32	
Stevens	5	5	18	72	3	7	35	52	3
Walla Walla	8	12	24	56	4/				
Whitman	2	17	25	56	4/				
Yakima	28	24	21	27	2	6	26	27	39
2/ Weighted Average	10.8	19.6	30.5	39.0	3	11	28	37	21

Source: Original data, compiled from Soil Conservation Service, National Resource Inventory, 1981

1/ No significant amount of range.

2/ Weighted by acreage in each county.

3/ Not available

4/ No significant amount of grazed woodland

Table 3. Pasture Condition in Washington, 1981[1/] (%)

County	Good	Fair	Poor
Adams 2/			
Asotin	29	29	43
Benton	13	50	38
Chelan	29	41	29
Columbia 2/			
Douglas 2/			
Ferry	31	54	15
Franklin 2/			
Garfield 2/			
Grant	40	40	20
Kittitas	32	55	14
Klickitat	9	45	45
Lincoln	29	43	29
Okanogan	14	72	14
Pend Oreille	38	25	38
Spokane	40	40	20
Stevens 3/	11	37	42
Walla Walla 2/			
Whitman	29	71	--
Yakima	42	35	23
Average:	28	46	26

Source: Original data, compiled from SCS National Resource Inventory, 1981

1/ Due to small sample size in survey of this resource, confidence level is low.
2/ Too few survey points.
3/ Eleven percent not computed in pasture data.

The Bureau of Land Management (BLM) and the U.S. Forest Service have also assessed the condition of rangeland under their respective jurisdictions, as discussed below.

From 1975 to 1981, 149,156 acres of public land under BLM's jurisdiction and leased for livestock grazing were surveyed for ecological condition. The remaining 83,334 unsurveyed acres of public land, in small tracts scattered throughout the Spokane Resource Management Area, were not surveyed because of cost.

Appendix E of the Final Environmental Impact Statement on the BLM Range Management Plan (______. 1985) provides survey results by management area, including: total area of public land, livestock number and class, grazing period beginning to end, number of AUM's authorized, ecological condition, and AUM estimated carrying capacity. Ecological condition of BLM rangeland, based on these surveys, are shown in Table 4.

Table 4
BLM Range Ecological Condition (Acres)

Climax	7,493
Late Seral	35,376
Middle Seral	40,725
Early Seral	59,556
*Seeding	1,249
*Unclassified	106,324

*Seeding - not defined

*Unclassified - Designation for areas without vegetation or unsuitable for grazing such as rock outcrops, sand dunes, or extremely steep slopes.

Written correspondence on file with the U.S. Forest Service provides information on rangeland within Forest Service jurisdiction. This information, supplied by the U.S. Forest Service Director of Ecology, Range, and Watershed, was used to develop Table 5, below.

Table 5
Ecological Status, Forest Service (1986)
Thousand Acres

Climax	87.98	8.0%
High Seral	158.84	14.6%
Mid-seral	418.28	38.2%
Low-seral	430.28	39.3%

SUMMARY OF RISKS TO RANGELAND

The only Environment 2010 ecological risk assessment to consider direct effects on range land is "Nonchemical Impacts on Rangeland," which identifies the following sources or stressors: recreation activity, overgrazing, erosion, and conversion to cropland. The various effects of these stressors include noxious weed introduction, native plant kills, soil compaction, loss of plant cover, alteration in mix of plant species, loss of topsoil, and loss of forage and cover for wildlife.

The risk assessment reviews range conditions in terms of the successional stages of vegetative cover--climax, late (or high) seral, middle seral, and early (or low) seral--and finds that, "...10% of Washington State rangeland is in 'Excellent' condition, 20% is in 'Good' condition, 32% is in 'Fair' condition, 35% is in 'Poor' condition and 3% is either unsurveyed, seeded or unclassified."

According to the risk report, "Over-grazing has been attributed as the cause of a 'less than good' (either poor or fair) rating of approximately 3,547,000 acres of grazable land in Washington State..." and "...Approximately 560,000 acres of grazingland are rated poor or fair due to inundation by noxious weeds." The report also notes an SCS estimate that 27 percent of all rangeland and 40 percent of all grazed forestland require additional protection from erosion. The estimated erosion rate for rangeland is 1.1 tons per acre per year, and for grazable forestland, .8 tons per acre per year on average. The thin soil cover and the low rate of natural soil formation on the range make even these low erosion rates (relative to cropland) unacceptable.

The "Nonchemical Impacts" report characterizes the scale of impacts on rangeland and grazed forestland as "broad," and bases this conclusion on the size of the range itself (23 percent of the state's land), and on the finding that 67 percent of the range is in a condition less than "Good." The report finds that the impacts are reversible, but warns that, "...rangeland restoration is an unusually long term proposition, requiring literally decades in most cases. The low precipitation rates, thin soils and competition between introduced plant species and native rangeland plants for limited water and nutrients are all factors in determining the length of time required to regenerate a degraded parcel of rangeland."

In addition to this ecological risk assessment, RCG/Hagler, Bailly prepared an economic risk analysis, "Welfare Effects of Nonchemical Impacts on Rangelands." This analysis uses the measurement of Animal unit months (AUMs) as an indicator of economic losses. The report defines an AUM as "..the amount of forage required by one mature cow with calf, or equivalent, for one month." The number of acres required to support one AUM varies by the condition of the range--the better the condition, the fewer the acres required.

The analysis calculates the the number of AUMs supported by those portions of the range in middle and early seral stages (fair and poor condition), and compares those figures with the number of AUMs those portions of the range would support if they were in the late seral stage (good condition). The difference is expressed in terms of lost AUMs. The analysis assigns a value of $8.00 per AUM, and calculates a total dollar loss of $1,877,276. Presumably this is an annual loss, but the report does not make this explicit.

A second calculation of economic loss expresses the loss in terms of lost value of beef. This analysis assumes that each AUM produces 50 pounds of beef, and that beef is worth $0.75 per pound to the rancher at sale. On this basis the report estimates a loss of $8,799,730, again presumably but not explicitly an annual loss.

CONCLUSIONS

The harsh environment of the range belies the fragility of this ecosystem. According to the ecological risk assessment, "The climax plant community on rangeland and grazed forestland is sensitive and highly productive. Additionally, the association of plant species on the semi-arid rangelands may be unique to those lands..."

The range is vulnerable to several stressors, the most important of which appear to be over-grazing and inundation by noxious weeds. Of the 4,669,261 acres of range in fair to poor condition, the degradation of some 3,547,000 acres (76%) is attibutable to over-grazing. For an additional 560,000 acres (12%), the inundation by noxious weeds caused the damage.

The sensitivity of the range is evidenced by the time required for it to recover from degradation. With thin soils and low precipitation rates, the range can take decades to return to its climax stage, if it ever does. A full two-thirds of the state's rangeland is currently in the middle or early seral stages--fair to poor condition. The large proportion of the rangeland in deteriorated condition, the long time required for recovery, and the demand for rangeland for agricultural and recreational purposes combine to suggest that the rangeland resource is, and will continue to be in jeopardy in Washington State.

POSITIVE ASPECTS OF THE RESOURCE

Regarding rangeland in good or excellent condition, the Washington Grazing Land Assessment states:

> About thirty percent of the state's rangeland is reported to be in satisfactory (good or excellent) condition, requiring no further treatment than continued careful grazing management. However, data...show that the largest category of excellent and good condition range is on shallow and very shallow sites where renovation treatments are difficult. Therefore, the proportion of land suitable for renovation which needs major treatment is much greater than the percentages would indicate. It should be noted that all

> land being used needs some form of management. Even adequately protected grazing land requires some form of a grazing system or plan and proper use.

The Washington Grazing Land Assessment also provides the following insight into the importance of rangeland:

> The demand for public grazing land use in Washington is high, to balance the summer forage needs of livestock operations based on disproportionately large amounts of lower elevation private land. With less rangeland acreage than other western states its condition becomes extremely important to stockmen and others who benefit directly or indirectly from range productivity. Washington stockmen depend on low cost range forage to keep them competitive with producers in other regions....

GRAZING LAND MANAGEMENT

Except for brush control, grazingland is managed by regulating the intensity, season, and frequency of grazing. Each agency with major responsibilities for managing grazinglands has employed a variety of land-management tools to restore and/or protect land-resource values. These strategies often involve one or more of the following:

1. Livestock Use Adjustments - A) kind or class of livestock, B) season of use, C) stocking rate, or D) pattern of grazing; and/or

2. Range Improvements and Land Treatments - A) fencing, B) water development, C) brush control, D) seeding, E) noxious weed control.

Each agency with jurisdiction over grazingland has some type of formal management plan to guide decisions regarding the need for, and type and timing of, rangeland improvements listed above. These plans, which may strongly influence the future condition of rangelands, are discussed briefly below.

Department of Natural Resources

Management of agricultural and grazing land under DNR's jurisdiction is guided by the Agricultural and Grazing Lands Program, finalized December 1988. The following are excerpts from that plan that most specifically affect management of grazing lands.

Policy Explanations: Trust Assist Management

Land Use Conversion

- Change the use of property to highest and best use when the capitalized value of expected net lease revenues and asset values are substantially greater than those of the current use.

Land use conversion (for example, converting grazing land to irrigated agricultural land) can increase income to the trusts; therefore, the department seeks opportunities to convert land to highest and best uses and to develop management plans that make such conversions possible. Land use conversion is contingent upon reasonable management costs and an acceptable level of risk. Keeping in mind that it is managing trust lands over time, the department will recognize and discount income potential. Converting grazing land to orchard, for example, would provide no return from the crop for several years, but an established orchard would likely provide substantially more income and increase the asset value over time. In such cases the department will analyze income loss and potential gain in current capitalized dollars.

Capital Investments by the Department

- Make capital investments on agricultural and grazing lands to enhance the income and asset value when such investments meet acceptable financial and risk criteria.

Development of agricultural and grazing lands has been successful despite wide fluctuations in product markets when each project begins with a realistic assessment of both anticipated costs and revenues. The department can make capital investment decisions according to individual case considerations, taking into consideration the possible economic benefits by analyzing the project's net present value, internal rate of return, and benefit/cost. The department prepares six-year capital project plans and updates them biennially. Ultimately, capital investments must be scrutinized by the Office of Financial Management before being submitted to the legislature for funding through the Resource Management Cost Account. The department will track the returns on capital investments.

The department's capital investments will be limited within budgeted funds to those projects that demonstrate economic feasibility and require little or no maintenance: irrigation wells, for example, require less maintenance than irrigation pumps.

Capital Investments by Others

- Authorize capital investments on agricultural and grazing lands when in the best interest of the trust beneficiaries.

Over the years, lessees have made substantial capital investments on trust agricultural and grazing lands to enhance income and management. Typical investments have included fencing, spring developments, storage facilities, orchards, irrigation systems and management residences. Lessees should note that the department does not subordinate trust land (the rights of the trust will remain superior to those of any lender); however, mortgages can be secured by the leasehold interest.

The department may authorize improvements that benefit the use for which the land is leased or that increase the value of the trust assets. All improvements on trust lands require prior written authorization; how the improvements will be made and how they will be disposed of is specified in contracts and defined by statute (RCW 79.01.092). Ownership of improvements at lease expiration typically will remain with those who placed the improvements on the land. RCW 79.01.136 and 79.01.148 mandate compensation for authorized improvements and define the means by which such improvements will be valued.

Applied Research

- Develop options for timely implementation of management techniques that are based on current research.

Department staff strive to stay current with applied research that, when implemented by lessees, will make the land more productive. Field staff maintain direct contact with lessees. The department, in cooperation with Washington State University Cooperative Extension, is available to provide both information and assistance.

The department, through the USDA Soil Conservation Service (SCS), can provide its lessees "field-proven" methods for reducing soil erosion. Using Resource Protection Agreements (RPA), the department along with SCS staff can develop an agreement with lessees that will permit them to incorporate new methods of farming into their management practices. Examples include annual cropping, leaving more stubble residue in the field, planting cover crops and conversion to "no till" farming.

Recognizing the diversity of land uses and lessee management, the department will be flexible in its recommendations for applying new technology. Many factors, including the cost and the degree of change from current methods must be considered by the department.

Weed and Pest Control

- Actively participate with public and private sectors in developing and implementing pest and weed management programs that are compatible with department goals.

The Noxious Weed Control law (RCW 17.10) insists upon control and emphasizes that primary control rests with landowners. Lessees are responsible for weed and pest control on leased land while the department is responsible for unleased lands. The department will participate at state, regional and local levels to meet its legal obligation to control weeds on trust lands. Recognizing that weed infestation is not bound by land ownership, the department will actively seek the cooperation of landowners, lessees and other agencies in the control of noxious weeds when in the best interest of the trust.

Pests may pose threats similar to those of weeds. There are instances when the department may undertake or assist with pest control. An example would be severe grasshopper infestations on rangeland.

Policy Explanations: Woodland Grazing

Grazing Systems

- Employ a cost-effective, flexible woodland grazing management system to provide sustained optimum resource production and protection.

Whether grazing is authorized by permit or lease, the department will be guided by the following common objectives:

- Secure the highest return through good management practices.

- Conserve the natural resources on both state and related lands through wise use, protection and development.

- Correlate the best practical, social and economic use of state lands with adjacent lands when in the best interest of the trust beneficiaries.

- Promote a healthy livestock industry that makes use of state land.

To achieve these objectives, the department is developing a grazing management program that will allow flexibility for managers and users to balance production and protection. The department is concerned with measures to sustain range in "good" condition and to improve range in "poor" condition. Management of trust grazing lands must be efficient and also effective to ensure that operations benefit the users of the grazing resource while meeting trust obligations.

Grazing Management Planning

- Coordinate grazing and forestry use in forest and management planning and communicate planned activities with affected parties.

To meet its objectives, the department will integrate grazing and forestry production in its resource management planning efforts and involve those affected. For example, the department participates in several Coordinated Resource Management Plans (CRMP) in Eastern Washington. CRMP is a process that allows lessees, permit holders, private and other public landowners, and the department to interact in a cooperative atmosphere in developing management plans for a designated geographical area. Through CRMP, the department and other participants are able to achieve their objectives while maintaining or improving the resource base.

Forest Service Grazing Land Management System

The forest service manages leases according to their Coordinated Management Plan, a plan that has been in effect in some form for at least 40-50 years. The following management strategies are outlined in the current Coordinated Management Plan:

1. Use appropriate methods, such as grazing use by livestock or wild ungulates, prescribed fire, and mechanical or chemical treatments, for managing range vegetation.

2. Identify and inventory range resource values, including riparian, upland, and other critical areas to determine which areas meet or do not meet forest land and resource management plan objectives.

3. Implement and monitor measures to restore and enhance plant diversity and productivity, water quality, and soil stability.

4. Enhance or maintain the habitat of threatened, endangered or sensitive species of plants and animals.

5. Determine suitability and potential capability for producing forage for grazing and browsing animals and for maintaining and enhancing habitat for fish and wildlife Management Indicator Species.

6. Consistent with forest land and resource management plans, make forage available to qualified livestock operators from lands that are suitable for livestock grazing.

7. Issue term permits, generally for ten-year periods with appropriate terms and conditions, to allow use of range vegetation and promote stability for livestock enterprises.

8. Coordinate, cooperate and consult with grazing permittees and grazing associations, and other interested parties in the development of allotment management plans.

9. Emphasize permittee and association responsibility and accountability for meeting terms and conditions of permits, allotment management plans, and annual operating plans.

10. Recover administrative costs of permit transactions initiated by the permittee.

11. Manage wild free-roaming horse and burro populations in a thriving ecological balance within established territories.

12. Manage noxious weeds, using integrated pest management techniques in close coordination and cooperation with adjacent landowners and agencies.

13. Use cost effectiveness in range vegetation management.

14. Optimize involvement of expertise within the Forest Service, from other agencies, organizations, permittees, and others in range vegetation management.

15. Integrate range management and resolve conflicts through Coordinated Resource Management by promoting voluntary cooperation among agencies, groups and individuals responsible for range resources on other land ownerships.

Bureau of Land Management Grazing Land Management System

In 1985, BLM issued a final Proposed Resource Management Plan and final environmental impact statement (FEIS) on that plan. The FEIS described several alternatives; Alternative B (Proposed Resource Management Plan was adopted as the plan under which BLM grazingland will be managed. As explained in the FEIS, this plan:

". . . would develop allotment management plans (AMPs) and/or coordinated resource management plans (CRMPs) for the I allotments to establish livestock use levels, grazing systems, seasons of use, and range improvements to accomplish multiple use objectives of livestock forage production, wildlife habitat, and watershed needs. CRMPs for the public land outside the I and M allotments would be developed. A moderate level of livestock use to maintain or protect other resource values would be emphasized. Authorized livestock use would initially remain at currently authorized levels for the 16 I category allotments but would be adjusted through collection and analyses of monitoring data to achieve 50 percent utilization of key forage species.

Maintain (M) Category Allotment. These are grazing allotments where satisfactory management has already been achieved through Conservation Plans, Coordinated Resource Management Plans, or Cooperative Agreements with adjoining landowners.

Improve (I) Category Allotment. These are grazing allotments that have a potential for resource improvement where BLM controls enough land to implement changes.

AMPs are developed to establish grazing systems which specify season of use, numbers of livestock, and range improvements and treatments designed to meet resource objectives. In some allotments, production increases may be realized only through improved grazing systems.

CRMP's are used in areas where there are multiple landowners (private, county, state, and federal) and/or where there may be concerns/problems for which an interdisciplinary (range, forestry, wildlife, watershed) approach would provide better technical assistance. Both of these types of management plans are used to document resource objectives and supply technical direction to achieve those objectives such as reducing soil erosion, improving deer winter range, increasing livestock forage, and so forth.

Since 1985, BLM has been working to develop AMPs and CRMPs for all designated I and M allotments, but this task is not yet complete. In addition to plan development, there has been some discussion of amending the Resource Management Plan to recategorize some allotments from M to I, however, the schedule for these amendments is undetermined.

SUCCESS OF EXISTING PROGRAMS

Both the SCS and BLM have conducted grazingland-condition surveys subsequent to the 1982 surveys. However, because analytical results are not yet available, examples are provided to illustrate the potential positive affect of applied range management.

Soil Conservation Service

Based on observations during recent grazingland surveys (data not yet available), Dennis Froeming (SCS, Spokane Office) feels that the data will show an overall improvement on grazinglands managed using strategies suggested by the SCS through their management plans.

The SCS has seen excellent results from their Resource Management System. The following are two examples of the success possible when suggested grazing-land management practices are used. The first example illustrates the use of managing, by grazing early in spring before perennial grasses emerge, rangelands dominated by annual grasses that have a ruminant population of perennials. Soil Conservation Service technical staff reviewed the grazing cycle of a rancher who was grazing cattle on approximately 400 acres. It was this ranchers practice to graze his livestock during the normal spring season when perennials were 6-8 inches tall. Prior to changing his grazing cycle, the vegetative composition was approximately 5% perennial grasses and 90%-95% annual grasses. Perennials provide a much more stable source of forage than do annuals, and are therefore the preferred grazingland vegetation for livestock forage.

Within three years, seeded perennials increased to about 80-90% of the total vegetation composition and annual grasses subsequently declined. Native species, which grow much more slowly than seeded grasses, also increased from about 10% of the total composition to roughly 30%-35%. This dramatic improvement was achieved simply by manipulating grazing rotation, and success was achieved at little or no cost.

In another case, one cattleman installed fencing to control livestock movement so that he could rest one part of the field and graze the other, rather than letting the cattle wander. Improvements encouraged the growth of the perennial grasses. As a result of the perennial growth he has been able to reduce his use of chemicals to control yellow-star thistle at a savings of from $1,200 to $400-$500 per year.

This rancher spent approximately $15,000 dollars for these improvements, however, positive results were not immediately realized -- it took a few years for improvements to show. Although this rancher has not yet recovered his expenses, he expects to within 6 to 8 years.

The SCS (_____. 1988) explains the disadvantages of deteriorated range, and points to the advantages of improvements such as those realized by the ranchers discussed above:

> Deteriorated range adversely affects livestock and wildlife populations. On poor range, animal growth is reduced. A Montana study showed that calves on overgrazed land weighed 75 pounds less than those raised on properly grazed, fair condition range. Going from fair to good range conditin increased calf weights another 25 pounds. If all the poor and fair range were improved to good condition, another 27 million poounds of beef could be produced. Fertility in cows would also be increased from 82 percent to 94 percent which would increase the number of calves weaned by almost 3,000. These increases in production could apply proportionately to Washington State with no appreciable increase in cost. For example, if all treatable range in Klickitat County were brought up to good or excellent condition, income could be increased 4 million dollars per year.
>
> About 3.2 million acres of poor/fair condition range are considered treatable in Washington. Improvements of these lands would result in increased forage and red meat production, improved water quality and wildlife habitat, and reduced flood hazards and soil loss.

BLM

Bureau of Of 390 BLM allotments, eight are grazed under either an Allotment Management Plan (AMP) or a Coordinated Resource Management Plan (CRMP). These allotments have been monitored since 1985, but data will not be available and analyzed sometime late 1990. However, initial site visits indicate the sites are generally improving compared to those that are not under management plans.

Impact of Population Growth

In development

Future Status

As the following Grazing Land Assessment discussion indicates, it is difficult to project future range condition:

> Little information is available for either the National Resources Inventory or U.S. Forest Service files regarding the changing trends in range condition. The question is whether the range is improving (upward trend), being depleted (downward trend), or not changing (static trend) is only partially answered on a state-wide basis at present.
>
> A preliminary estimate of trends may be had by comparing the results of the 1981 Natural Resources Inventory results with similar information from the 1967 Soil and Water Conservation Needs Inventory. To do this, it is necessary to assume that the 1967 conservation needs category "treatment adequate" is equivalent to the 1981 NRI categories for "good" and "excellent" range condition. Rangeland under "treatment adequate" in 1967 amounted to 30.5 percent of the total, while 1981 good and fair condition acreage amounted to 30.4 percent, indicating no change over this 15 year period. This result is much closer than expected in a 2% sample, and undoubtedly overemphasized the confidence that can be placed in the outcome. Estimates of change in pasture and grazed woodland condition are not readily available.
>
> Trend evaluations are critical to management decisions, but practically impossible to observe without at least two observations separated by 4 to 6 years. This is why permanent monitoring plots are essential. Follow-up data will have to await future inventory work.

The SCS has completed an additional survey of rangeland condition since publication of the Grazingland Assessment, however, an analysis of data collected will not be available until until 1990, at the earliest.

Dennis Froeming, Soil Conservation Service Range Manager (Spokane Office) estimates that there will be a dramatic improvement in grazingland quality over the next 20 years. He has seen a tremendous change in attitude towards maintaining good quality riparian habitat, and feels that this improved attitude will have spinoff effects including improved attitudes towards management upland.

He has observed that ranchers recognize that there may be more than one way to profit from grazinglands. Currently, people trespass on grazingland for hunting and other recreational opportunities. This "trespass" is now being seen as a commercial opportunity -- i.e. charging for the privilege of recreating on privately held grazinglands. This may be the way of the future, but potential impacts (either beneficial or detrimental) have not been analyzed. However, eventually, the "trespass fee" could provide incentive to ranchers to invest in grazingland improvements to increase the land value to hunters, which in turn would increase all wildlife values of such lands.

The U. S. Forest Service provided the following information indicating the trend of range condition on U. S. Forest Service land:

Table 6
Rangeland Condition - Trends
U.S. Forest Service Land

Towards Potential (Towards Climax)	871.18	79.5%
Away from Potential	112.43	10.3%
Static	111.85	10.2%

Note: The Forest Service qualifies interpretation of trends shown as away from potential:

"...most of the acres are transitory range temporarily grazed during forest regeneration. Ecologically, these acres are on a steady upward trend toward a timber-type climax. From a range view, these same acres are on a downward trend (away from grazing potential as measured by forage production and plant composition). The mix of the two confuses and presents a false picture of the range condition....

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THE STATE OF THE ENVIRONMENT REPORT

VOLUME II
Part 3
Section D

Land Resource
Characterization Report
for
Agriculture Lands

ENVIRONMENT 2010

State of Washington
October, 1989

AGRICULTURAL LANDS RESOURCE CHARACTERIZATION
EXECUTIVE SUMMARY

FINDINGS: Washington farmers are using the state's agricultural lands generally in accordance with the lands' inherent capabilities. Technological inputs can mask the impact of erosion on crop yields, and farmers must continue or increase these inputs to manitain crop yields. The consistently high production values of agricultural output are evidence of an important resource well used. Most Washington soils remain in Phase 1 of the Soil Conservation Service's evaluation of erosion--the cropland is losing topsoil, and farmers are working the bottom part of the original A and the top of the B horizons. According to the SCS, farmers can continue to work in this phase at high levels of production indefinitely, given proper management of the resource.

Erosion poses a serious threat to Washington's cropland. The state-wide average annual erosion rate is over three tons per acre higher than the SCS maximum acceptable rate (five tons/acre/year). All of the excessive erosion occurs east of the Cascades. Seven of the top ten counties in net farm income are on the east side, and the composite average annual erosion rate for these counties is 9.48 tons per acre per year. Regardless of its cause, erosion depletes soil fertility and water retention capacity, and topsoil loss eventually leads to decreased production capacity. In addition to this long-term cost to farmers, erosion also significantly increases short-term costs in several ways.

Despite the long-run consequences and the high short-term costs of erosion to farmers, the costs of erosion controls are as much as three times higher than the economic benefits to the farmers. The Conservation Reserve Program (CRP) is succeeding in providing economic incentives to farmers to take highly erodible land out of production, but some farmers still earn more income by farming their CRP-eligible land. CRP is limited, too, in its applicability: some of the cropland experiencing high erosion rates is highly productive land that should remain in production, but with additional erosion controls in place.

POSITIVE ASPECTS OF THE AGRICULTURAL LAND RESOURCE: One of the main benefits of agriculture, and therefore one of the positive aspects of the agricultural land resource, is so obvious that it is often taken for granted: food. Washington State farmers produce an abundance of food. There are many elements that contribute to the agriculture economy in the state, but the state's cropland provides the essential base. The Department of Agriculture's AG-2000 report states that, "The natural resource endowment is an integral part of the productivity that has propelled Washington farmers to produce more potatoes per acre, more milk per cow, and more dryland wheat per acre than farmers in any other state." One of the most important positive aspects of Washington's agricultural land, therefore, is that it supports the state's vibrant farm economy.

The agricultural land resource also supports a cherished American institution--the family farm. Our somewhat idealized esteem for the institution occasionally leads to the mistaken conclusion that the family farm is a nostalgic relic that has passed its usefulness. But the data suggest that our confidence in the family farm is well placed. The USDA itself studied this issue and reached the conclusion that, "...the economies associated with size in farming are achieved by the one-man fully mechanized farm."

The family farm in Washington is both a part of American tradition and an important contributor to contemporary agricultural production. The generally good condition of the state's croplands is directly attributable to the capable stewardship of these farmers. The inherent quality of the agricultural land resource provides the opportunity for sustainable, high levels of agricultural production, and the family farms embody both the tradition and the modern efficiency necessary to make the most of the opportunity.

PROJECTIONS: The introduction of AG-2000 states that, "...to recognize and design the attitudes, decisions, and actions today that will chart the course for the next generation of agriculture has proved a formidable challenge in this industry." Among the emerging issues in Washington agriculture, AG-2000 identifies natural resource use and conflicts, including the following: water, soil, and chemical use; regulatory controls on production practices; and environmental-economic conflicts. The AG-2000 Natural Resource Management paper states that, "Agriculture has been placed in defensive positions regarding many resource use issues, and this has weakened the industry's efforts to provide leadership in negotiating natural resource use guidelines."

In anticipation of future conflicts and controversies over these emerging issues, AG-2000 develops a set of strategies in natural resource management. The AG-2000 approach recognizes three objectives: "1) the need for an equitable decision-making process regarding natural resource use and the environment; 2) the importance of developing managerial and regulatory processes to increase efficiency in natural resource use; and 3) the need to provide ongoing education for both the public and agriculture industry about agriculture and the environment." The centerpiece of the AG-2000 strategy is a proposed "...multi-interest coalition of natural resource users, including agriculture." This coalition would provide "...a vehicle for reconciling conflicts regarding natural resources within agriculture." By developing its multi-interest coalition strategy, AG-2000 is demonstrating a confidence in the people of Washington to formulate their own agriculture future.

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AGRICULTURAL LANDS RESOURCE CHARACTERIZATION

I. GENERAL DESCRIPTION OF WASHINGTON'S AGRICULTURAL LANDS

The most important of the several land types that support agricultural practices is cropland, of which there are 7,793,400 acres in Washington state--6,140,000 acres of dry cropland and 1,653,400 acres of irrigated (Soil Conservation Service 1982). This resource characterization focuses on these lands. The range and forest land resource characterizations consider the other lands--pasture, range, and grazable forest lands--that support agriculture.

Much of the data in this report comes from the Soil Conservation Service (SCS), in particular, from the SCS's National Resources Inventory (NRI). SCS conducts this survey every five years, and this report relies on both the 1977 and 1982 findings. The 1987 NRI data are not yet available in detail.

Two commonly used measures of agricultural land are number of farms and land in farms. Washington currently has approximately 38,000 farms, and 16,000,000 acres of land in farms, of which almost half is in pasture, range, and woodlands. Table 1 shows the number of farms and acres of land in farms for 1974-1988 for the state.

TABLE 1: NUMBER OF FARMS AND LAND IN FARMS IN WASHINGTON

Year	Number of Farms (1000s)	Land in Farms (1000 acres)
1974	38.0	16,300
1975	34.0	16,100
1976	34.0	16,100
1977	34.0	16,100
1978	36.0	16,100
1979	37.0	16,300
1980	38.0	16,300
1981	39.5	16,400
1982	39.0	16,400
1983	38.0	16,300
1984	38.0	16,100
1985	38.0	16,100
1986	38.0	16,000
1987	38.0	16,000
1988	38.0	16,000

Source: Washington Department of Agriculture and USDA

Over this same 1974-1988 period, the number of farms in the nation declined from 2,796,000 to 2,159,000, a loss of 637,000 farms, and the land in farms declined from 1,084,433,000 acres to 998,692,000 acres, a loss of 85,741,000 acres. Washington's stability during this period contrasts sharply with the national trends.

The stability of the state's number of farms and land in farms in recent years also contrasts with the state's own longer history. Table 2 presents the farm and farmland trends in the state for selected years from 1959-1982. According to these figures, Washington had 18,692,057 acres of land in 51,554 farms in 1959. This table comes from the 1987 State of Washington "Data Book" published by the Office of Financial Management. The figures come from the Bureau of the Census so they do not perfectly agree with the figures used in the previous table, but they are reasonably close and are useful for this comparison.

TABLE 2: FARM AND FARMLAND TRENDS

	1959	1964	1969	1974	1978	1978[1]	1982[1]
Total Farmland (Acres)	18,692,057	19,052,041	17,559,187	16,661,902	17,002,288	16,721,836	16,469,678
By Farm Size:							
Under 10 Acres	32,192	21,946	17,601	15,642	26,923	19,009	30,403
10-49 Acres	449,880	412,785	267,244	221,077	317,532	245,424	299,868
50-259 Acres	1,921,032	1,702,860	1,296,720	1,138,933	1,243,462	1,101,408	1,110,379
260-999 Acres	3,247,282	3,030,900	2,691,569	2,377,192	2,362,678	2,304,302	2,241,323
1000+ Acres	13,041,671	13,883,550	13,286,053	12,909,058	13,051,693	13,051,693	12,787,705
Total Number of Farms	51,554	45,574	34,033	29,410	37,688	30,987	36,080
By Farm Size:							
Under 10 Acres	6,710	4,604	3,708	3,330	5,950	4,161	6,425
10-49 Acres	18,694	17,098	10,817	8,739	13,289	9,896	12,717
50-259 Acres	16,263	14,290	10,734	9,411	10,512	9,110	9,384
260-999 Acres	6,256	5,815	5,128	4,553	4,592	4,459	4,336
1000+ Acres	3,631	3,767	3,646	3,377	3,345	3,361	3,218

1 Census procedures and methodology were changed for the 1982 census of agriculture. The 1978 data were adjusted to provide data comparable with the 1982 census results.

Source: U.S. Department of Commerce, Bureau of the Census

Table 2 also provides data by farm size. It shows, for example, that in 1982 the state had 3,218 farms of 1000 acres or more, and that these farms held 12,787,705 of the state's 16,469,678 acres of land in farms. The number of remaining farms, all under 1000 acres in size, is 32,862. These farms held the 3,681,973 remaining acres of the 16,469,678 total. The average farm size for all those farms under 1000 acres is 112 acres per farm.

Each of the land measures is useful in its own way, but the various land categories can be confusing. Different agencies have different specific interests that guide their choices of sources for figures and definitions. Table 3 provides an overview of the various land categories used in this report.

TABLE 3: SUMMARY OF AGRICULTURAL LAND CATEGORIES

Cropland	
Dryland	6,140,000
Irrigated	1,653,400
Total Cropland	7,793,400
Other*	8,206,600
Total Land in Farms	16,000,000

* Other includes pasture, range, and grazable forest land.

Source: SCS and Washington Department of Agriculture

In characterizing the agricultural land resource in Washington, this report concentrates on the 7,793,400 acres of cropland. The other lands that are a part of the total land in farms, along with certain public range and grazable forest lands, all contribute to the agricultural production of the state. The purpose of this report, however, is not to evaluate Washington's agricultural industry, but rather to characterize the state's agricultural land as a resource.

Table 4 shows the distribution of dryland and irrigated cropland throughout Washington's 39 counties.

TABLE 4: DISTRIBUTION OF CROPLAND BY COUNTY

County	Dryland	Irrigated	Total
AREA 1	155,649	68,439	225,088
Clallam	3,423	7,777	11,200
Island	6,197	1,770	7,967
Jefferson	1,680	670	2,350

King	11,969	3,600	15,569
Kitsap	657	880	1,537
Pierce	8,528	7,100	15,628
San Juan	4,129	300	4,429
Skagit	61,016	6,500	67,516
Snohomish	15,048	15,400	30,448
Whatcom	43,002	25,442	68,444
AREA 2	87,994	35,100	123,094
Clark	23,230	12,500	35,730
Cowlitz	3,713	4,000	7,713
Grays Hbr.	11,434	2,700	14,134
Lewis	31,789	7,000	38,789
Mason	1,444	600	2,044
Pacific	5,816	900	6,716
Skamania	787	600	1,387
Thurston	6,547	6,000	12,547
Wakiakum	3,234	800	4,034
AREA 3	2,388,150	752,500	3,140,650
Adams	654,662	190,000	844,662
Chelan	7,117	34,000	41,117
Douglas	547,275	25,500	572,775
Grant	230,987	406,000	613,987
Lincoln	838,996	52,000	890,996
Okanogan	109,113	45,000	154,113
AREA 4	1,248,037	871,400	2,119,437
Benton	265,818	156,000	421,818
Franklin	234,925	132,300	367,225
Kittitas	25,394	95,400	120,794
Klickitat	188,980	30,000	218,980
Walla W.	476,020	97,600	573,620
Yakima	56,900	360,100	417,000
AREA 5	2,108,767	78,740	2,187,507
Asotin	82,179	1,000	83,179
Columbia	185,559	6,000	191,559
Ferry	16,584	7,300	23,884
Garfield	199,778	1,940	201,718
Pend O.	23,759	4,700	28,459
Spokane	395,583	31,200	426,783
Stevens	126,767	13,600	140,367
Whitman	1,078,558	13,000	1,091,558
TOTALS	5,988,597	1,807,179	7,795,776

The Table 4 figures come from the 1977 National Resources Inventory, and follow the SCS regionally-defined areas. A brief examination of the acreage distribution reveals that most of Washington's cropland is in the Eastern part of the state. Areas 3, 4, and 5--all east of the Cascades--have a combined total of 7,447,594 of the state's 7,795,776 acres of cropland, or 96 percent. (Note that because these figures come from the 1977 National Resources Inventory they differ slightly from the 1982 NRI figures used previously. A county-by-county distribution of cropland was not available for 1982.)

II. CURRENT STATUS OF AGRICULTURAL LANDS IN WASHINGTON

This report relies on two indicators of the agricultural land resource in the state--agricultural production, and the condition of cropland soils.

The State Department of Agriculture and the United States Department of Agriculture (USDA) gather thorough and reliable production data that provide a strong sense about the condition of the land. The assumption here is that agricultural production and the condition of agricultural land are highly correlated. But agricultural production is an imperfect indicator because the production values reflect so much more than just the condition of agricultural land. In its AG-2000 report, the Washington State Department of Agriculture identifies a wide array of internal and external factors influencing the industry. Federal farm policy, national and international economic conditions, and weather, among other influences, all play a role in agricultural production. In addition, where marginal or depleted cropland contribute to agricultural production, the overall production values do not distinguish between the contributions of good and poor soils. Nor do production values necessarily capture the long-term productivity of agricultural land.

The second indicator--the condition of cropland soils--strengthens the agricultural land resource characterization by compensating for some of the weaknesses of the production indicator. Because production values cannot tell us if the cropland is marginal or depleted, and because Environment 2010 is interested in the long-term productivity of the state's resources, this report attempts to describe the soil condition of agricultural land to the extent possible. The data base for this indicator is not nearly as strong as the production data base, but the Soil Conservation Service does provide good information on erosion and land capability, and recent Washington state studies offer supplemental data. The soils condition indicator is also imperfect, but together the two indicators provide a fair characterization of agricultural land in the state.

A. Production

Washington ranks at or near the top in the nation's production of several important commodities--hops, spearmint oil, peppermint oil, fall potatoes, barley, wheat, sweet cherries, apples, pears, apricots, grapes, prunes and plums, peaches, asparagus, dry onions, red raspberries, cranberries, strawberries, and milk. (Washington Department of Agriculture) This resource characterization focuses entirely on cropland, however, so livestock and related commodities are not included in the production analysis because these agricultural outputs are supported primarily by pasture, range, and grazable forest lands, not by croplands.

Table 5 summarizes farm production in the state for the years 1973-1987. Even without the livestock contribution, state agricultural production has held near $2 billion per year for the 1980s. Field crops consistently lead the way, followed by fruits and nuts, specialty crops, vegetables, seed crops, and berry crops.

TABLE 5: SUMMARY OF FARM PRODUCTION
1,000 dollars

Year	Field Crops	Fruit & Nuts	Vege-tables	Seed Crops	Berry Crops	Total Crops	Specialty Products	State Total
1973	915,653	220,901	60,733	32,434	15,356	1,245,077	123,016	1,368,093
1974	1,068,376	239,328	83,711	31,021	12,951	1,435,387	122,699	1,558,086
1975	1,077,227	208,846	93,933	26,045	12,747	1,418,798	120,356	1,539,154
1976	920,547	283,467	92,295	30,320	14,988	1,341,617	108,776	1,510,393
1977	753,390	361,917	86,718	27,073	18,176	1,247,274	149,987	1,397,261
1978	955,076	417,810	103,679	35,325	20,840	1,532,730	141,595	1,674,325
1979	1,012,707	457,566	127,098	31,969	21,905	1,651,245	186,000	1,837,245
1980	1,432,130	369,823	119,527	41,795	17,263	1,980,538	160,400	2,140,838
1981	1,411,703	438,382	138,790	31,975	22,279	2,043,129	173,192	2,216,321
1982	1,356,088	388,951	144,915	N/	28,788	1,918,742	170,089	2,088,831
1983	1,484,640	502,141	138,770	N/	26,750	2,152,301	179,020	2,331,321
1984	1,508,748	461,495	149,682	N/	21,990	2,141,915	195,398	2,337,313
1985	1,229,998	490,021	155,976	25,195	28,657	1,929,847	215,693	2,145,560
1986	1,052,796	683,039	162,274	26,151	24,859	1,949,119	226,690	2,175,809
1987	971,956	517,165	173,381	35,618	32,114	1,730,234	243,489	1,873,723

Source: State Department of Agriculture

Table 6 displays net farm income by county. These figures are not strictly production numbers, but rather a reflection of how farm profits are distributed throughout the state.

TABLE 6: NET FARM INCOME BY COUNTY

County	Farm Income ($1,000)	% of State	Co. Rank
AREA 1	226,253	19.79	
Clallam	5,656	.39	30
Island	4,422	.39	31
Jefferson	1,635	.14	36
King	42,831	3.77	10
Kitsap	1,225	.11	38
Pierce	28,444	2.50	16
San Juan	1,521	.13	37
Skagit	47,062	4.14	6
Snohomish	35,887	3.16	14
Whatcom	57,570	5.06	4
AREA 2	104,384	9.18	
Clark	22,173	1.95	19
Cowlitz	9,099	.80	27
Grays Harbor	15,682	1.38	23
Lewis	22,468	1.98	18
Mason	2,320	.20	35
Pacific	6,571	.58	29
Skamania	1,060	.09	39
Thurston	20,656	1.82	21
Wakiakum	4,355	.38	32
AREA 3	282,747	24.87	
Adams	41,194	3.62	12
Chelan	50,996	4.49	5
Douglas	25,035	2.20	17
Grant	76,757	6.75	2
Lincoln	46,792	4.12	8
Okanogan	41,973	3.69	11
AREA 4	346,434	30.46	
Benton	43,592	3.83	9
Franklin	31,531	2.77	15
Kittitas	11,997	1.06	24
Klickitat	12,087	1.06	25
Walla Walla	39,047	3.43	13
Yakima	208,180	18.31	1

TABLE 6: NET FARM INCOME BY COUNTY (CONT.)

County	Farm Income ($1,000)	% of State	Co. Rank
AREA 5	176,934	15.57	
Asotin	4,082	.36	33
Columbia	17,094	1.50	22
Ferry	9,079	.80	28
Garfield	11,773	1.04	26
Pend Oreille	2,604	.23	34
Spokane	47,070	4.14	7
Stevens	21,917	1.93	20
Whitman	63,315	5.57	3
STATE TOTALS	1,136,752	100.00	

Source: Bureau of Economic Analysis unpublished data compiled by Gary Smith, Washington State University; cited in Journal of Soil and Water Conservation

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The distribution of farm income differs significantly from the distribution of cropland. Yakima--the top-ranked county by income--has over 18 percent of the state's net farm income yet only five percent of the cropland. Similarly, Area 1, with three percent of the cropland, earned almost 20 percent of the net farm income. Areas 3, 4, and 5--east of the Cascades--earned just over 70 percent of the income with 96 percent of the cropland. (Note that the net farm income figures include livestock and related commodities, and that the land figures do not include the grazable lands that support this agricultural production.)

Several factors explain the disparity between the distribution of cropland and net farm income. The costs of production and distribution, the acreage required for each commodity, variable market prices, and the type of agriculture a region supports all influence the ratio of acreage to income. That there are regional differences is normal; it would be surprising if there were not.

The scale of the differences, and the relative county rankings are mildly surprising. As the top-ranked county by net farm income, Yakima earns more than the next three counties combined (Grant, Whitman, and Whatcom). King County, generally regarded as an urban county, ranks tenth in farm income.

Tables 7, 8, and 9 provide the details on production for field crops; fruit, nut, and berry crops; and vegetables. Wheat, hay, and potatoes lead all field crops. Apples represent approximately 60 percent of the fruit, nut, and berry crops. And asparagus, sweet corn, onions, and green peas lead vegetable production.

TABLE 7: FIELD CROPS -- TOTAL CROP VALUE

($ in Thousands)

Harvest Year	1979	1980	1981	1982	1983	1984	1985	1986	1987
Wheat	460,200	637,676	659,932	561,076	636,783	553,208	437,333	293,294	308,570
Hay	183,309	216,563	170,314	201,894	206,848	235,141	219,278	172,440	147,041
Potatoes	123,548	193,314	209,034	198,000	229,840	293,164	219,524	266,385	244,404
Barley	43,205	93,848	110,200	110,184	140,352	143,325	110,448	75,150	65,629
Oats	2,973	3,906	3,504	3,478	3,347	3,672	3,218	2,360	3,119
Corn, Grain	34,958	42,240	45,201	72,000	63,712	69,750	57,240	36,720	28,560
Corn, Silage	20,900	27,531	24,182	30,360	28,750	26,450	26,620	27,000	22,000
Hops	38,454	86,166	89,205	93,067	92,061	86,732	66,002	56,439	49,365
Lentils	35,160	43,358	22,688	21,165	9,775	11,882	18,270	26,637	10,709
Dry Beans	19,200	29,700	25,530	10,341	6,497	12,585	12,922	11,926	10,668
Dry Edible Peas	13,884	17,993	14,729	18,614	19,161	15,743	12,981	18,054	14,840
Peppermint	7,644	6,800	5,500	5,838	7,144	10,524	9,528	8,100	10,811
Spearmint	9,472	13,085	11,234	7,571	10,670	14,672	17,334	19,891	15,910
Other[1]	19,800	19,950	20,450	22,500	29,700	31,900	19,300	38,400	38,980
Total	1,012,707	1,432,130	1,411,703	1,356,088	1,484,640	1,508,748	1,229,998	1,052,796	970,606

[1] Includes grass silage, soybeans, triticale, etc.

Source: State Department of Agriculture
U.S. Department of Agriculture

TABLE 8: FRUIT, NUT, AND BERRY CROPS -- TOTAL CROP VALUE

($ in Thousands)

Harvest Year	1979	1980	1981	1982	1983	1984	1985	1986	1987
Apples	332,613	247,695	301,530	252,895	348,790	326,220	348,740	488,400	312,400
Pears, Bartlett	27,540	26,459	21,303	21,736	25,325	21,996	27,484	28,352	32,322
Pears, Other	25,017	28,112	34,049	30,269	23,648	33,432	41,642	47,480	34,573
Grapes	20,971	25,865	30,102	31,299	34,252	20,853	20,642	37,120	55,356
Red Raspberries	8,854	4,700	7,410	11,892	7,482	8,047	9,433	10,506	12,120
Strawberries	5,696	6,038	6,440	8,072	7,777	5,424	6,971	6,496	8,184
Peaches	4,991	5,549	4,719	6,021	6,244	9,239	7,365	9,105	7,076
Apricots	865	965	771	1,540	1,751	1,665	1,508	3,319	2,765
Cherries, Sweet	41,101	30,139	41,479	37,888	55,709	40,654	36,527	59,437	68,332
Cherries, Tart	605	317	343	308	674	665	556	568	NA
Cranberries	3,925	3,442	5,379	4,192	6,563	5,706	8,214	5,310	6,903
Prunes	2,822	3,436	1,688	3,454	2,374	2,716	2,240	3,329	1,668
Blueberries	2,626	2,790	2,783	4,283	4,637	2,390	3,462	2,021	4,309
Filberts	291	354	231	271	144	175	287	179	348
Other[1]	1,508	1,225	2,434	3,619	3,521	4,298	3,602	6,265	NA
Total	479,425	387,086	460,661	417,739	528,891	483,480	518,673	707,887	546,356

1 Includes miscellaneous fruits, nuts, and berries.

Source: State Department of Agriculture
U.S. Department of Agriculture

TABLE 9: VEGETABLE CROPS -- TOTAL CROP VALUE

($ in Thousands)

Harvest Year	1979	1980	1981	1982	1983	1984	1985	1986	1987
Green Peas	30,967	18,406	17,907	25,455	20,037	26,932	23,616	20,431	21,714
Asparagus	26,371	20,894	29,268	33,145	35,158	37,454	42,443	40,612	40,257
Sweet Corn	23,214	20,675	23,909	35,856	24,187	21,240	27,240	24,531	30,867
Onions	8,215	14,562	22,330	7,910	21,558	20,344	13,540	23,770	27,342
Carrots	8,376	11,128	9,781	7,436	8,871	10,941	11,257	12,270	13,021
Cucumbers	1,863	1,998	2,422	NA[3]	NA[3]	2,717	3,108	2,448	3,055
Lettuce	2,387	3,072	3,112	2,398	3,080	3,373	2,717	3,175	3,576
Snap Beans	1,441	1,478	829	1,227	811	823	777	990	982
Cabbage	1,295	1,550	1,790	NA[3]	NA[3]	NA[3]	NA[3]	NA[3]	NA[3]
Other[2]	22,969	24,214	25,652	31,488	25,068	25,858	31,278	34,047	32,567
Total	127,098	117,977	137,000	144,915	138,770	149,682	155,976	162,274	173,381

1 Fresh Market and Processing combined.

2 Includes beets, spinach, lima beans, broccoli, cantaloups, cauliflower, celery, hothouse cucumbers, eggplant, garlic, green onions, parsnips, peppers, pumpkins, radishes, rhubarb, rutabagas, turnips, squash, tomatoes, watermelons, etc. Also includes fresh market production of field cucumbers, snap beans, and green peas.

3 Estimates discontinued.

NA - Not Available.

Source: State Department of Agriculture
U.S. Department of Agriculture

B. <u>Soil Condition</u>

The Soil Conservation Service identifies eight land capability classes based on the suitability of soil for cultivation. The SCS describes the land capability classes as follows:

I. Soils with few limitations that restrict their use.

II. Soils with moderate limitations that reduce the choice of plants or that require careful management.

III. Soils with severe limitations that reduce the choice of plants, require special conservation practices, or both.

IV. Soils with very severe limitations that reduce the choice of plants, require careful management, or both.

V. Soils that are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife.

VI. Soils with severe limitations that make them generally unsuitable for cultivation and limit their use largely to pasture, range, woodland, or wildlife.

VII. Soils with severe limitations that make them unsuitable for cultivation and restrict their use largely to pasture, range, woodland, or wildlife.

VIII. Soils and landforms with limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife, water supply, or to esthetic purposes. (SCS)

The very definitions of the land capability classes suggest the appropriate agricultural uses, and the SCS reports that Washington farmers and ranchers generally use their land according to its capability. (SCS) Table 10 shows the distribution of Washington dryland and irrigated cropland across the SCS land capability classes. The data for this table come from the 1982 SCS National Resources Inventory.

TABLE 10: DISTRIBUTION OF WASHINGTON CROPLAND ACROSS SCS LAND CAPABILITY CLASSES (1000 acres)

Class	Dryland	Irrigated	Total
I	2.2	144.6	146.8
II	655.7	624.9	1,280.6
III	3,400.2	375.4	3,775.6
I-III	4,058.1	1,144.9	5,203.0
IV	1,650.8	448.6	2,099.4
I-IV	5,708.9	1,593.5	7,302.4
V	11.1	0.0	11.1
VI	336.3	45.6	381.9
VII	83.7	11.6	95.3
VIII	0.0	2.7	2.7
V-VIII	431.1	59.9	491.0
Total	6,140.0	1,653.4	7,793.4

Source: SCS 1982 National Resources Inventory

Table 10 shows that of the 7,793,400 acres of cropland in the state in 1982, 5,203,000 acres were in the land capability classes I-III, the soils suitable for frequent cultivation. Class IV soils--characterized as marginal for cropland by the SCS--comprised 2,099,400 additional cropland acres. This marginal designation, however, does not mean that the soils are not productive, but rather that they are vulnerable to erosion. If they are frequently cultivated, they may lose productivity over time because of topsoil losses. Many of these class IV acres are devoted to vineyards and orchards, some with permanent cover grasses between trees. The remaining 491,000 of 1982 Washington State cropland acres fell into classes V-VIII, soils limited or generally unsuitable for cultivation.

The SCS also defines "prime farmlands" as a separate cropland category. The SCS describes the general criteria for prime farmland as follows:

> Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses (the land could be cropland, pastureland, rangeland, forest land, or other land, but not urban built-up land or water). It has the soil quality, growing season, and moisture supply needed to produce, economically, sustained high yields of crops when treated and managed,

including water management, according to acceptable farming methods. In general, prime farmlands have an adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks. They are permeable to water and air. Prime farmlands are not excessively erodible or saturated with water for a long period of time, and they either do not flood frequently or are protected from flooding.

According to the SCS National Resources Inventory, Washington State had 2,308,000 acres of prime farmland in 1982--1,418,500 acres in cropland, and 889,500 acres in pasture, range, and forest lands. The prime farmland falls into the land capability classes I-III. Table 11 summarizes the state's cropland acreage and characteristics.

TABLE 11: SUMMARY OF WASHINGTON STATE CROPLAND ACREAGE AND CHARACTERISTICS

Class	Acres	% of Total Cropland	Description
I-III			
Prime	1,418.5	18.2	Best cropland
Other	3,784.5	48.6	Suitable for frequent cultivation
Subtotal	5,203.0	66.8	
IV	2,099.4	26.9	Marginal cropland
V-VIII	491.0	6.3	Generally unsuitable for cultivation
Total	7,793.4	100.0	

Source: SCS

The land capability classes, along with the prime farmland category, provide a good sense of the inherent characteristics of Washington's agricultural land. They do not, however, offer any information about the effects of agricultural practices or other forces on the condition of the land, and without this information, the agricultural land characterization is incomplete. The most important single factor in this regard is erosion of topsoil.

Erosion is the wearing away of the land surface by running water, wind, ice, or other geologic agents. The SCS National Resources Inventory reports in detail on wind and water erosion including sheet and rill erosion. Sheet erosion is the removal of a thin, fairly uniform layer of soil by runoff water. Rill erosion is a process in which numerous small channels only several inches deep are formed. Rill erosion occurs mainly on recently cultivated soils (Soil Conservation Society of America).

A recently published soil science and management textbook identifies the following effects, among others, of soil erosion:

> Erosion first removes the topsoil. Topsoil affords the best root environment by providing the best structure, the most air, and an active population of living organisms. Once topsoil is lost, only the less productive subsoil remains.
>
> The topsoil contains most of the soil's organic matter and plant nutrients. Erosion carries away nitrogen, phosphorus, and any nutrient stored mostly in organic matter.
>
> As erosion strips away the soil surface, the profile becomes thinner, decreasing the root zone. This is a particular problem on already shallow soils. A major effect of this shrinking root zone is reduced value of total water-holding capacity.
>
> Gullies cut up fields into odd-shaped pieces and make it very difficult to operate farm equipment. (Plaster)

Another recent study reports that, "As the topsoil layer is lost, subsoil becomes part of the tillage layer, reducing the soil's organic matter, tilth, and aeration, and adversely affecting other structural characteristics that make it ideal for plant growth. This overall deterioration in soil structure is usually accompanied by a reduced nutrient retention capacity, which lowers productivity further. Additional chemical fertilizer can often compensate for the loss of nutrients, but the deterioration of soil structure is difficult to remedy" (Brown and Wolf).

The SCS calls soil erosion on dryland and irrigated cropland "the most serious land resource problem in Washington State..." (SCS) The generally accepted maximum rate of soil erosion is five tons per acre per year. Soil is a renewable resource only as long as it is managed for sustainable production. When managed for maximum economic production in the short term, soil becomes a nonrenewable resource because soil loss or erosion exceeds its capacity to be renewed. The erosion process is complex and the formation process is similarly complex. The cropland soils in Washington are renewing, but it is very difficult to measure or predict the exact rate. The rate of weathering of rock to soil may be one-half to one ton per acre per year, but since much of the cropland in Washington is primarily wind blown deposits this may not mean very much. The five tons per acre per year tolerance is often used as a maximum rate of soil loss because it is thought this rate in combination with technology changes and inputs as well as weathering meets the goal of a sustainable soil resource for agricultural production.

The environmental damage of erosion is reflected to some extent in production. A survey of several studies found a relationship between soil erosion and productivity for both corn and wheat. Specifically, the survey revealed that in the Palouse area of Washington State the loss of one inch of topsoil resulted in a yield reduction of 1.6 bushels per acre, a 6.9 percent decline in productivity (Brown and Wolf). Another study (Nowak) found several costs--both environmental and economic--resulting from excessive soil erosion. These costs include the following:

> The nonuniform distribution of chemicals resulting from soil movement and washing. This may result in yield losses due to pest pressure or crop damage from excessive levels of chemicals being deposited on localized parts of the same field.
>
> Damage to adjacent, incompatible crops due to washed off and deposited chemicals from other fields.
>
> Costs due to additional machinery wear and tear from tillage in heavier and possibly rocky subsoils after topsoils have been eroded.
>
> Increased energy costs for machinery due to higher drag coefficients of tillage implements in heavier subsoils.
>
> Increased costs to clean out drainage and irrigation structures obstructed by eroded soils. There are also possible legal expenses if these are not adequately maintained.
>
> Increased irrigation costs due to reduced water holding capacity of eroded soils. There could also be yield reductions in nonirrigated crops due to reduced water retention capacities in eroded soils.

Loss of cropland productivity, sedimentation, water pollution, increased chemical use, and loss of fishery habitat are some of the long term consequences and costs associated with erosion. Conservation practices are designed to reduce these impacts. Many of the on-farm conservation practices, such as conservation tillage, have a positive economic effect at the farm level. Other practices require that the impact on society be included before they are economically feasible. A few practices will only be considered and implemented when non-economic values become of over-riding importance.

In Washington State the effects of erosion are significant. Table 12 shows the topsoil losses to erosion by county for the state.

TABLE 12: EROSION OF CROPLAND BY COUNTY

County	Cropland (acres)	Average Annual Erosion (tons)	Tons/Acre/ Year
AREA 1	225,088	423,962	1.88
Clallam	11,200	49,754	4.44
Island	7,967	22,539	2.82
Jefferson	2,350	5,370	2.28
King	15,569	22,767	1.46
Kitsap	1,537	1,954	1.27
Pierce	15,628	29,828	1.90

San Juan	4,429	9,158	2.06
Skagit	67,516	102,016	1.51
Snohomish	30,448	61,248	2.01
Whatcom	68,444	119,328	1.74
AREA 2	123,094	263,318	2.14
Clark	35,730	83,960	2.35
Cowlitz	7,713	19,246	2.51
Grays Hbr.	14,134	30,968	2.19
Lewis	38,789	84,578	2.18
Mason	2,044	4,688	2.29
Pacific	6,716	14,332	2.13
Skamania	1,387	5,584	4.03
Thurston	12,547	11,094	.89
Wakiakum	4,034	8,868	2.19
AREA 3	3,140,650	22,366,162	7.12
Adams	844,662	5,667,972	6.71
Chelan	41,117	108,585	2.64
Douglas	572,775	3,452,150	6.02
Grant	613,987	5,269,922	8.27
Lincoln	890,996	7,171,968	8.05
Okanogan	154,113	695,565	4.51
AREA 4	2,119,437	15,302,036	7.22
Benton	421,818	2,413,454	5.72
Franklin	367,225	2,251,200	6.13
Kittitas	120,794	583,182	4.82
Klickitat	218,980	1,224,900	5.59
Walla W.	573,620	5,881,000	10.25
Yakima	417,000	2,948,300	7.07
AREA 5	2,187,507	25,854,006	11.82
Asotin	83,179	746,111	8.97
Columbia	191,559	2,458,267	12.83
Ferry	23,884	119,420	5.00
Garfield	201,718	2,411,036	11.95
Pend O.	28,459	132,895	4.67
Spokane	426,783	4,120,830	9.66
Stevens	140,367	675,635	4.80
Whitman	1,091,558	15,189,812	13.90
STATE TOTALS	7,795,776	64,209,484	8.24

Source: SCS 1977 National Resources Inventory

Erosion is no more evenly distributed throughout the state than cropland or net farm income. The composite erosion rate for Areas 1 and 2--west of the Cascades--is 1.97 tons per acre per year, a rate well below the five tons per acre per year standard. Areas 3, 4, and 5, on the other hand, have a composite erosion rate of 8.53 tons per acre per year. At this rate the topsoil is disappearing faster than its ability to regenerate itself.

An examination of the erosion rates for the top ten ranked counties by net farm income reveals that six of the counties have erosion rates in excess of the five tons per acre per year standard. Table 13 lists the erosion rates for each of the ten counties.

TABLE 13: EROSION RATES FOR TOP TEN COUNTIES RANKED BY NET FARM INCOME

	County	Rank	Erosion Rate
East Side	Yakima	1	7.07
	Grant	2	8.27
	Whitman	3	13.90
	Chelan	5	2.64
	Spokane	7	9.66
	Lincoln	8	8.05
	Benton	9	5.72
	Composite	9.48	
West Side	Whatcom	4	1.74
	Skagit	6	1.51
	King	10	1.46
	Composite	1.61	

Source: SCS and Bureau of Economic Analysis

The difference in erosion rates is dramatic. The west side counties are well under the acceptable rate while the east side counties, with the exception of Chelan, are well over. The composite erosion rate for the seven top-ten counties on the east side is 9.48 tons per acre per year, almost twice the acceptable rate.

In an effort to control erosion on highly erodible lands, the USDA, through the SCS and the Agricultural Stabilization and Conservation Service, established the Conservation Reserve Program. Farmers can receive a subsidy for enrolling their highly erodible land in the program. A recent study in the Palouse, however, suggests that a disparity exists between farmers' perceptions and the USDA determination of highly erodible land. The Washington State Palouse farmers' own estimate of their highly erodible land, given in light of the USDA definition, was 2,539 acres. The actual amount of highly erodible land based on the USDA definition is 11,362 acres. (This acreage is for the study sample only; the total highly erodible acreage in the Palouse is significantly greater.) The researchers conclude that, "This difference of opinion may be one reason why voluntary erosion control programs have been ineffective," and, in support of this conclusion, they cite a study that found a strong relationship between participation in CRP and the extent to which farmers thought their land had erosion problems (Osterman and Hicks).

Despite this difference of opinion, Washington had 877,084 acres enrolled in CRP as of April 1989. This total, along with the above-stated findings, suggests that the state has a significant amount of highly erodible land.

This same study cites an example of another federal program that works as a disincentive for conservation--the set-aside program requirement that cropland be removed from production to reduce surpluses. "Most of the farmers in the Palouse," the study states, "conventionally summer fallow this ground or plant a cover crop of peas that is subsequently plowed under." But, the study continues, "Summer-fallowed ground is extremely vulnerable to erosion." The researchers go on to report the results of a single summer storm that caused an average soil loss of 40 tons per acre over 30,000 acres in the Palouse (Osterman and Hicks).

The cumulative effects of erosion are difficult to assess, and there is no available data base on which to rely. It is clear, however, that persistent erosion at rates in excess of the soil's ability to regenerate itself will result in reduced productivity over time. The production values of Washington agriculture suggest that at present the soil remains in a condition sufficient to sustain high levels of output. In those areas where erosion rates far exceed soil loss tolerance, the productivity of the land will diminish faster than in areas where erosion rates are consistent with soil loss tolerance. Soils in land capability classes IV and VI are especially vulnerable.

The SCS categorizes the cumulative effects of erosion into three phases. In Phase 1 the land is losing topsoil, and farmers are working in the lower part of the original A horizon and in the upper B horizon. In Phase 2 farmers are working in the B horizon; in Phase 3, the lower B and C horizons. The USDA horizon classifications include numerous subcategories and descriptions of soil characteristics for each of the horizons, but for the purposes of this analysis, an understanding that the A, B, and C horizons represent the top three layers of topsoil is all that is required. According to the SCS, most Washington State soils are currently in Phase 1, and with proper management can remain there indefinitely. (McClinton)

The erosion rates measure the amount of topsoil lost, an important indicator of soil condition, but not the only measure. Soil fertility and the soil's physical properties are also important factors, and agricultural practices affect both of these factors. No agency routinely gathers data on fertility and physical characteristics of soil, so an analysis of these factors is necessarily more limited than the erosion analysis. One recent study, however, is pertinent even if limited in its applicability.

A Washington State University study, conducted by Professor John P. Reganold, and endorsed by the SCS (McClinton), compared the soil properties as influenced by organic and conventional farming systems. An abstract of the study follows:

> This paper summarizes data from previous and current studies on two adjacent farms, one organically managed and the other conventionally managed, in the Palouse region of eastern Washington. The 320-hectare organic farm has been managed without the use of commercial fertilizers and only limited use of pesticides since the farm was first plowed in 1909. The 525-hectare conventional farm, first cultivated in 1908, began receiving recommended rates of commercial fertilizers and pesticides in 1948 and the early 1950's, respectively. The organically-farmed Naff silt loam soil had significantly higher organic matter, cation exchange capacity, total nitrogen, extractable potassium, water content, pH, polysaccharide content, enzyme levels, and microbial biomass than did the conventionally-farmed Naff soil. Also, the organically-farmed soil had significantly lower modulus of rupture, more granular structure, less hard and more friable consistence, and 16 centimeters more topsoil. This topsoil difference between farms was attributed to significantly greater erosion on the conventionally-farmed soil between 1948 and 1985. The difference in erosion rates between farms was most probably due to their different crop rotation systems; i.e., only the organic farm included a green manure crop in its rotation, and it had different tillage practices. These studies indicate that, in the long-term, the organic farming system was more effective than the conventional farming system in maintaining the tilth and productivity of the Naff soil and in reducing its loss to erosion. (Reganold)

The results of this study cannot be applied across the board to other farms or other areas, but the findings do help illuminate the previously identified connection between the loss of productivity and erosion. The WSU study cites several other studies to support the statement that, "Organic matter has a profound impact on soil quality; it encourages granulation, increases water storage, nutrient supply, and soil organism activity, and improves soil fertility and productivity." (Reganold) The loss of topsoil to erosion reduces the organic matter, and consequently reduces water retention capacity, nutrient supply, fertility, and overall productivity.

C. Summary of Risks

Three Environment 2010 risk analyses consider threats to agricultural lands--"Nonchemical Impacts on Agricultural Land," "Ambient Air Pollution," and "Global Warming and Stratospheric Ozone Depletion."

The Global Warming report presents its findings on the agricultural effects of climate change and ozone depletion as preliminary, complex, and uncertain. In summarizing the potential effects of climate change, the report states, "In the agricultural sector, a climate change could induce shifts in crop pest and disease infestations. Expansion of irrigation and shifts in regional agricultural production patterns could imply more competition for water resources, a larger potential for ground and surface water pollution, loss of wildlife habitat, increased soil erosion, and changes in the structure of local economies."

On the issue of ozone depletion, the Global Warming report distinguishes between two distinct effects. Stratospheric ozone depletion directly affects crop yield adversely. And stratospheric ozone depletion also increases the amount of tropospheric ozone, which itself affects crop yield adversely. Conversely, a reduction of the tropospheric ozone serves to increase crop yield. (Canning) The Ambient Air Pollution report puts the tropospheric ozone finding into a Washington State context. This report cites plant damage from ozone, but finds that this damage "...is likely to be concentrated in forested areas downwind and to the east of urban centers in western Washington. Ozone damage is not likely on the Olympic Peninsula or in Eastern Washington." (Johnson)

The tropospheric ozone effects are better understood and less speculative than the stratospheric ozone depletion effects, and the finding that tropospheric ozone is concentrated in western Washington suggests that farmers on the west side of the Cascades are more likely to encounter ozone-related problems than are farmers on the east side.

The Nonchemical Impacts report considers two main threats--erosion and the conversion of cropland to other purposes. Table 14 summarizes the effects of erosion on cropland for the three available years of the National Resources Inventory.

TABLE 14: CROPLAND EROSION IN WASHINGTON STATE

	Dryland		Irrigated		Total Cropland		
	Water	Wind	Water	Wind	Water	Wind	Total
Year							
1977	8.25	.23	.81	1.10	7.81	.43	8.24
1982	6.18	1.99	1.46	8.24	5.20	3.29	8.49
1987	6.73	2.26	1.25	7.71	5.58	3.40	8.98

Source: SCS National Resources Inventories
1977, 1982, 1987

The Nonchemical Impacts report finds that the state-wide erosion rates exceed the SCS recommended maximum rate of five tons per acre per year, and that the erosion of croplands varies considerably from county to county. Some counties' erosion rates fall well below the SCS maximum rate, while others' rates are as high as 13.9 tons per acre per year, over two-and-one-half times the accepted maximum. In addition, not all farmers with the most highly erodible land are participating in the federal Conservation Reserve Program (CRP), the SCS program designed to take the most vulnerable land out of production, because despite the federal payment for participation in CRP, farmers can earn more income by farming the eligible land.

On the issue of conversion of cropland to other uses, the Nonchemical Impacts report finds that, "During the period 1982-1987 approximately 23,000 acres per year were converted from rural to urban uses..." Of this total, 1,350 acres per year were a combination of cropland and pastureland.

The cropland totals for the state have declined slightly over the period covered by the SCS National Resources Inventory. In 1977 Washington had 7,951,000 acres of cropland; in 1982, 7,793,400 acres; and in 1987, 7,640,200 acres. The total loss of cropland from 1977-1987 was 310,800 acres, some of which was lost to urban use, and some of which converted to range or pastureland. Of the 153,200 acres of cropland lost between 1982 and 1987, most was land the SCS considers better off out of production, that is, planted to permanent grass cover or otherwise enrolled in the CRP. Some of this cropland became idle as a result of bankruptcies. (McClinton)

In addition to these risk assessments, RCG/Hagler, Bailly prepared a report on the welfare effects of nonchemical impacts on agricultural lands. This report estimates the dollar cost of erosion for all Washington State cropland to be $16,099,020, based on the 1982 NRI. The annual cost of erosion is determined, in this report, by multiplying the topsoil lost to erosion (in tons) by $0.30 per ton.

D. Conclusions

Washington farmers are using the state's agricultural lands generally in accordance with the lands' inherent capabilities. It should be noted that technological inputs can mask the impact of erosion on crop yields and that these inputs must continue or increase to manitain crop yields. The consistently high production values of agricultural output are evidence of an important resource well used. Most Washington soils remain in Phase 1 of the SCS's evaluation of erosion--the cropland is losing topsoil, and farmers are working the bottom part of the original A and the top of the B horizons. According to the SCS, farmers can continue to work in Phase 1 at high levels of production indefinitely, given proper management of the resource.

Erosion poses a serious threat to Washington's cropland. The state-wide average annual erosion rate is over three tons per acre higher than the SCS maximum acceptable rate (five tons/acre/year). All of the excessive erosion occurs east of the Cascades. Seven of the top ten counties in net farm income are on the east side, and the composite average annual erosion rate for these counties is 9.48 tons per acre per year. Regardless of its cause, erosion depletes soil fertility and water retention capacity, and topsoil loss eventually leads to decreased production capacity. In addition to this long-term cost to farmers, erosion also significantly increases short-term costs in several ways.

Despite the long-run consequences and the high short-term costs of erosion to farmers, the costs of erosion controls are as much as three times higher than the economic benefits to the farmers. The Conservation Reserve Program (CRP) is succeeding in providing economic incentives to farmers to take highly erodible land out of production, but some farmers still earn more income by farming their CRP-eligible land. CRP is limited, too, in its applicability: some of the cropland experiencing high erosion rates is highly productive land that should remain in production, but with additional erosion controls in place.

E. Positive Aspects of the Agricultural Land Resource

One of the main benefits of agriculture, and therefore one of the positive aspects of the agricultural land resource, is so obvious that it is often taken for granted: food. Washington State farmers use the state's cropland to produce an abundance of food. Washington's wheat and apples, to name two prominent commodities, are known around the world. Residents of the state enjoy a bounty of fresh fruits and vegetables throughout a relatively long growing season.

According to the Department of Agriculture's AG-2000 report, "Of Washington's major manufacturing industries, only agriculture markets a significant share of total output within the state. Approximations based on farm level dollar values indicate that roughly 25 percent of Washington's agricultural output is sold to consumers within the state, 25 percent is foreign export, and 50 percent is sold in the rest of the United States." (Washington Department of Agriculture) There are many elements that contribute to the agriculture economy in the state, but the state's cropland provides the essential base. AG-2000 states that, "The natural resource endowment is an integral part of the productivity that has propelled Washingtonfarmers to produce more potatoes per acre, more milk per cow, and more dryland wheat per acre than farmers in any other state." One of the most important positive aspects of Washington's agricultural land, therefore, is that it supports the state's vibrant farm economy.

The agricultural land resource also supports a cherished American institution--the family farm. America's esteem for the family farm has roots in the Jeffersonian ideal, and has grown over time to almost mythical proportions. As with other highly-valued institutions, the nation's affection for the family farm in the abstract does not necessarily evidence itself in concrete terms. America loves her farmers ...and tends to take them for granted.

This idealized esteem occasionally leads to the mistaken conclusion that the family farm is a nostalgic relic that has passed its usefulness, an attitude that is sometimes apparent in federal policy making. A 1985 study by the Council of State Planning Agencies found, for example, that, "When it comes to federal agricultural programs, family farm operations have gotten the short end of the stick for some time" (Nothdurft) There is a new myth in agriculture that bigger is more efficient and therefore better, and this idea seems to dominate federal agriculture policy. But the data suggest that our confidence in the family farm is well placed. The USDA itself studied this issue and reached this conclusion:

> We are so conditioned to equate bigness with efficiency that nearly everyone assumes that large-scale undertakings are inherently more efficient than smaller ones. In fact, the claim of efficiency is commonly used to justify bigness. But when we examine the realities we find that most of the economies associated with size in farming are achieved by the one-man fully mechanized farm.

The family farm in Washington is both a part of American tradition and an important contributor to contemporary agricultural production. The generally good condition of the state's croplands is directly attributable to the capable stewardship of these farmers. The inherent quality of the agricultural land resource provides the opportunity for sustainable, high levels of agricultural production, and the family farms embody both the tradition and the modern efficiency necessary to make the most of the opportunity.

III. CURRENT PROGRAMS FOR CONTROL OF DEGRADATION TO AGRICULTURAL LANDS

All levels of government exercise some degree of control over agricultural lands. This section briefly considers federal, local, and state programs in turn.

A. Federal

Any element of federal farm policy that influences farmers' decisions about how to use their land is, in effect, a control program. The previously cited set-aside program that actually works as a disincentive for conservation is an example. An analysis of federal farm policy, however, is well beyond the scope of this report. This section, therefore, considers only the Conservation Reserve Program.

The goal of the CRP is to convert highly erodible land to other uses--permanent grasses, trees, wildlife habitat, or similar uses. As of April 1989 Washington farmers and ranchers had enrolled 877,084 acres in the program. The CRP contract requires farmers to keep their enrolled land out of commodity production and refrain from grazing it for 10 years. Most of this land is converted to grass and may return to production when the CRP contracts expire, but the SCS expects CRP to follow the soil bank experience of the early 1960s. Eighty percent of the land that originally went in to the soil bank remained there.

Taking cropland, even highly erodible cropland, out of production may seem to contradict the goal of maintaining high levels of agricultural output. CRP-eligible land, however, tends to be the least economical of all cropland. It requires the highest inputs of fertilizer and management. By taking this land out of production, a farmer receives an income for the 10 years of the contract, and can reallocate the resources of the farm to other lands. Often farmers find that their production remains at their pre-CRP levels, and that their net income increases.

B. Local

Several Washington State researchers recently surveyed all of the county planning departments in the state and found that the protection of agricultural land is a major concern at the county level. Respondents named the maintenance of the agribusiness sector as the primary consideration in protecting agricultural land, with preservation of open space and rural lifestyles second. The survey found that, "Twenty different kinds of agricultural land protection strategies have been adopted by 32 of Washington's 39 counties." Table 15 identifies ten of the various strategies, and lists the number of counties employing the strategies.

TABLE 15: IMPLEMENTED AGRICULTURAL LAND PROTECTION STRATEGIES IN WASHINGTON STATE

Strategy	Counties
Comprehensive planning	30
Large lot zoning	20
Agricultural exclusive zoning	9
Agricultural nonexclusive zoning	14
Purchase of development rights	1
Purchase of resale/lease with restrictions	1
Transfer of development rights	2
Promotion of open space taxation	21
Development permit system	12
Right to farm ordinance	2
Other	10

Source: Christensen, et. al., in Journal of Soil and Water Conservation

The county planners report that their measures are only moderately effective at keeping farmland from being converted to other uses. The survey found that, "...sixty percent of the planners believed there should be a statewide program involving incentives and guidelines for agricultural land protection." The study concludes that, "While counties would generally support a statewide effort to protect farmland, planning department officials revealed that there is some opposition to state land use controls and would prefer to retain local administration of such a policy."

C. State

Conservation Districts. In 1939 Washington State government formed conservation districts responsible for promoting soil and water conservation on agricultural lands in the state. These conservation districts are subdivisions of state government operating at the local level. A report by the Washington Association of Conservation DIstricts and the Washington Conservation Commission identifies the four general categories of the conservation districts' activities. Districts "provide technical assistance for site-specific resource management, increase public awareness of natural resource problems and solutions, deliver resource programs to local land users, and coordinate services to address local conservation needs."

Organic Certification. In 1988 Washington became the first state to offer state certification of organic food products. The purpose of the legislation is stated in the Revised Code of Washington:

> The legislature recognizes a public benefit in establishing standards for food products marketed and labeled using the term "organic" or a derivative of the term "organic." Such standards shall also facilitate the development of out-of-state markets for Washington food grown by organic methods.

The Washington State Department of Agriculture administers the organic certification program. Producers must apply for certification every year. In its first year the program enrolled 63 farms, most of which reapplied for the second year along with enough new applicants to total approximately 150 certified producers for 1989. There are organic growers in 30 of the 39 counties, and they are producing organic food products across the full Washington State agricultural spectrum. The Department anticipates an enrollment of 300 next year, and an additional 200 in the new "transitional" certification category that begins in 1990.

Unlike the federal CRP, the various local ordinances, and the state Conservation Districts, the organic certification program was not established with resource conservation goals in mind. It was instead a response in part to consumer demand, and in part to the concerns of organic growers. Nevertheless, the program does regulate farm practices, within the organic certification context, and organic practices tend to conserve the agricultural land base (Office of Technology Assessment).

IV. EFFECTS OF POPULATION GROWTH ON AGRICULTURAL LANDS

The Washington State Office of Financial Management forecasts a state population of 6,013,253 for the year 2010. This forecast represents a population growth of 1,448,253 people, or a 31.7 percent increase, over the 1988 population.

Population growth is likely to affect the state's agricultural lands in two ways. The first is the direct pressure to convert agricultural land to urban or built-up uses to accomodate the new residents. The second effect is indirect--a growth in population means more hungry mouths to feed. This increase in the demand for food exerts additional pressure on agricultural lands to produce more. Alternatively, the population growth could simply shift the proportion of Washington agricultural output sold in the state. Washington residents currently consume 25 percent of the state's agricultural production; this percentage could increase as the state's population increases, and the percentage that is sold out of state could decrease accordingly.

The projected population growth is distributed unevenly across the state's 39 counties, but even if the growth pattern were uniform, the effects on agricultural lands would be different from county to county. The amount of agricultural land in the county, the availability of other land, and the pathway of development each play a role in the overall effect of population growth on agricultural lands.

The percentage increase of growth may be a less important indicator of potential effects than is the increase in the actual number of people. Whatcom County, for example, is expected to grow by 27.7 percent while Chelan County is expected to grow by 27.1 percent, a similar increase. But Whatcom County will be adding 33,012 new residents while Chelan County will be adding 13,449, a difference of 19,563.

The agricultural land base in the counties is also an important consideration in evaluating the effects of growth. The projected growth for Skagit County, for example, is 24,453; for Spokane County, 28,733. Skagit County has 67,516 acres of cropland, and Spokane County has 426,783 acres. Any pressure resulting from population growth is likely to affect Skagit County cropland more adversely than Spokane County cropland because Spokane has so much more.

Table 16 lists the top ten ranked counties by net farm income alongside the population growth projections and cropland for each of the counties.

TABLE 16: POPULATION PROJECTIONS AND CROPLAND ACREAGE FOR TOP TEN RANKED COUNTIES BY NET FARM INCOME

County	Growth (n)	% +/-	Cropland (acres)
Yakima	38,514	20.7	417,000
Grant	18,951	36.0	613,897
Whitman	-4,279	-11.0	1,091,558
Whatcom	33,012	27.7	68,444
Chelan	13,449	27.1	41,117
Skagit	24,453	8.1	67,516
Lincoln	-611	-6.3	890,996
Benton	-22,088	-21.1	421,818
King	533,696	37.7	15,569

Source: OFM and SCS

An examination of the table reveals a wide range of values. Whitman County, with a projected loss of 4,279 residents and cropland in excess of one million acres, represents one end of the spectrum, while King County, with a projected gain of over 500,000 residents and 15,569 acres of cropland represents the other. By the light of these figures, King County would seem to be in the gravest danger of cropland losses resulting from growth. It has the fewest acres and the highest projected growth. But an analysis based on these data is not nearly refined enough to reach any valid conclusions.

A careful analysis of cropland losses and the consequent effects on agricultural production and rural communities must include a consideration of many more elements. What local controls will mitigate the effects of growth? Which cropland specifically is at risk? Is the cropland prime farmland, or is it highly erodible land? Some counties may lose little in total acreage converted from cropland to built-up uses, but if that acreage is prime farmland along river bottoms the loss would nevertheless be substantial. Other counties may lose more acreage but less valuable land in terms of production.

V. PROJECTIONS: THE FUTURE OF WASHINGTON STATE AGRICULTURAL LANDS

The Washington State Department of Agriculture serves two main constituencies--all those people who eat food, and all those who grow it. Inasmuch as the latter group is only slightly less diverse than the former, it is not surprising that the Department of Agriculture, and indeed the agriculture industry generally, is buffeted by strong winds of opinion blowing in different directions. Recognizing this situation in its AG-2000 report, the Department of Agriculture identifies the need for agriculture to provide leadership in resource allocation decisions "...rather than respond defensively to areas of controversy."

The introduction of AG-2000 states that, "...to recognize and design the attitudes, decisions, and actions today that will chart the course for the next generation of agriculture has proved a formidable challenge in this industry." The report is comprehensive in its scope, and emphasizes that it is "...in both development and execution, an industry plan." It will be the industry's responsiblity to implement the plan, and the Department of Agriculture's role to facilitate that implementation as appropriate. Notwithstanding its agriculture industry emphasis, AG-2000 addresses itself, in one particular section, to the concerns of Environment 2010. The report includes five separate strategy discussion papers, one of which is Natural Resource Management.

Among the emerging issues in Washington agriculture, AG-2000 identifies natural resource use and conflicts, including the following: water, soil, and chemical use; regulatory controls on production practices; and environmental-economic conflicts. The Natural Resource Management paper states that, "Agriculture has been placed in defensive positions regarding many resource use issues, and this has weakened the industry's efforts to provide leadership in negotiating natural resource use guidelines." An example of agriculture finding itself in a defensive posture occurred in the early part of this year when the Natural Resources Defense Council issued a report that claimed that Alar, the trade name of a farm chemical used on apples, posed a serious health risk to children. Despite the fact that apple growers were operating within federal and state guidelines, and notwithstanding the safety claims made by governmental authorities, the growers suffered serious losses.

A central issue in the future of agriculture, in the state and in the nation, is the resolution of this type of conflict. On the one hand are the producers, who operate within the environmental regulations, and who believe that they are growing safe food. On the other hand are advocates of chemical-free farming, people who do not trust governmental authorities' assurances, and who believe that the only way to insure that food is safe is to grow it without chemicals. As the Alar controversy demonstrates, farmers are vulnerable to consumer behavior in the marketplace.

The Alar controversy also illustrates what happens when there are deep disagreements about what is or is not a fact. Conventional farmers--those using chemical fertilizers and pesticides--want to continue using the products that are essential to their farm production until those products are proven harmful. Consumers concerned about their own safety or the safety of their children want the chemical use to stop until it is proven safe. A vast amount of new information and research will be necessary to reconcile the two points of view.

Responsible people from both points of view recognize the validity of the other side. Farmers are not indifferent to the health of children, and consumer advocates do not want to put farmers out of business. The term "sustainable agriculture" is sometimes used to describe those farm practices that minimize chemical inputs, and responsible consumer and environmental advocates know that no agriculture can wear the mantle of sustainability if it does not first sustain farmers.

In anticipation of future conflicts and controversies of this type, AG-2000 develops a set of strategies in natural resource management. The AG-2000 approach recognizes three objectives: "1) the need for an equitable decision-making process regarding natural resource use and the environment; 2) the importance of developing managerial and regulatory processes to increase efficiency in natural resource use; and 3) the need to provide ongoing education for both the public and agriculture industry about agriculture and the environment." The centerpiece of the AG-2000 strategy is a proposed "...multi-interest coalition of natural resource users, including agriculture." The report includes the following discussion:

> A multi-interest coalition might not endorse all proposals offered by the agricultural industry, but the caucus provides a mediated process for examining agricultural initiatives. Recognizing that in agriculture there are also different viewpoints on natural resource use, the structure and representation in a multi-interest coalition also provides a vehicle for reconciling conflicts regarding natural resources within agriculture. Most importantly, agriculture will be afforded the opportunity to take the initiative in setting the agenda for natural resource management affecting this industry.

The AG-2000 report does not pretend to predict the future, but it does start developing a strategy to help shape policy and decision making regarding the future of agriculture in Washington. Specific outcomes of specific conflicts will depend on the development of new information, and to a large extent Washington agriculture in the year 2010 will depend on how those conflicts are resolved. By developing its multi-interest coalition strategy, AG-2000 is demonstrating a confidence in the people of Washington to formulate their own agriculture future.

ADDENDUM TO AGRICULTURAL LANDS RESOURCE CHARACTERIZATION

FARM SIZE AND THE ISSUE OF "HOBBY FARMS"

An examination of the relationship between farm size (in acres) and farm sales reveals the diversity of agriculture in the state of Washington. On average, the correlation generally follows the intuitively appealing pattern of sales increasing with acreage: average sales per farm steadily increase with each increment of acreage. This pattern holds until farm size reaches 1000 acres. The average sales dip for farms in the 1000-1999-acre range, and then increase again for farms 2000 acres and larger. Table A provides the details.

The problem with this analysis is that it glosses over important differences that exist within each farm size category. The bottom row of Table A hints at these underlying differences. The average sales per acre (average sales/average size) is highest for farms 1-9 acres, holds fairly steady for size categories up to 260 acres, and then drops sharply through the larger farm categories. This unevenness suggests that not all economies are related to larger size, and that other factors besides acreage have an effect on average farm sales.

Table B uses the same acreage categories and breaks out the number of farms within each size category by value of sales. The sales groupings start with annual sales of less than $1000 and run all the way to sales of $1,000,000 and over. The data in Table B do not support the stereotypical idea of a hobby farm as having about five acres and low annual sales. On the contrary, if what we mean by "hobby farm" is that the farm is not a commercial enterprise, then hobby farms come in all sizes. While most of the farms in the lowest sales groupings are also the smallest in terms of acreage, there are also a significant number of higher-acreage farms in the low sales groups. In the highest acreage category (2000+), for example, there are 22 farms with annual sales less than $1000. Of farms over 100 acres, 604 have sales less than $1000, and 2718 have sales less than $10,000.

These same data also demonstrate that a farm need not be particularly large in order to be commercial. At one extreme are the 15 farms in the 1-9-acre category with sales of $500,000-999,999. A total of 110 farms in this size category have sales over $100,000. In the 10-49-acre category there are 23 farms with sales over $1,000,000, and 524 farms with sales over $100,000. These low-acreage, high-sales farms are most likely intensively managed organic producers, truck farms, or small orchards.

That the data do not conform to a rigid notion of what constitutes a hobby farm or a small farm or a commercial farm advances our understanding of the complexities and diversity of Washington agriculture, but does not satisfy our need for an understanding of the hobby farm segment. That hobby farms may be small or large makes the task of grouping hobby farms more difficult, and if anything, intensifies the need to insure that hobby farmers follow practices that are sound both agriculturally and environmentally.

TABLE A: SUMMARY OF SALES AND FARM SIZE

	Total	1-9	10-49	50-69	70-99	100-139	140-179	180-219	220-259	260-499	500-999	1000-1999	2000+
Number of farms	33,559	6,040	11,362	1,956	2,114	1,788	1,358	888	680	2,228	1,855	1,626	1,664
Sales ($1000)	$2,919,634	$65,034	$262,477	$94,913	$163,935	$182,379	$143,674	$120,811	$112,628	$399,387	$552,238	$369,209	$452,949
Avg sales/farm	$87,000	$10,767	$23,101	$48,524	$77,547	$102,002	$105,798	$136,048	$165,630	$179,258	$297,702	$227,066	$272,205
Avg farm size	480	5	24	58	81	116	157	197	238	357	708	1,406	6,238
Avg sales/avg size	$181	$2,153	$963	$837	$957	$879	$674	$691	$696	$553	$420	$162	$44

Source: Bureau of Census

TABLE B: SUMMARY BY SIZE OF FARM, 1987

Item	Total	1 to 9 acres	10 to 49 acres	50 to 69 acres	70 to 99 acres	100 to 139 acres
FARMS AND LAND IN FARMS						
Farms ..... number	33 559	6 040	11 362	1 956	2 114	1 788
percent	100.0	18.0	33.9	5.8	6.3	5.3
Land in farms ..... acres	16 115 568	27 906	269 450	112 704	171 826	207 124
Average size of farm ..... acres	480	5	24	58	81	116
MARKET VALUE OF AGRICULTURAL PRODUCTS SOLD						
Total sales (see text) ..... farms	33 559	6 040	11 362	1 956	2 114	1 788
$1,000	2 919 634	65 034	262 477	94 913	163 935	182 379
Average per farm ..... dollars	87 000	10 767	23 101	48 524	77 547	102 002
Farms by value of sales:						
Less than $1,000 (see text)	5 605	1 681	2 799	275	246	178
$1,000 to $2,499	4 994	1 625	2 392	271	266	157
$2,500 to $4,999	4 166	1 002	1 819	312	276	216
$5,000 to $9,999	3 507	738	1 280	300	272	244
$10,000 to $19,999	2 780	464	848	146	209	206
$20,000 to $24,999	904	104	286	45	65	58
$25,000 to $39,999	1 783	161	463	94	113	100
$40,000 to $49,999	885	55	249	48	41	51
$50,000 to $99,999	2 995	100	702	173	176	125
$100,000 to $249,999	3 605	61	400	227	308	245
$250,000 to $499,999	1 373	34	65	48	99	166
$500,000 to $999,999	634	15	36	13	34	30
$1,000,000 or more	328	-	23	4	9	12

TABLE B: SUMMARY BY SIZE OF FARM, 1987--CONT.

Item	140 to 179 acres	180 to 219 acres	220 to 259 acres	260 to 499 acres	500 to 999 acres	1,000 to 1,999 acres	2,000 acres or more
FARMS AND LAND IN FARMS							
Farms ..... number	1 358	888	680	2 228	1 855	1 626	1 664
percent	4.0	2.6	2.0	6.6	5.5	4.8	5.0
Land in farms ..... acres	213 658	175 059	161 717	796 430	1 313 326	2 285 965	10 380 403
Average size of farm ..... acres	157	197	238	357	708	1 406	6 238
MARKET VALUE OF AGRICULTURAL PRODUCTS SOLD							
Total sales (see text) ..... farms	1 358	888	680	2 228	1 855	1 626	1 664
$1,000	143 674	120 811	112 628	399 387	552 238	369 209	452 949
Average per farm ..... dollars	105 798	136 048	165 630	179 258	297 702	227 066	272 205
Farms by value of sales:							
Less than $1,000 (see text)	111	59	45	111	53	25	22
$1,000 to $2,499	78	51	25	76	40	8	5
$2,500 to $4,999	155	79	60	165	47	25	10
$5,000 to $9,999	162	102	74	189	84	46	16
$10,000 to $19,999	187	113	86	248	139	95	39
$20,000 to $24,999	58	22	20	95	79	46	26
$25,000 to $39,999	90	83	48	206	195	143	87
$40,000 to $49,999	51	29	27	88	101	88	57
$50,000 to $99,999	110	99	95	295	381	386	353
$100,000 to $249,999	171	116	87	406	353	528	703
$250,000 to $499,999	124	86	66	190	174	97	224
$500,000 to $999,999	49	38	37	120	133	67	62
$1,000,000 or more	12	11	10	39	76	72	60

Source: Bureau of Census

The Soil Conservation Service (SCS), in cooperation with Conservation Districts and local Extension offices, offers a program to assist hobby farmers in the adoption of best management practices. According to one SCS staff member involved in this effort, the hobby farms have been the source of some environmental problems. Hobby farms tend to release more pollutants acre for acre than commercial farms. The hobby farmers have limited backgrounds in agriculture, and as a result may keep more animals per acre, and may not understand how to manage a grazing system. In addition, these hobby farmers usually rely on off-farm income, and consequently spend more time away from the farm. For some, the farm is a second home. The limited amount of time spent on the farm, along with inadequate knowledge or training, contributes to the problems associated with improper management practices. On the positive side, SCS reports that these hobby farmers intend to operate responsibly. Attendance at weeknight and weekend programs is consistently higher than expectations, and by their participation these farmers are demonstrating their commitment to adopting best management practices. Any conclusions drawn from this anecdotal information are necessarily limited.

In the absence of firm figures or even a standard definition of hobby farms, this analysis cannot do justice to the hobby farm issue, but it does uncover some interesting findings:

Small farms (in terms of acreage) can have high annual sales.

If hobby farms are those with low sales, then hobby farms come in all sizes.

At least in the recent SCS experience, hobby farmers may have limited agricultural backgrounds, but appear to be committed to adopting best management practices.

The safest conclusion to reach from this presentation is that Washington agriculture is incredibly diverse in terms of the relationship between farm size and annual sales. Further conclusions about the status of hobby farms in Washington must await further research and analysis. (See Family Farm ing: A New Economic Vision by Marty Strange for a full discussion of the farm size issue on the national scale.)

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THE STATE OF THE ENVIRONMENT REPORT

VOLUME II
Part 4

Wetland Resource Characterization Report

ENVIRONMENT 2010

State of Washington
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About the authors:
Douglas J. Canning (BA, MS, Environmental Science), is a special area management planner with the Planning Section, Shorelands and Coastal Zone Management Program, Washington Department of Ecology. Michelle Stevens (BA, MS, Wetlands Ecology) is a wetlands ecologist with the Wetlands Section, Shorelands and Coastal Zone Management Program.

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WETLANDS RESOURCE CHARACTERIZATION

SUMMARY

Current Status of Washington's Wetlands

Washington is a rapidly growing state with a finite wetland resource. The best information available at this writing indicates that there are approximately 938,000 acres of wetlands in Washington (U.S. Fish and Wildlife Service estimates, 1989). Estimates of pre-settlement acreage vary widely depending on what historical information and research assumptions are used. Estimates vary from 33 to 50 percent of the wetlands have been lost. Localized areas have experienced much higher losses; 70 percent of the tidally influenced emergent wetlands in the Puget Sound have been lost due to diking, dredging, and filling activities. Urbanized wetlands in the Puget Sound have suffered losses ranging from 90 to 98 percent (Bortelson, 1980).

In both western and eastern Washington, many of the remaining wetlands have experienced some degree of degradation to vegetation, soils, or hydrology. All areas inventoried have been degraded to some extent; it is difficult to determine the condition of the land prior to European settlement (Kunze, 1989; Evans, 1989). Mitigation has had a very poor track record for adequately compensating for lost wetland values and function (Kunz et al., 1988).

With increasing populations and a decreasing developable land base, wetland losses are continuing and are expected to increase in the absence of regulatory and preservation/acquisition programs. This will result in continued loss of wetland functions and values. For example, loss of fish and wildlife habitat may lead to declines in populations and less opportunities for hunting, fishing, and passive observation. Continued loss of hydrologic functions of wetlands for flood control and water quality improvement will lead to greater municipal costs to provide these benefits through engineered structures.

Comprehensive planning is a key component to protecting the remaining wetland resource base and providing opportunities for continued human growth and development. Advanced planning for development through such activities as the Special Area Management Plans developed by the U.S. Army Corps of Engineers, Advanced Identification by the Environmental Protection Agency, watershed management plans, and sensitive area planning by state and local governments assist in maintaining wetland areas for all the functions and values which they serve.

Principal Threats to Washington's Wetlands

Human Threats

Direct

1. Drainage for crop production, timber production, and mosquito control.

2. Dredging and stream channelization for navigation channels, flood protection, coastal housing developments, and reservoir maintenance.

3. Filling for dredged spoil and other solid waste disposal, road and highway construction, and commercial, residential, and industrial development.

4. Construction of dikes, dams, levees, and sea walls for agriculture, hydroelectric energy, flood control, water supply, irrigation, and storm protection.

5. Discharges of materials (e.g. pesticides, herbicides, other pollutants, nutrients from domestic sewage and agricultural runoff, and sediments from dredging and filling, logging, and agriculture, and bacteria from septic and other sources).

6. Mining of wetland soils for peat, coal, sand, gravel, phosphate, and other materials.

7. Vegetation removal, particularly through forestry and other land clearing activities.

Indirect

1. Sediment production from erosion through road construction, land clearing activities through agriculture, forestry and urbanization, and bank destabilization.

2. Introduction of exotic plant species, reduced wildlife habitat values, and reduced species diversity and food chain support from disturbance adjacent to and within wetlands.

3. Hydrologic impacts due to extraction of ground water, oil, gas, sulphur, and other minerals.

4. Stormwater impacts from increased peak flows; and pollutants, sediment and nutrients accumulating in wetland areas.

5. Reduced groundwater exchange capacity from filling springs, and reducing points of groundwater discharge and recharge.

6. Subsidence, including natural rise of sea level.

7. Soil compaction, erosion, and bank destabilization from livestock grazing.

Natural Threats

1. Flooding, particularly rain or snow events, hurricanes and other storms.

2. Droughts.

3. Fire.

4. Ice scour.

5. Erosion.

6. Biotic effects, e.g. muskrat, nutria, and goose "eat outs."

Trends in Recent Years

Several estimates of wetland loss have been attempted in recent years. All differ from each other, but review of them offers some general understanding of the state of Washington's wetlands. It should be noted that all projections of loss are conservative estimates; whatever numbers are given, significant loss of Washington's wetland base is indicated.

According to the U.S. Fish and Wildlife Service discussion paper on Wetlands and Deepwater Habitats in the state of Washington (July, 1989), all wetlands and deepwater habitats comprised about 5.5 percent of the state of Washington in the early 1980s. Wetlands made up about 2 percent and deepwater habitats about 3.5 percent of the state. Within the state of Washington only about 67 percent of the estimated wetland acres at pre-settlement remained in the early 1980s. Deepwater habitats decreased by only about 4 percent. These estimates of loss are very conservative; actual wetland losses are expected to be higher than these estimates. In addition, losses do not account for conversion from forested riparian types to deepwater habitat for reservoir construction; they also do not account for degradation. In summary, Washington has lost over 33 percent of the state's wetlands.

Other loss projections for Washington include the following losses for freshwater wetlands in the following selected areas of western Washington (Boule et al., 1983):

Tenino and Yelm (south Thurston County): 55%
Tacoma South (Pierce County): 82%
Lake Washington (King County): 70%

A detailed analyses by the U.S. Geological Survey of historical wetland acreage of 11 estuaries in Puget Sound estimates that 100 percent of the Puyallup River, 99 percent of the Duwamish River, and 96 percent of the Samish River wetlands have been lost (Bortleson et. al., 1980). In the remaining 9 estuaries studied, acreage losses ranged between +0.2 percent to -89.7 percent.

Some local indicators of recent trends are available in Washington. Based on field inventory observations, Snohomish County estimates losses of 15 wetland acres per month, or 180 acres per year. Based on this figure, statewide losses for the eight counties with similar growth projections plus King and Pierce counties would be 1,800 acres per year for urbanized counties.

A Department of Ecology study of SEPA documents for rural and suburban wetland losses throughout Washington found that a conservative estimate of wetlands loss is 530 acres per year (Hull and MacIvor, 1987). This study found that well over twice the number of acres of wetland were drained as were filled. This is a concern because the Clean Water Act 404 permitting process covers filling but not draining of wetlands. Over 74 percent of the wetlands observed as impacted on the project sites were between one-half and five acres in size; of the wetlands extending off-site, 46 percent were found to be under five acres in size. Small, isolated wetland fills are also not covered under the 404 permitting process.

A review of the annual loss of wetlands through issuance of permits under Section 404 of the Clean Water Act indicates 185 acres are lost per year in Washington. This estimate is extremely conservative and does not reflect the acreage losses of isolated wetlands issued under Nationwide 26 of the Clean Water Act, nor do they reflect losses from activities other than placement of fill in wetlands.

Besides outright wetland loss, wetland and riparian systems in the state have been so degraded that it is difficult to piece together what these systems looked like prior to European settlement. All wetland sites have been adversely impacted to some degree by upslope or upstream activities. Virtually all sites inventoried in Washington have been disturbed to varying degrees by human or livestock activities. The best sites are recovering from these impacts and are no longer in a pristine state.

Mitigation through creation and restoration has proved to be largely unsuccessful in compensating for wetland losses. Between 1980 and 1986, mitigation negotiations resulted in the exchange of 152 acres of natural wetlands for 100 acres of created/restored wetlands, a proposed replacement rate of 67 percent (Kunz et al., 1988). This includes only those wetlands under the jurisdiction of and regulated by Section 404 of the Clean Water Act. It does not include areas unregulated, which make up the bulk of the wetland losses (Hull and MacIvor, 1987). In addition, it does not account for the poor success rate on the ground of a created wetland's ability to provide values and functions within the context of the landscape. A net loss in wetland diversity has occurred in wetland mitigation design, with little attempt at replication of forested or peat wetlands.

<u>The Likely Future</u>

One case example is the Green River Valley where growth information is based on estimates from the Puget Sound Council of Governments. The Green River Valley contains the largest supply of vacant, zoned commercial and industrial land in the Seattle metropolitan area. The supply of zoned land is virtually exhausted in Seattle and is running low on the Eastside. A large portion of the vacant, industrially-zoned land in the Kent Valley contains wetland areas. The supply of land in the valley is expected to last only until the mid-1990s; therefore, only a two- to four-year supply is available. The market is extremely tight, land prices continue to escalate, and development pressure in this area is extremely high.

This example demonstrates that wetland losses are likely to continue or increase in the absence of comprehensive legislation and/or funding to carry out acquisition and protection programs. Population densities continue to increase, particularly in Thurston, Mason, Island, Snohomish and Kitsap, Clark, Douglas, Franklin, King, and Pierce counties. Increases in population by the year 2000 are as high as 30 percent for some Puget Sound counties, and average 17 percent statewide (1987 OFM population trends). In many areas such as the Green River Valley and Mill Creek, most buildable upland sites have already been developed. Increased population growth and reduced available upland alternatives can only translate into increased wetland loss. In addition, development pressure often results in isolation and truncation of wetland/upland ecosystems, reducing the value of the wetland for wildlife. Urbanization results in increased run-off with oils, gasoline, nutrients from fertilizers and pesticides, sediment and increased stormwater from impermeable surfaces degrading remaining wetlands. Degradation due to pollution, introduction of exotic plant species, habitat loss, and other factors is likely to continue also.

Mitigation replacement rates of acreage only to compensate for lost wetlands is only 67 percent for activities permitted under Section 404 of the Clean Water Act. Many wetland losses occur without mitigation. Without stronger wetland regulations, increased mitigation monitoring and reliability, and better enforcement wetland losses will increase exponentially in the next decade.

Benefits Derived from Washington's Wetland

Groundwater recharge and discharge.
Flood storage and desynchronization.
Shoreline anchoring and dissipation of erosion forces.
Sediment trapping.
Nutrient retention and removal.
Food chain support.
Habitat for fisheries.
Habitat for wildlife.
Active recreation.
Passive recreation, aesthetics, and heritage value.
Native plant reserves.
Biological diversity.

Successful Methods for Protecting Washington's Wetlands

There has been no known systematic evaluation of successes in protecting Washington's wetlands, however, the following methods have been shown to be useful:

- Expanded regulatory authority, particularly over isolated wetlands and over activities other than placement of fill. This can be implemented at the federal, state, or local level.

- Preservative through acquisition in fee, conservation easements, or other securing methods.

- Inclusion in buffer strips, greenbelts, or open space required of development projects.

- Tax incentive programs, such as the Washington State Open Space Act.

1. RESOURCE DESCRIPTION

Wetlands inventory and evaluation in Washington State is in progress, and as yet is incomplete. On May 9, 1988, Governor Booth Gardner signed Executive Order 88-03 directing the Department of Ecology to undertake a study of Washington's wetlands. The Executive Order consists of the following three sections:

Section 1. *A study report shall be submitted to the Governor by November 30, 1988.* The report, 1988 Washington Wetlands Study Report (Ecology, 1988a), was completed on schedule; copies are available from Wetlands Section, Shorelands and Coastal Zone Management Program, Washington Department of Ecology. Much of this report is adapted from the executive order report.

Section 2. *The Executive Order encouraged the formation of an advisory committee to assist Ecology in carrying out its charge.* A broad-based advisory committee was created by Ecology in July, 1988. The committee met eight times between August and November, 1988, providing Ecology with advice on technical and policy matters.

Section 3. *Ecology was directed to assess the extent, types, and sizes of Washington's wetlands, and to evaluate the extent and causes of wetlands alteration and loss.* To accomplish this task, Ecology contracted with the U.S. Fish and Wildlife Service (U.S. FWS) to produce digitized National Wetlands Inventory maps for the entire state, plus a report comparing the extent of wetlands in the mid-1980s to historical wetlands information. Maps, tabular data summaries, and the wetlands trends report was submitted to Ecology in June, 1989. Portions of the U.S. FWS report were available in draft form during the preparation of this report, and have been incorporated where appropriate.

1.1 Introduction

Washington State is divided by the Cascade Mountains into two distinct physiographic regions, providing a wide range of climatic conditions and a considerable diversity of geology, soils, vegetation, and water regimes. This physiographic diversity has produced a tremendous variety of wetlands in Washington, ranging from alpine and subalpine meadows in the higher elevations of the Cascade and Olympic mountain ranges, to salt marshes along the Pacific Coast; river mouth estuaries within the greater estuary of Puget Sound; and vast areas of freshwater marshes in the Columbia Basin, which result from both natural interior drainage and from irrigation activities.

Washington has over 2,400 miles of shoreline, most of which is found west of the Cascades. This includes the Pacific Ocean, large estuarine areas such as Grays Harbor and Willapa Bay, Puget Sound itself, and many large river systems which drain into both Puget Sound and the Pacific Ocean. The Skagit River, for instance, is the largest West Coast river system north of San Francisco Bay -- with the obvious exception of the Columbia River -- and the estuarine wetlands at the mouth of the Skagit are both extensive and biologically rich.

While many of the freshwater wetlands of western Washington are associated with ponds, lakes, rivers, and other shorelines, many more are isolated from open water and owe their existence to saturated soil conditions. The water source for isolated wetlands is from rainwater or snowmelt, and usually is associated with the groundwater through springs or seeps.

The wetlands of eastern Washington are more localized in their distribution but even more varied than their western counterparts in terms of seasonality, chemistry, and plant species composition. The climatic regimes of eastern Washington give rise to a variety of permanent and intermittent streams and wetlands. Flowing water wetlands along rivers and streams are very dynamic ecosystems, with flashy hydrology resulting in very rapid high water events in the spring and drier conditions in summer and fall. Bogs and fens are generally very acidic, nutrient poor and form over a period of thousands of years. Vernal ponds and playas form in the spring, provide important habitat for waterfowl and migratory birds, then dry up by summer. These intermittent wetland systems are often saline, and contain some of the same plants found in tidal areas.

Many existing wetlands in eastern Washington, particularly in the Columbia Basin, have been rearranged by human's activities. Large hydroelectric projects in the Columbia River produced large expanses of open water habitat, converting hundreds of miles of riparian habitat adjacent to rivers. Subsequent irrigation projects created wetlands through water redistribution and high water tables, though many valuable riparian wetlands have been eliminated by irrigation projects and farming and livestock activities.

Washington is a rapidly-growing state, and it is estimated that half the state's wetlands have been directly or indirectly lost to various types of development since the turn of the century. Many of those which remain have been degraded through altered hydrologic conditions; compaction of soil through livestock grazing or use of heavy equipment while soils are wet; attempted draining; introduction of exotic species such as reed-canary grass, smooth cordgrass, Russian olive, and purple loosestrife taking over native plant communities; and using wetlands for dumping of garbage, tires, and sometimes hazardous materials. The two principle causes of direct wetland alteration in Washington in the past have been the establishment of agriculture and the siting of ports and industrial facilities. Wetland alteration is currently occurring through urban expansion, forestry and grazing.

In many areas of western Washington, including the Skagit and Nisqually River deltas, the original loss of wetlands can be attributed to the creation of farmland through the construction of dikes -- a practice that was encouraged by federal policy beginning with the Swampland Acts of 1849 through 1860.

In the case of estuaries, the conversion of wetlands to industrial land took place as ports and cities were established -- including Tacoma, Everett, and Aberdeen -- at the mouths of major western Washington rivers. Large river surge plain forests entering the Puget Sound, Grays Harbor and coastal areas were cleared for forestry, and large log booms floated down river to ports or railroads where logs could be shipped.

Only half of the surge plain rivers still have forests, and vast expanses of those that remain have been channeled, diked, and converted to agriculture or residential uses.

Filling of wetlands in these major port areas was originally done because they were the most convenient and seen as the least valuable places to dump ballast. The practice later became a major focus of port activities in western Washington to create more land for water-related industrial and commercial activities. It is estimated that more than 90 percent of the original saltwater wetlands in urban estuaries of Puget Sound have been filled or otherwise eliminated.

It was not until the late 1960s and early 1970s that the public started to understand and appreciate the functions and values associated with wetlands and, with this increased awareness, public policy began to be changed through the passage of federal and state laws to protect wetlands. Some nonregulatory programs, dating as far back as the early 1940s, were established to protect wetlands. The 1929 Migratory Bird Conservation Act, 1934 Duck Stamp Act, 1961 Wetlands Loan Act and 1986 Emergency Wetlands Resources Act establish funding to acquire habitat for migratory waterfowl. Private groups such as Ducks Unlimited have continued donating private funds for acquisition of private property.

The federal Clean Water Act was passed in 1972 and is still the primary tool with which the federal government protects wetlands -- although the Act only regulates the discharge of dredged or fill material into wetlands. Executive Order 11990 ended most federal assistance for wetland conversion through requiring federal agencies to consider the effect of any proposed activity on federal lands.

The Washington Legislature passed the Shoreline Management Act in 1971 and this Act is the only state law which specifically addresses the regulation of activities in wetlands -- although 75 percent of the state's wetlands are left out of the Act's definition of shoreline "associated wetlands". Many local governments in the state have passed local ordinances restricting or regulating adverse impacts to wetland areas. Work in wetlands below ordinary high water in waters of the state can be regulated under the Hydraulics Code.

1.2 Wetlands Definitions

Wetlands are transitional areas between open water and upland. While the line between upland and wetland is generally indistinct in nature, for planning and regulatory purposes a line must be drawn. To determine the wetland edge, wetland definitions are based on three parameters: water (hydrology), soils and vegetation. The U.S. Fish and Wildlife Service wetland definition is the most comprehensive. While all wetland areas must have hydrology, either soils or vegetation may be included to meet the wetland definition. The Clean Water Act definition is a more rigorous definition, and all three parameters must be present on a site.

However, the new Federal Wetland Delineation Methodology, approved this year by the Army Corps of Engineers, Environmental Protection Agency, Fish and Wildlife Service and Soil Conservation Service, provides one consistent regulatory approach for delineating wetlands. The differences between the two definitions for vegetated wetlands is reduced by use of the new methodology.

In Washington State, three definitions have generally been applied to implement various federal, state, and local regulations and wetland management programs:

1.2.1 U.S. Fish and Wildlife Service

The following definition, developed by Lewis M. Cowardin et al. in 1979, has been adopted by the Fish and Wildlife Service for inventorying and mapping the nation's wetlands through the National Wetland Inventory. It is also the basis for all local inventories in Washington, as well as some state and local regulations:

> Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water... Wetlands must have one or more of the following attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

1.2.2 Clean Water Act

This definition applies to all waters of the United States regulated under the Clean Water Act, including dredge and fill permits under Section 404 (33 CFR 323.2). Although this definition is also based on conditions of soil, water regime, and vegetation, it requires that a positive indicator of all three features be present -- as opposed to one or more positive indicators with the Cowardin method. This definition is also used in several local wetland ordinances:

> The term wetlands means those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

1.2.3 Shoreline Management Act

In 1971, the Washington Legislature adopted a definition of wetlands for purposes of implementing the Shoreline Management Act (Chapter 90.58 RCW). This definition relies largely on a measurement of 200 feet from the ordinary high water mark of certain streams, lakes, and tidal waters plus associated marshes, bogs and swamps to establish the landward limit of the Act's jurisdiction. The definition of associated marshes, bogs and swamps uses the U.S. Fish and Wildlife Service definition. Because the scope of the Shoreline Management Act is limited to lakes at least 20 acres in size and streams with flows of at least 20 cubic feet per second (cfs), the following definition under the Act includes only a fraction of the state's wetlands:

> Wetlands or wetland areas means those lands extending landward for two hundred feet in all directions as measured on a horizontal plane from the ordinary high water mark; floodways and contiguous floodplain areas landward two hundred feet from such floodways; and all marshes, bogs, swamps, and river deltas associated with the streams, lakes, and tidal waters which are subject to the provisions of this chapter; the same to be designated as to location by the department of ecology; Provided, That any county or city may determine that portion of a 100-year floodplain to be included in its master program as long as such portion includes, as a minimum, the floodway and the adjacent land extending landward two hundred feet therefrom.

1.2.4 Discussion

The official definition of the term "wetlands" is of great concern to farmers, developers, state agency staff, local government officials, and members of the public concerned about the protection of wetlands because the definition will determine the overall scope of any new state-mandated or state-funded program to identify, protect, and/or acquire wetlands.

The advantages and disadvantages of the two primary federal definitions were discussed with the Governors Wetlands Executive Order Advisory Committee. No consensus was reached by the Advisory Committee on the topic of wetlands definition. The Committee was almost evenly split between favoring the U.S. Fish & Wildlife Service and Clean Water Act definitions.

This report uses the U.S. Fish & Wildlife Service definition (Cowardin, et al., 1979) where there is a choice. As a practical matter, wetlands inventories conducted in the past may have used any of a number of definitions, often undefined. Prior to 1979, the most common definition used by researchers was Circular 39 (Shaw & Fredine, 1956), also a U.S. Fish & Wildlife Service sponsored definition.

1.3 Wetlands Types

The following description of wetland plant communities generally follows the current classification system of the U.S. Fish and Wildlife Service (Cowardin, et al., 1979). Information from the draft report being prepared by the U.S. Fish and Wildlife Service (U.S. FWS) for Ecology to be titled Wetlands of Washington has been summarized and adapted for this report. These descriptions are keyed to the ecoregions of Washington state: Coast Range Ecoregion; Puget Lowland Ecoregion; Cascade Ecoregion; Eastern Cascades Slopes and Foothills Ecoregion; Columbia Basin Ecoregion; Northern Rockies Ecoregion.

Many factors influence wetland plant community structure. Like all plant communities, climate, soils, elevation, aspect, fire history, human activities and animal activities such as herbivory and pollination mechanisms play important roles in plant species abundance and composition. In wetland plant communities, water source, frequency and duration significantly influence soil chemistry and pH, the stability or dynamics of the plant community over time, and plant species composition. The presence and abundance of a wetland plant species depends upon its life history and adaptation to its local environment (Van der Valk, 1981).

In addition, the distribution of vegetation in wetlands has been strongly influenced by disturbance such as logging, plowing, burning, mowing or grazing by livestock; invasion of exotic species such as purple loosestrife, reed canary grass and Russian Olive; and alteration of water quality and quantity influencing the wetland.

Wetland ecosystems vary within the landscape and watershed in which they occur. The dynamics and relative stability of wetland systems vary widely. Peat systems generally include bogs, which are separated from surface and groundwater sources, and fens, which are hydrologically connected to surface or groundwater. Bog systems form very slowly, at a rate of one inch in 40 years in western Washington and one inch in 100 years in eastern Washington. This slow rate of peat accumulation is due to the lack of decomposition in permanently saturated systems. Peat systems have very low pH, as low as 4.0, and low nutrient availability. These systems are very stable for long periods of time; since the last glacial period, peat formation has been relatively constant. Small changes in water quality or quantity can significantly impact bog systems. Nutrient input of fertilizer, wastewater or stormwater can significantly adversely impact these peat systems.

Riparian systems are dynamic systems. They rely on extreme 10 or 100 year events to maintain ecological dynamics. The accretion and deposition of river sediments, rechannelization and hydrologic configuration of rivers, is altered on an annual basis. Successional sequences in rivers is in a fluctuating equilibrium, with river bars, old oxbows, deposition and accretion areas constantly changing over time. In riparian systems, up to 80 percent of the water moving through the system can be subsurface. These systems depend on rapid and extreme hydrologic changes to maintain the successional equilibrium.

Surge plain wetlands form near the mouths of rivers flowing into tidal waters. High tide causes a backwater effect in these systems, with fresh river flowing into high tidal waters, and backing up into the wetlands. Dendritic tidal channels form convoluted micro-topography; flooding and tidal changes are constants in these systems. Most of the area is below the ordinary high water mark; tree and shrub reproduction occurs on down logs and stumps. Cutting in these areas can eliminate successful forest reproduction.

Wetland succession is referred to as "hydrosere succession." This refers to a fluctuating equilibrium of plant communities driven by the constant hydrologic and climactic changes associated with wetland systems. Succession from open water to emergent vegetation to shrub and forested woody vegetation is not usually linear. Instead, floods, fire and other natural disturbances cause constant fluctuations in the vegetation. Extreme events such as a hundred year flood generally cause the system to develop more open water habitat; periods of relative stability cause forested system development. Dry periods cause trees to pioneer a site; wet periods cause them to die, creating habitat for cavity nesters.

The mosaic of open water, different vegetation seral stages, and the edge created through the interface of these structurally diverse types, represents a high quality wetland ecosystem with high habitat value.

Wetlands of Washington occur in all five National Wetland Inventory systems. Marine wetlands are mainly restricted to Pacific Ocean intertidal beaches and rocky shores. The majority of estuarine wetlands are found within Puget Sound, Grays Harbor, Willapa Bay and the mouth of the Columbia River. Palustrine wetlands are the predominant wetland type throughout the state. Lacustrine and riverine wetlands mainly consist of lake shores, river bars, and aquatic beds.

The following sections will describe common wetlands types and wetland communities for each ecological wetland system within Washington's ecoregions. These community descriptions are based upon a literature review specific to Washington wetlands and data collected during the National Wetland Inventory mapping process. Data has also been provided from plant associations developed on national forest lands and an inventory done for the Columbia Plateau region of Washington.

1.3.1 Marine

The Marine System includes the open ocean overlying the continental shelf and associated coast line. Important vegetated deepwater habitats include kelp beds and surfgrass beds. These areas are classified as marine, subtidal, aquatic beds. Kelps persist on rocky reefs near the intertidal shores.

Marine wetlands consist of beaches (unconsolidated shores) and rocky shores. Wetlands within this zone dominated by macrophytic plants are classified as estuarine habitats (Cowardin, et al., 1979). These marine wetlands front the Pacific Ocean, occur along the strait of Juan de Fuca, San Juan Islands coast lines, and off shore rocky islands. Macroalgae are the most visible rocky shore inhabitants. Extensive beaches occur only along the southern Washington coast and spits at the mouth of Grays Harbor and Willapa Bay. The high energy environment keeps these habitats unvegetated.

1.3.2 Estuarine

The estuarine system is characterized by semi-enclosed coastal areas where sea water brought in by tides and wind mixes with freshwater supplied either from coastal or interior watersheds. Adjacent vegetation is inundated with brackish waters at least occasionally. Estuarine water extends upstream in coastal rivers to where the salinity of ocean derived salts is less than 0.5 parts per thousand (ppt; o/oo). A variety of estuarine wetlands exist due to the variations in estuarine water salinities and the duration and frequency of flooding. These include estuarine subtidal and intertidal aquatic beds, estuarine intertidal shores, estuarine emergent wetlands and estuarine scrub-shrub and forested wetlands. Major estuarine habitats are found at the mouth of the Columbia River, Willapa Bay, and Grays Harbor in the Coast Range ecoregion. The waters of Puget Sound and adjacent lands are the other major estuarine habitats located in the Puget Sound ecoregion.

Estuarine: Subtidal and Intertidal, Aquatic Beds. Vegetated sandy and muddy substrates adjacent to intertidal zones are often dominated by eelgrass (Zostera marina, Z. japonica). Green algae (Ulva spp.) are common co-dominants. Rocky substrates are commonly dominated by the kelps Nereocystis and Laminaria. Padilla Bay is famous for it expansive eelgrass beds. Other major stands of eel grass occur throughout Puget Sound. Portions of intertidal channels dewatered at low tide are commonly dominated by eelgrass and Lilaeopsis occidentalis.

Estuarine: Intertidal, Shores. Estuarine, intertidal, unconsolidated shores consist of gravels, sand and mud exposed by tides. Commonly known as "tidal mud flats" drastic water fluctuations discourage most plant communities from colonizing these sites. However, during summer months, wide extensive mats of green and blue green algae may develop. The macroalgaes are commonly found on estuarine, intertidal, rocky shores. The estuarine, intertidal shores of Willapa Bay, Grays Harbor, and the Columbia River are Washington's largest areas of this habitat type and famous for their values as migratory bird feeding areas.

Estuarine: Intertidal, Emergent Wetlands. Plant communities within estuarine, intertidal, emergent wetlands are a result of tidal salinities, flooding duration, inland freshwater mixing and disturbance. These areas are commonly referred to as salt marshes. Broad expanses of these wetlands are common in Grays Harbor, Willapa Bay, and the mouth of the Columbia River. Estuarine, intertidal, emergent plant community distribution at the mouth of the Columbia River are somewhat different than those found in Grays Harbor and Willapa Bay. The large volumes of Columbia River freshwater mixing with marine waters results in plants more commonly associated with freshwater systems growing adjacent to plants commonly associated with saline waters.

Regularly flooded estuarine plant communities (low salt marshes) typically occur from about six feet above mean lower low water to mean higher high water. Salinities can be variable, from saline (30 to 35 ppt) to brackish (5 to 7 ppt). Sites regularly flooded with highly saline waters areas are dominated by pickleweed (Salicornia virginica), salt grass (Distichlis spicata), seaside arrowgrass (Triglochin maritimum), Jaumea (Jaumea carnosa), and saltmarsh sandspurry (Spergularia marina).

More brackish regularly flooded sites commonly contain the above mentioned species in addition to Olney's Three Square (Scirpus americanus), Lyngby's sedge (Carex lyngbyei), redtop (Agrostis alba), hard stem bulrush (Scirpus acutus) and cattail (Typha latifolia). Smooth cordgrass

(Spartina alterniflora), a species common to Atlantic coast low salt marshes, has become established in Willapa Bay and appears to be expanding its range.

Intertidal emergent wetlands irregularly flooded by estuarine waters normally occur above mean higher high water. These "high salt marshes" also may have a wide range in flood water salinities and very often have a more varied plant community than low salt marshes.

Estuarine: Scrub Shrub and Forested Wetlands. Estuarine scrub shrub and forested wetlands are characterized by woody species typically found as a boundary condition between freshwater woody wetlands and estuarine emergent wetlands and along channel levees and dikes. Flood waters normally are very brackish and these habitats more closely resemble freshwater wetlands. Woody species less than 6 meters tall are considered scrub shrub and those greater than 6 meters tall considered forest (Cowardin, et al., 1979). Common species include western crabapple (Pyrus fusca), hooker's willow (Salix hookeriana), Sitka willow (Salix sitchensis), red Osier dogwood (Cornus cernua), Pacific ninebark (Physocarpus capitatus), black twinberry (Lonicera involucrata), red alder (Alnus rubra), western red cedar (Thuja plicata) and Sitka spruce (Picea sitchensis).

1.3.3 Riverine

The riverine system is mainly a deepwater habitat system. Riverine wetlands consist of exposed portions of the river bed, aquatics within the river channel and non-persistent emergents within the river channel.

By far, the most common Riverine wetland class is the Riverine, Unconsolidated Shore, commonly know as the river bar or gravel bar. Many of these bars become vegetated with pioneering species such as dandelions, fireweeds, etc., during low flows, but disappear when the annual high flows scour the vegetation from the bar.

It is common in many tidal lower perennial, and slower portions of upper perennial reaches for rivers bottoms to bè dominated by various algae, aquatic mosses and rooted vascular aquatics. True water-cress (Nasturtium offininale) and yellow-cress (Rorippa spp.) are probably the most conspicuous riverine aquatics. Riverine non-persistent emergents, other than the cresses, are not common. Occasionally species such as yellow water lily (Nuphar polysepalum), arrow-head (Sagittaria cuneata, S. latifolia), water-plaintain (Alisma plantago-aquatica), or smartweed (Polygonum spp.) may occupy river channels with slow flows, but these areas are not extensive. Most often persistent vegetation is found in or adjacent to river channels.

1.3.4 Lacustrine

The Lacustrine system is mainly a deepwater habitat system consisting of lakes, reservoirs and deep ponds. Wetlands are restricted to shallow water (less than 2 meters at low water or the maximum extent of non-persistent emergents (Cowardin, et al., 1979) and exposed shorelines. Vegetated wetland classes consist of aquatic beds and non-persistent emergents. Lacustrine aquatic bed species are the same as those noted for Palustrine aquatic bed. Lacustrine emergent wetlands usually border lake shores. Persistent vegetation is also common along the margins of lakes, but is considered to be in the Palustrine system (Cowardin et al., 1979). Common non-persistent emergent species include arrow-head, water-plaintain, smartweed, yellow water lily, common mare's-tail (Hippuris vulgaris), and pondweed (Potomogeton spp).

1.3.5 Palustrine

The majority of Washington's wetlands are freshwater wetlands, classified as Palustrine wetlands. Palustrine wetlands include most of the vegetated freshwater wetlands, and form marshes, swamps, bogs, wet meadows, shallow ponds and many riparian habitats. Wetlands are transition zones between open water and upland. Some wetland plant species, known as obligate wetland plants, are found only in permanently flooded or saturated conditions. Other wetland plants, known as facultative, grow in both wetland and upland conditions. Palustrine wetland plant communities will be discussed by class in the following subsections, with some discussion of dominant plant species and plant community dynamics.

Palustrine forested wetlands, commonly referred to as swamps, are dominated by woody vegetation greater than 6 meters (20 feet). They are the most structurally diverse wetlands found in Washington. Most forested wetlands occur along rivers or in river floodplains, but are also common in upland depressions, seepage areas and adjacent to estuarine systems. These wetlands occur in tidal and nontidal freshwater situations. Common species occurring in wetlands include: red alder, thin-leafed alder, black cottonwood, western red cedar, Sitka spruce and hemlock.

Palustrine scrub-shrub wetlands are characterized by woody vegetation less than 6 meters tall. Such wetlands have been referred to as swamps and bogs. These wetlands are most commonly found along rivers or in valley bottoms, but as with forested wetlands, may be locally abundant in upland depressions, seepage areas and adjacent to estuaries. Scrub-shrub wetlands occur in tidal and nontidal freshwater areas. Common species occurring in wetlands include willows, red Osier dogwood, Douglas spiraea, snowberry, hawthorn, wild rose, and gooseberry.

Palustrine emergent wetlands are the most common wetland type inventoried in Washington. They are dominated by persistent and non-persistent grasses, sedges, rushes, cattails, forbs and ferns. Such wetlands have commonly been referred to as marshes, wet meadows, fens, bogs and prairies. There are over 350 species of grasses and grasslike (sedges, rushes, etc.) plants and over 850 species of forbs which occur in Washington wetlands. Many are found in association with other classes of wetlands (scrub-shrub and forested).

Palustrine aquatic beds occur throughout Washington's ecoregions usually where water is semipermanent or permanent. Most often shallow ponds or the littoral zone of lakes support this vegetation type. Some aquatics float through the water column, while others float on the surface like duckweed. There are many rooted vascular plants which float on the water surface, such as water lilies and water butter-cup.

1.3.5.1 Coast Range and Puget Lowland Ecoregion

Forested Wetlands. Several types of forested wetlands occur within Washington's Coast Range and Puget Lowland Ecoregions. Within the coastal sand dune systems, forested communities occupy some deflation plain wetlands. These sand dune forested wetlands are found along the sand spits of Grays Harbor and Willapa Bay.

Forested wetlands occupying lowlands adjacent to estuaries are commonly known as coastal swamps. These surge plain wetlands are formed through freshwater tidal action formed when the river backs up during high tide. These areas are characterized by high water tables throughout the growing season, with daily water level fluctuations based on tidal action. Plant communities are nearly identical under tidal and nontidal freshwater flooding regimes. Large tracts of freshwater tidally flooded forested wetlands are found along the lower Chehalis River, Willapa River, Black River (Thurston County), Skagit River delta, and Nisqually River delta. Nontidal coastal swamps are also found at the above mentioned areas and in lowlands bordering the major estuaries of Washington.

Inland from the coast within the Coastal Range and Puget Lowland Ecoregions, forested wetlands are found primarily in river valleys and occupying depressional areas particularly in the glacial drift portions of the Puget Lowland. Examples of these wetlands are found along the lowland valleys of the Chehalis, Willapa, Newaukum, Cowlitz, Lewis, and Columbia rivers as well as the lower reaches of the Skykomish, Skagit, Stillaquamish, and Nooksack rivers.

Scrub-Shrub Wetlands. Many deflation plain wetlands within the coastal dunes are dominated by shrubs. The stabilized dunes at the southern end of the Long Beach Peninsula often contain circum-boreal sphagnum bogs, with a compliment of ericacious shrubs such as Labrador tea (Ledum groenlandicum), bog laurel (Kalmia occidentalis) and small cranberry (Vaccinium oxycoccus). These areas are characterized by saturated sphagnum based peat soils with no external drainage. These extremely acid, nutrient deficient conditions favor a specialized plant community.

Commercial "cranberry bogs" are sometimes created in upland sites, and other times are wetland bogs which have been manipulated to favor growth and reproduction of small cranberry. Normally small cranberry would be just one component of a natural bog.

Scrub-shrub wetlands are common along the Columbia River, particularly freshwater tidal portions of the lower Columbia. Dominant species include willows (particularly Salix hookeriana and S. sitchensis), red Osier dogwood (Cornus cernua), salmonberry (Rubus spectabilis), Indian plum (Oemleria cerasiformis), Douglas spirea (Spiraea douglasii), black twinberry (Lonicera involucrata) and Pacific ninebark (Physocarpus capitatus). Thirty species of willow are found in Washington wetlands. Five species may grow to tree size, but the majority remain shrubs. All but three species are found nearly exclusively in wetlands. Most species are wide spread though the state, however, some species such as River Willow (Salix fluviatilis) have very restricted ranges. River Willow is found only along the lower Columbia River.

Scrub-shrub wetlands inland from the coast are common and extensive in some areas of the Coast Range and Puget Lowland Ecoregions. Extensive tracts of these wetlands may be found in the Willapa and Chehalis River valleys and in the lowland valleys between Longview and Olympia. Isolated depressional scrub-shrub wetlands are very numerous in the glacial drift portions of the Puget Sound and Olympic Peninsula. Some species such as Douglas spirea and willow may form nearly monotypic stands while most other species usually are intermixed with other shrub species or are components of forested stands. Herbaceous species associated with scrub-shrub wetlands depend upon duration of flooding, saturation and degree of disturbance. Common understory species in both shrub and forested wetlands include skunk cabbage (Lystichitum americanum), slough sedge (Carex obnupta), water parsley (Oenanthe sarmentosa) and water buttercup (Ranunculus spp.)

Emergent Wetlands. In the Coastal Range ecoregion, Palustrine emergent wetlands are found above high tide, in dunes, along water courses and adjacent to water bodies. Within Washington's coastal dune systems, emergent dominated wetlands are found in deflation plains, dune swales, adjacent to dune lakes, and lake edges throughout the ecoregion. Common wetland indicators include slough sedge, tufted hairgrass (Deschampsia cespitosa), Pacific silverweed (Potentilla pacifica), redtop (Agrostis alba), soft rush (Juncus effusus), baltic rush (Juncus balticus), skunk cabbage, water parsley and water buttercup.

Seepage wetlands on the coastal bluffs are scattered but not uncommon.

Diked former tide lands are a common Palustrine emergent wetland type adjacent to Estuarine emergent wetlands. These former salt marshes have been diked off from estuarine tidal influence and are typically used as pasture or converted to agricultural uses. They are found adjacent to all the major estuaries along the Pacific coast and Puget Sound. The Nisqually National Wildlife Refuge contains excellent examples of this type or wetland as well as estuarine wetlands. These areas hold major potential for restoration and enhancement and if acquired and monitored could increase the estuarine and palustrine emergent base in Washington state resulting in a net increase in estuarine wetland acreage (Bob Ziegler, Washington Department of Wildlife, personal communication, 1989).

Large areas of former estuarine marshes and coastal forest swamps (particularly in the Snohomish, Skagit, and Nooksack river deltas) have been diked, cleared and converted to agriculture. Many of these areas would establish wetland plant communities if normal farming practices were ceased. These "farmed wetlands" occur not only in coastal areas, but are also common in river valleys and other bottom lands throughout the state. This would provide a major opportunity by 2010 to increase very valuable wetland resources through restoration.

Inland from the coast, emergent wetlands in the Coastal Range are found mainly in river valley bottoms, adjacent to water bodies or in meadow complexes. Extensive emergent wetlands are found throughout the valley bottoms of the Puget lowlands and as isolated depressions in the glacial drift of the northern Puget lowlands. Extensive tracts of valley bottom wetlands are found in the Chehalis River lowlands in the vicinity of Centralia and the Napavine and Grand Prairie in the Winlock vicinity.

There are many plant species found in emergent wetlands depending upon degree of wetness, water chemistry, climate, disturbance, etc. Many are closely associated with wetlands dominated by woody species. Sedges, rushes and grasses are usually the first types of plants to come to mind when considering emergent wetlands, however many species of forbs are equally common.

1.3.5.2 Cascade Ecoregion

Forested Wetlands. Forested wetlands in the Cascade Mountains are common but not as extensive as in lower elevations. They are found along rivers and streams, in depressions, adjacent to wet meadows and water bodies and on slopes with abundant seepage. Forested wetland tree species do not differ from forested wetlands of the Puget Lowland Ecoregion within the western hemlock and Douglas-fir dominated forests.

Black cottonwood and red alder are common along stream courses. Cedar/hemlock and alder swamp understory species may differ in higher elevation wetlands. Alder swamps tend to be quite wet, with salmonberry, slough sedge, skunk cabbage, lady fern, and deer fern as understory dominants. Cedar/hemlock swamps are more varied. Dense shrub components of these systems include snowberry, Indian plum, wild rose, ninebark, bitter cherry, red-stem ceanothus and red-osier dogwood.

As elevation increases, silver fir and mountain hemlock become the predominate forest types. Forested wetlands in these high elevations become less common and less diverse. At this altitude forested wetlands are found at ground water seepage areas and along narrow stream corridors.

Scrub-Shrub Wetlands. Scrub-shrub wetland species differ little from Puget Lowland scrub-shrub wetland species in the Douglas-fir/western hemlock forests of the Cascade Ecoregion. They occur along rivers and streams, adjacent to wet meadows and water bodies and less often in isolated depressions. With increases in elevation, scrub-shrub understory species differ somewhat, but shrub overstory species are the mostly the same. In the high elevation silver fir/mountain hemlock forests, several shrub other species become more common. Sitka alder forms dense, monotypic stands in sites of heavy snow accumulation and abundant water seepage.

Above tree line, scrub-shrub wetlands are mostly restricted to narrow stream corridors or seepage areas.

Emergent Wetlands. Palustrine emergent wetlands are abundant in the Washington Cascades, particularly as wet meadow complexes in mountain basins and at the edges of lakes and ponds. Sedges, rushes and grasses compose the bulk of these emergent wetland plants, however, many forbs occur throughout wet meadow complexes. At high elevations, subalpine emergent wetlands contain some different dominant species. The alpine zone in the Cascade mountain is not well developed. Above timberline is mostly rock, glaciers, snow fields, and rubble.

1.3.5.3 Eastern Cascades Ecoregion

Forested Wetlands. The Eastern Cascades Ecoregion is a transitional zone between the very moist forests of western Washington and the arid high desert of eastern Washington. Ponderosa pine is the predominate upland forest tree with lodgepole pine occurring in either drier or wetter sites than Douglas-fir. Forested wetlands are restricted to stream corridors, edges of wet meadows and lakes, and occasionally in isolated depressions. Dominant forest species include thin-leaved alder, aspen, water birch, and black cottonwood. Good examples of this type of wetland occur in the vicinity of Conboy Lake National Wildlife Refuge and Trout Lake.

Scrub-Shrub Wetlands. Scrub-Shrub wetlands in the Eastern Cascades Ecoregion are mainly restricted to river and stream corridors and adjacent to wet meadows. River bank species most commonly are willows (Salix lasiandra, S. exigua, S. amygdaloides), red osier dogwood, Douglas hawthorn (Crataegus douglasii), wood rose (Rosa woodsii), Nootka rose (R. nutkana), current (Ribes aureum, R. sanguineum, and R. cireum), serviceberry (Amelanchier alnifolia), Douglas hawthorn (Crataegus douglasii), water birch. Species such as snowberry and Douglas spirea are more commonly found adjacent to wet meadows. Bogs are very uncommon in the eastern Cascades area; species common in bog systems include bog blueberry (Vaccinium uliginosum), bog willow (Salix pedicellaris), Labrador tea, bog laurel, and bog cranberry. Scrub-shrub wetlands dominated by saplings of quaking aspen and lodgepole pine may occur where disturbance by logging or fire has recently occurred.

Emergent Wetlands. Palustrine emergent wetlands in this ecoregion are not extensive. Most emergent wetlands in this area are dominated by reed canary grass, hardstem bulrush (Scirpus acutus), softstem bulrush (Scirpus validus), three-square bulrush (Scirpus americanus), and cattail. In smaller wet meadows such as those in the vicinity of Trout Lake, sedges such as beaked sedge (Carex rostrata), inflated sedge (Carex vesicaria), Nebraska sedge (Carex nebrascensis), clustered field sedge (Carex praegraciis), tufted hair grass, and giant wildrye (Elymnus cinereus).

1.3.5.4 Columbia Basin Ecoregion

Forested Wetlands. The arid Columbia Basin Ecoregion supports few forested wetlands except along major water courses and adjacent to springs. The largest tracts of forested wetlands occur along the Yakima and Methow rivers, Satus Creek, and in the Yakima Valley, and to a lesser extent along the Okanogan and Similkameen rivers. These riparian forests are composed of black cottonwood, aspen, and water birch. In some areas, white alder is locally prominent.

Scrub-shrub Wetlands. Scrub-shrub wetlands are more common than forested wetlands in the Columbia Basin; dominant species include those listed for the east Cascades region. They are mainly restricted to river floodplains, intermittent stream banks, backwaters of reservoirs and irrigation wasteways. Scrub-shrub dominated seeps and springs are common.

Occasionally, scrub-shrub vegetation will dominate isolated pothole depressions. Extensive tracts of scrub-shrub wetlands occur along the Yakima River, Toppenish Creek, the Similkameen River floodplain north of Palmer Lake and the Okanogan River floodplain immediately south of Lake Osoyoos. The Winchester and French Hill irrigation water wasteways are a complex mix of scrub-shrub and emergent wetlands as are backwater areas of Potholes Reservoir. Willows (Salix exigua, S. amygdaloides, S. lasiandra var. caudata), hawthorn and water birch are important components, similar to the east cascades region. Hackberry (Celtis reticulata) occurs in localized areas along the Palouse and Snake Rivers.

Russian olive is a major problem in scrub-shrub forested areas where it eliminates cottonwood which provides a higher habitat value for multiple wildlife species. It is expected to dominate riparian systems in eastern Washington within the next 90 years, the life span of cottonwood (U.S. FWS, Ft. Collins). This species spreads rapidly, is extremely difficult to eradicate, and has limited value for wildlife in dense monotypic stands. Reed canary grass and purple loosestrife are also problems in eastern Washington. Some of the wasteway areas in Grant County are 10-12 foot high dense jungles of purple loosestrife; it can invade and completely take over an area in one growing season. This species is detrimental to wildlife and agriculture.

Very distinct wetland scrub-shrub communities develop on saline and alkaline soils. Salt tolerant shrub species such as black greasewood (Sarcobatus vermiculatus), and alkali seepweed (Suaeda intermedia) are most common with inland salt grass (Distichlis spicata stricta) as understory. Elynus cinereus occurs in less alkaline areas.

Emergent Wetlands. Palustrine emergent wetlands are locally abundant in certain areas of this dry ecoregion. Many of these emergent wetlands are formed from elevated groundwater levels from irrigation, and are used for grazing. Common species are reed canary grass, hardstem bulrush, softstem bulrush, alkali bulrush, and cattail. The floodplain of Toppenish Creek (Toppenish National Wildlife Refuge) contains broad floodplain emergent wetlands as does the floodplain of Cow Creek in the Moses Lake area. The Winchester and French Hills irrigation water waste ways have developed a complex of emergent and scrub-shrub wetlands. Pothole wetlands have developed in the Moses Lake and Grand Coulee areas as a result of water development projects. Vernal pools fed by precipitation are locally common in the "channeled scablands" between Ritzville and Cheney, northeast Douglas County and south central Okanogan County in the Omak Lake area.

Common herbs found in the emergent wetlands of eastern Washington include fowl mannagrass (Glyceria striata) around seeps, blue vervain (Verbena hastata), spearmint (Mentha spicata), monkeyflower (Mimulus guttatus), rough bugleweed (Lycopus asper), water speedwell (Veronica angalus-aquatica), and Watson's willowherb (Epilobium watsonii). Prairie cordgrass (Spartina pectinata) is thought to have occurred along the Columbia in historic times (Shelley Evans).

Most of the Columbia River area is heavily disturbed through intensive grazing and agricultural practices. Very little is known about undisturbed, pre-settlement plant communities. At one time, season-long, year-round grazing was accompanied by removal of vegetation along riparian areas. Many stream channels became very unstable, with headcutting and widening of the channel. Shallow channel configurations resulted in less temperature moderation, causing more icing in winter and hotter summer water temperatures; this is detrimental for fish habitat. With fencing and revegetation of some of these areas, sediment begins to accrete around the vegetation. Stream channels become deeper and narrower, and intermittent streams often become perennial. Forage value increases outside of the riparian area, as water tables rise (pers. comm. Wayne Elmore, BLM).

1.3.5.5 Northern Rockies Ecoregion

Forested Wetlands. Forested wetlands occur along water courses and in poorly drained sites in the lower elevations of this ecoregion. Low elevation forested wetlands adjacent to marshes and wet meadows are usually dominated by quaking aspen with snowberry being the most common understory shrub and red osier dogwood and willow more common on wetter sites. At higher elevations, forested wetlands in depressional areas and seepage slopes are dominated by Engelman spruce and quaking aspen and sometimes lodgepole pine. Common understory shrubs are Sitka alder, red osier dogwood, and prickly current. Forested wetlands dominated by western red cedar and western hemlock also occur on seepage slopes and wet bottomlands. In the subalpine forested wetlands, subalpine fir and Engelmann spruce are the dominant tree species. Lodgepole pine also commonly occurs. Forested sites saturated by late melting heavy snow packs have an understory dominated by Sitka alder and sedges.

Scrub-shrub Wetlands. Palustrine scrub-shrub wetlands within the Rocky Mountain Ecoregion are very similar in species composition to those found in the lower elevations of the Eastern Cascades Ecoregion and at high elevations, similar to high elevation scrub-shrub wetlands found in the Cascades Ecoregion.

Emergent Wetlands. The major river valleys, lake margins and meadows along and near the head waters of streams are where most of the emergent wetlands occur within this ecoregion. Large areas of emergent wetlands and farmed wetlands are in the Colville River floodplain and Pend Oreille River floodplain in the vicinity of Cusick and Calispell Lake. Moses Meadows in Okanogan County is a good example of a headwater emergent wetland. The wettest sites are dominated by cattail and hard stem bulrush. Wetland plants typical of seasonally and temporarily flooded emergent wetlands are essentially the same as those listed for Columbia Basin wet meadows. As in the Columbia Basin, plant species composition may vary greatly with the degree of wetness and disturbance.

1.4 Major Functions and Values of Wetlands

The information contained in this section has been edited from the 1988 Washington Wetlands Study Report (Ecology, 1988a).

Wetlands have many important ecological functions and values that have only begun to be understood and appreciated by the public in recent years. Because wetlands were traditionally regarded as places to be drained and filled when necessary to accommodate development, almost half the nation's wetlands were deliberately eliminated since colonial times for various, and often beneficial, purposes. The use of wetlands has become a major public policy issue in recent years due to open conflicts between those who want to preserve them and those who wish to convert them to other uses. Only recently has public policy been changed to reflect an appreciation of wetlands as resources having important ecological functions and values.

Wetlands provide essential escape cover and feeding, nesting, and breeding habitat for many species of fish and wildlife; in fact, wetlands are generally considered to be the most productive ecosystems in the world. Some species, including furbearers such as beaver, mink, and muskrat, spend their entire lives within a particular wetland while others, including deer and anadromous fish such as salmon, depend on wetlands during part of the year or part of their life cycle. During times of drought, wetlands play an especially critical role in providing food and water for wildlife.

Waterfowl and migratory shorebirds are particularly dependent on wetlands for their survival. Major north-south migration routes for ducks, geese, and swans roughly correspond to the regions of greatest wetland concentration. Washington, with thousands of acres of natural and human-created wetlands, plays a major role in both production and wintering of waterfowl in the Pacific Waterfowl Flyway. Several million waterfowl use Washington's wetlands during their annual spring and fall migrations and over half a million "resident" ducks and geese are produced in the ponds and potholes of central and eastern Washington each year. In addition to waterfowl, millions of shorebirds concentrate in Washington's wetlands each year.

Coastal wetlands provide critical habitat for many species of game fish and commercially-important food fish and shellfish. Because wetlands are important sources of nutrients, they play an important role in the food web, and because wetland plants also provide escape cover for juvenile fish, they serve as important rearing habitat for both marine and anadromous fish. In a 1980 study, the dockside value of estuarine-dependent fish and shellfish caught by U.S. fisheries was estimated at over $1.1 billion.

The Washington Department of Wildlife has identified the loss of wetland habitat as the number one problem affecting both waterfowl and furbearer populations in this state. Since wetland areas also provide critical rearing and feeding areas for salmon, sea-run cutthroat trout, steelhead trout, and other anadromous fish, continued loss of this habitat could become a major limiting factor in maintaining wild stocks of these fish.

1.4.1 Flood Control

Wetlands play an important role in slowing and storing flood waters. Riverine wetlands and floodplains provide flat expanses where flood waters are able to spread out and slow down, thereby reducing the height and velocity of floods. Once the velocity of floodwaters is stemmed, the water may then drain slowly out of these wetland areas, reducing streambank erosion and flood peaks downstream. If the soil in a wetland area is not fully saturated, the soil itself will provide some storage capacity during periods of flooding. Shallow depressions where these wetlands usually form will also hold standing water for weeks or months, slowly recharging groundwater.

Building structures or filling within floodway areas confines flood flows to narrower channels and causes increased flood heights and rates. Studies have shown that flood peaks may be as much as 80 percent higher in watersheds without wetlands than in similar basins with large wetland areas. For example, a U.S. Army Corps of Engineers study on the Charles River in Massachusetts predicted that a 40 percent reduction in wetland areas along the river would increase flood damages by at least $3 million annually.

1.4.2 Erosion Control

Wetlands effectively reduce erosion of shorelines from tides, waves, wind, and river currents by slowing down and dissipating much of the water's energy and by stabilizing shorelines with their root systems. Replacing wetlands with bulkheads, riprap, and other shore-hardening structures often causes the erosive forces to be transferred to other areas and other properties downstream or downcurrent. In many coastal areas of Washington, shoreline erosion is a major problem and the ability of wetlands to reduce erosion can result in substantial economic benefits.

1.4.3 Sedimentation and Pollution Control

Wetlands improve water quality by filtering out sediments, nutrients, and toxic chemicals. Moving water carries sediments and other materials in suspension and, as this water enters a wetland, its flow decreases so that soil and other suspended material settles out. The sediment is then trapped by the wetland vegetation and held in place by the root system. This trapping and storing of sediment contributes greatly to the reduction of siltation in lakes, and reservoirs.

Many pollutants, including nutrients, disease organisms, and toxic chemicals, have a tendency to adhere to suspended matter and the ability of wetlands to trap and temporarily retain this matter can reduce the level of both organic and inorganic pollution in water supplies. Some dissolved nutrients such as nitrogen and phosphorus may be taken up directly by plants during the growing season and by chemical absorption and precipitation at the wetland soil surface. As organic and inorganic suspended material settles out in a wetland, some pollutants associated with this trapped material may be converted by biochemical processes to less harmful forms, some may be taken up by the wetland plants and either recycled or transported away, and some may simply remain buried in the bottom sediments. While the trapping and storing of pollutants certainly results in improved water quality, questions have been raised about the long-term environmental effects of this function on the food chain. Bacteria found in wetland soils may also break down or transform chemical compounds into less harmful forms.

1.4.4 Water Supply

In many parts of Washington, wetlands are important as areas where water can soak into the soil, adding to the supply of ground water, or as areas where springs and seeps can collect in small pools or ponds, increasing the available supply of surface water. For example, irrigation has caused ground water levels to rise in parts of the Columbia Basin in eastern Washington, creating many wetlands, including the Potholes, which now provide important waterfowl and shorebird habitat. In other parts of eastern Washington, temporary or seasonal wetlands serve a valuable role in the spring by recharging ground water from snowmelt runoff.

1.4.5 Agriculture

While many wetlands have been converted to crop production, others left in their natural state provide benefits to the agricultural economy. Wetlands serve as catch basins to hold surface water and they recharge ground water for agricultural uses. They also trap sediment and runoff from cultivated land, thereby reducing soil loss and the pollution of water supplies. Some berry crops such as cranberries and blueberries are also produced in farmed wetlands.

1.4.6 Education and Research

Because wetlands contain a variety of flora and fauna not found in other environments, they provide unique educational and scientific research opportunities. The diversity of wetland plant life (over 5,000 species nationwide) creates habitats for every form of animal life, including insects, amphibians, reptiles, mammals, and birds.

Ecological relationships are easily observed in wetlands, making them excellent locations for teaching the environmental sciences at every level from elementary school through graduate education. The tremendous diversity of plant and animal life and the unique interactions of the land and water interface also present biological research opportunities not found in other ecosystems. Research, particularly in botany and ornithology, is often conducted in the coastal and inland wetlands of Washington.

1.4.7 Open Space and Recreation

The scenic and recreational qualities of wetlands are highly valued in Washington. Many of our most popular scenic attractions and recreational areas feature wetlands. Included here would be the Nisqually and Skagit River deltas, Padilla Bay, and the Potholes area of central Washington.

The economic contribution of wetland-related outdoor recreation to the state's economy -- including hunting, fishing, hiking, boating, and birdwatching -- runs into millions of dollars annually.

1.4.8 Other Values and Functions

In addition to the values and functions discussed above, there may be other less obvious but important intrinsic reasons for preserving wetlands and other natural areas. Natural systems can provide baseline conditions that help determine the extent to which the environment has been affected by human activity and pollution. They may provide models for restoring or replacing significantly altered habitats. Or they may be valuable in and of themselves, as part of the natural order of things, regardless of any tangible benefits or ecological services society may receive from them.

2. CURRENT STATUS OF WETLANDS

This section summarizes information about the current status of wetlands in Washington State. As noted in the findings of the 1988 Washington Wetlands Study Report (Ecology, 1988a), documentation of the current status of Washington's wetlands is incomplete.

2.1 Key Indicators of Wetlands Status

According to the U.S. Fish and Wildlife Service discussion paper on Wetlands and Deepwater Habitats in the State of Washington (July, 1989), all wetlands and deepwater habitats comprised about 5.5 percent of the state of Washington in the early-1980s. Wetlands made up about 2 percent and deepwater habitats about 3.5 percent of the State. Within the state of Washington only about 67 percent of the estimated wetland acres at pre-settlement remained in the early 1980s. Deepwater habitats decreased by only about 4 percent. These estimates for loss are based on assumptions about pre-settlement condition which are very conservative; actual wetland losses are expected to be higher than these estimates. In addition, losses do not account for conversion from forested riparian types to deepwater habitat for reservoir construction; they also do not account for degradation. In summary, Washington has lost over 33 percent of the state's wetland, based on very conservative estimates.

This section is intended to identify the "major stress agents" upon Washington's wetlands, thereby linking the resource characterization (Section 1) and the Risks to Wetlands (Section 2.2).

The Environment 2010 Technical Advisory Committee developed the following threat definition for the loss or degradation of wetlands:

Definition:

Loss or degradation of wetlands is a conversion or alteration which results in a net reduction to total wetland area and/or impairment of the physical functions and ecological values of the affected wetland. Examples include draining and filling of wetlands.

Major stressors:

Alteration of hydrology - increased flows, higher peak events
Alteration of hydrology - decreased flows, loss of water, draining
Decreased water quality - increased sediment, nutrient or pollutants
Compaction of soils, oxidation of peat
Introduction of exotic plant species
Isolation of wetland in the context of the landscape

Major sources:

Draining
Filling
Diking (e.g railroad berms, road building, etc.)
Urbanization
Agricultural operations
Forestry operations

Major damage pathways:

Human Health

None

Ecological

- Decreased floral & faunal species diversity
- Loss of food chain support
- Loss of feeding, nesting, and breeding habitat for waterfowl
- Loss of habitat for furbearers (e.g. beaver, mink, etc.)
- Loss of habitat for anadromous and game fish during early phases of their life cycle
- Loss or deterioration of aquifer recharge functions
- Loss or deterioration of capacity for biofiltration of contaminants, sediment and nutrients
- Loss or deterioration of ability to desynchronize flood events

Economic Damages

- Loss of aesthetic values
- Cost of alternative forms of flood control
- Loss of fish and wildlife for fishing and hunting
- Loss of passive recreation opportunities
- Reduced water quality

Additionally, Environment 2010 reviewers have noted the following issues:

Agricultural operations are a threat to wetlands loss and/or degradation, citing grazing as a specific example of an uncontrolled activity. Jurisdictions which have adopted wetland ordinances typically exempt grazing due to the financial and other problems associated with protective fencing.

Another general problem resulting from all activities is the loss of vegetated wetland edges and vegetated and aquatic connectors (corridors). For many wildlife species a wetland without a vegetated edge is an incomplete habitat. One hundred and twenty one western Washington species depend on wetlands and wetland edges for some or all of their life cycle requirements (Zeigler, 1988; Brown, 1985; Guenther & Kucera, 1978).

Peat mining is destructive of a special kind of wetland, mostly in western Washington. Peat forms at the rate of 1 inch in 40 years in western Washington, 1 inch in 100 years in eastern Washington (Rigg, 1958) Once mined, it cannot be replaced.

Palustrine forested wetlands take a minimum of 20 years to reestablish, and usually 40 to 200 years to reach maturity. In wetlands, trees are usually stressed by flooding, and grow very slowly. Replacing of forested wetland systems takes a long period of time; if compaction of the soil, altered hydrology or invasion by weedy plants occurs, the area may never be restored to its original characteristics, values or functions. A review of Department of the Army (Section 404) permits in Washington state indicates that forested systems were not being mitigated for or replaced (Kunz et. al., 1986).

Vegetation removal in shallow water wetlands for purposes of lake management is destructive of habitat used by fish and waterfowl. Lake management is conducted for aesthetic purposes, for enhancement of recreational activities such as swimming, boating, and water skiing, and for the control of exotic and invasive weed species.

2.2 Risks to Wetlands

The major causes of wetland loss and degradation are summarized in Table 2.1. The Environment 2010 Technical Advisory Committee identified the major threats to wetlands as (1) wetlands loss and degradation, and (2) hydrologic disruption; minor threats were identified as (1) global warming, (2) point source discharge, (3) nonpoint source discharge, and (4) inactive hazardous waste sites.

Other major threats to wetlands were identified as: (1) impacts on wetlands from nonchemical impacts on forest land; (2) impacts on wetlands from nonchemical impacts on recreation lands; (3) impacts on wetlands from nonchemical impacts on rangelands; and (4) impacts on wetlands from nonchemical impacts on agricultural lands.

Table 2.1 Major causes of wetlands loss and degradation.

Human Threats

Direct

1. Drainage for crop production, timber production, and mosquito control.
2. Dredging and stream channelization for navigation channels, flood protection, coastal housing developments, and reservoir maintenance.
3. Filling for dredged spoil and other solid waste disposal, road and highways, and commercial, residential, and industrial development.
4. Construction of dikes, dams, levees, and sea walls for flood control, water supply, irrigation, and storm protection.
5. Discharges of materials (e.g. pesticides, herbicides, other pollutants, nutrient loading from domestic sewage and agricultural runoff, and sediments from dredging and filling, agricultural and other land development) into waters and wetlands.
6. Mining of wetland soils for peat, coal, sand, gravel, phosphate, and other materials.

Indirect

1. Sediment diversion by dams, deep channels, and other structures.
2. Hydrologic alterations by canals, spoil banks, roads, and other structures.
3. Subsidence due to extraction of ground water, oil, gas, sulphur, and other minerals.

Natural Threats

1. Subsidence, including natural rise of sea level.
2. Droughts.
3. Hurricanes and other storms.
4. Erosion.
5. Biotic effects, e.g. muskrat, nutria, and goose "eat outs."

Source: Zinn & Copeland, 1982 and Gosselink & Bauman, 1980, in: Tiner, 1984.

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2.2.1 Wetlands Loss

The following discussion is summarized from the wetlands loss and degradation analysis except as noted.

1. According to a report completed by the U.S. Fish and Wildlife Service (1989), wetlands made up about 2 percent of the land area of the state of Washington in the early 1980s. Conservative estimates from this study indicate that only about 67 percent of the original acres remain, a reduction from 1.4 million to 938,000 acres. Deepwater habitat decreased by only 4 percent. These estimates for loss are based on assumptions about pre-settlement condition which are very conservative; actual wetland losses are expected to be higher than these estimates. In addition, losses do not account for conversion from forested riparian types to deepwater habitat for reservoir construction; they also do not account for degradation. Forested systems are very difficult to accurately estimate by aerial photography. In summary, Washington has lost over 33 percent of the state's wetlands, based on very conservative estimates.

2. Other indicators of recent trends are available in Washington. Based on field inventory observations, Snohomish County estimates losses of 15 wetland acres per month, or 180 acres per year. Statewide losses for the eight counties with similar growth projections plus King and Pierce counties would be 1,800 acres per year in urbanized counties.

3. State Environmental Policy Act Wetlands Evaluation Project (Draft) (Hull & MacIvor, 1987). The unpublished SEPA study done by Department of Ecology estimates that roughly half of Washington's original 800,000 acres of wetlands have been lost due to development, a figure that mirrors national wetland loss estimates. This study also indicated that freshwater marshes and forested wetlands experienced the greatest losses from development and that most of the wetlands lost were small, between 0.5 and 5 acres in size. This report also identified draining as a greater cause of wetlands loss than filling in those sites visited for the study. A conservative estimate of wetlands loss -- wetlands outside the jurisdiction of the Shoreline Management Act and considered under SEPA -- is 530 acres per year.

4. Wetlands of the United States: Current Status and Recent Trends (Tiner, et al., 1984). Tiner et al., estimated original wetlands acreage in the contiguous United States at 215 million acres. This acreage estimate had decreased by about 50% to 108.1 million acres by the mid-1950s. Of 99 million acres remaining in the mid-1970s, 94 million acres were estimated to be fresh water or palustrine wetlands and 5.2 million acres estuarine wetlands. Of the estimated 11 million acres of wetlands lost during a 25-year period between the mid-1950s and mid-1970s, 96 percent were estimated to be palustrine or freshwater wetlands; agricultural development was estimated to be responsible for 87 percent of these losses. Estuarine wetlands only

account for about 5 percent of remaining wetlands but are generally better protected by state laws. It is estimated that 90 percent of the estuarine wetlands loss in California and four other coastal states is due to residential home construction.

5. Inventory of Wetland Resources and Evaluation of Wetland Management in Western Washington (Boule et al., 1983). Boule, et al. included acreage loss estimates that are very consistent with Tiner, et al. The 458,000 acre annual loss figure cited by Tiner has been reduced since the mid-1970s largely due to a decline in the rate of agricultural draining activities as well as better state and federal wetland protection laws. Boule et al. includes three case studies in Washington showing the following losses of freshwater wetland acreages in the following USGS quadrants:

   Tenino and Yelm (south Thurston County): 55%
   Tacoma South (Pierce County): 82%
   Lake Washington (King County): 70%

6. Historical changes of shoreline and wetland at eleven major deltas in the Puget Sound Region, Washington. (Bortleson, Chrzastowske & Helgerson, 1980). Bortleson, et al. evaluated wetland loss at the major river deltas of the Puget Sound and found a loss of 28 to 100 percent of wetlands (Table 2.4).

7. U.S. Environmental Protection Agency, Region 10. EPA evaluated records of 2,300 Corps of Engineers Public Notices in Washington for activities requiring permits under Section 404 of the Clean Water Act and/or Section 10 of the Rivers and Harbors Act, and determined a loss rate of 186 acres per year for Washington (Table 2.3). This represents a portion of wetland losses in Region 10 since activities which damage or destroy wetlands but do not require a permit are not included. Examples of non-404 permitted activities which may cause physical degradation of wetlands include logging activities, drainage, water impoundment, activities markedly changing runoff or recharge, major water withdrawals, and activities which result in changes to watersheds or the hydraulic regime.

8. Wetlands of the United States (Shaw & Fredine, 1956). Shaw and Fredine estimated an average national wetlands loss rate of 0.40 percent per year, or 2,034 acres per year for Washington (Table 2.2). Estimated annual loss for Idaho and Oregon are also shown for comparison.

Table 2.2. Estimated[1] Annual Loss of Wetlands in Washington, Oregon, and Idaho.

State	Acres of Wetlands Remaining	Approximate Yearly Loss (acres)
Idaho	95,140	380
Oregon	412,120	1,650
Washington	938,000[2]	2,034

[1] Based on an estimate of the number of acres of wetlands in each state (Shaw and Fredine, 1956) and a 0.4 percent per year loss rate (Shaw and Fredine, 1956) for Idaho, Oregon and Washington. The loss rate for Alaska is based on only a review of 404 permitted projects (Faris et al, 1987).

[2] Based on USFWS report, 1989.

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Table 2.3. Annual Loss of Wetlands in Washington, Oregon, and Idaho Based on Review of Section 404 Permit Activities.

State	Palustrine	Estuarine	Marine	Lacustrine	Riverine	TOTAL
Idaho	21.20	0	0	0.38	3.33	24.91
Oregon	112.22	6.35	0.11	0.11	56.51	175.30
Wash'n	32.22	144.38	0.19	0.73	7.10	185.62

Palustrine: nontidal wetlands dominated by trees, shrubs, and persistent emergent vegetation (i.e., wet meadows, freshwater marshes).

Estuarine: deepwater tidal habitats and adjacent tidal wetlands, including emergent saltwater marshes.

Marine: open ocean and the high energy coastline.

Lacustrine: wetlands and deepwater habitats contained within a depression (i.e., lakes).

Riverine: all wetland and deepwater habitats within a channel.

* * * * * * * *

Table 2.4. Estimated historical changes in natural habitat of principle estuaries of Washington State.

Estuary	Estimated (km^2) sub-aerial wetland		
	Historical	Present	% change
Nooksack	4.5	4.6	+0.2
Lummi	5.8	0.3	-89.7
Samish	11.0	0.4	-96.4
Skagit	29.0	12.0	-58.6
Stillaguamish	10.0	3.6	-64.0
Snohomish	39.0	10.0	-74.4
Duwamish	2.6	0.1	-99.2
Puyallup	10.0	0	-100.0
Nisqually	5.7	4.1	-28.1
Skokomish	2.1	1.4	-33.3
Dungeness	0.5	0.5	0

Source: Bortelson et al., 1980.

* * * * * * * *

Other Environment 2010 risk analysts identified the following impacts leading to wetlands loss.

In the past, dam construction, particularly on the Columbia River system, was the cause of riparian wetlands loss. The amount of loss is not known to have been documented. Presently the loss rate due to dam construction is presumed to be low to none, however the threat is considered to remain.

Flood control actions, e.g. diking and bank protection, can lead to secondary effects of increased stream bank erosion downstream and the loss or degradation of riparian wetlands.

Urbanization sets in motion a chain of events such that building construction, paving, and soils compaction lead to large percent increases in impervious surface coverage which leads to chronic hydrologic shifts (increased winter and flood flows, and decreased summer flows); the increased winter and flood flows cause chronic bank erosion and loss of riparian wetlands.

Existing sea level rise is known to cause shoreline erosion and loss of coastal (Pacific Ocean and Puget Sound) wetlands; the loss rate is unknown. Accelerated sea level rise due to global warming will aggravate this loss to an as yet uncertain degree. Losses caused by accelerated sea level rise will be attributable to erosion, inundation, and transformation of fresh water wetlands to saline wetlands.

2.2.2 Wetlands Degradation

Losses due to degradation are based upon estimates by inventories conducted by the Washington Natural Heritage Program statewide. Estimates of degradation are based upon deviance from pre-settlement condition; this is measured by how closely the plant community species composition, soils, and hydrology approximates pre-settlement condition. According to these criteria, all wetlands inventoried in the state of Washington have some adverse impact from degradation (Kunze, 1989). The purpose of these inventories is to identify pristine wetlands for potential preservation by The Nature Conservancy or some other state, federal, local, or private group. There are many wetlands which still have high quality even though they do not meet the stringent requirements of the Heritage Program.

Methodologies to assess wetland values and functions have not been developed which provide consistency, reliability, accuracy, and replicability for the Pacific Northwest region. Due to the fact that a methodology is not in place, inventory evaluations of wetland values and functions tend to be general and relatively simplistic. The only information on wetland degradation through loss of functions and values is inferred from lowered fish numbers (particularly coho), lowered waterfowl numbers, or increased flooding and water quality problems.

This should not imply that wetland managers are not concerned about degradation of wetlands - quite the contrary, the level of concern regarding degradation equals the concern regarding direct loss. Degradation is occurring due, but not limited to, the following factors: vegetation removal; introduction of exotic plant species; hydrologic disruption, e.g. diversion of surface water, lowering of water tables caused by ground water withdrawals, and alteration of the timing and quantity of seasonal surface water flows; compaction of soils or oxidation of organic soils; isolation of the wetland so the area has less upland habitat edge and more disturbance so that it is no longer used by wildlife. Additionally, wetlands managers are also concerned about degradation due to nonpoint pollution (principally urban, agricultural, and forestry runoff) and point source pollution (principally industrial discharges and accidental spills).

Other Environment 2010 risk analysts identified the following impacts leading to wetlands loss. Typically, they were unable to quantify their conclusions due to a lack of quantitative data.

Surface water diversions can change the character of wetlands. By altering the hydrologic regime -- the timing and abundance of water -- the plant species composition will be shifted towards a community with greater or lesser predominance of hydrophytes.

Livestock grazing can lead to the loss of wetlands vegetation and the alteration of the plant species composition. Stressed habitats such as this are more susceptible to invasion by exotic plant species.

Urbanization causes, in addition to the hydrologic shifts described above, adverse changes in the quality of runoff water. The load of pollutants finds its temporary or permanent resting place in the sediments of lakes, wetlands, and estuaries. Contaminated sediments have been associated with changes in the species composition and abundance of aquatic and estuarine habitats. Additionally, inactive hazardous waste sites have been associated with similar effects.

2.3 Impacts on Wetlands from Nonchemical Impacts

2.3.1 Impacts on wetlands from nonchemical impacts on forest land

Nonchemical impacts on forest lands include physical modifications (e.g. road building) and other impacts that affect Washington's forests. These impacts often result from changes in the use of the forest that alter the mix of commodities produced; they influence the profitability of current and future economic activities and diminish or alter ecological values, constrain recreational opportunities, and preclude future use.

Specific examples include compaction of wetland soils; drainage of wetlands to increase merchantable timber production; habitat loss through short-term removal of habitat; habitat loss through long-term impacts to pristine and old-growth wetlands. In addition, hydrologic functions of wetlands such as stormwater retention are reduced by canopy removal. Increased sediment input from slopes can cause sediment deposition in wetlands beyond the threshold capacity; resulting vegetation die-off and species changes reduce habitat value.

Conversion of forest land to non-forest uses, for example, causes increased loading of wildlife into remaining wetland and forest land. When the carrying capacity of the remaining land is exceeded, the excess wildlife population dies.

Conversion of forest land also causes a reduction in the diversity of fauna supported in forest and wetland ecosystems. In particular, loss of the wetland/upland "edge" causes reduction in plant and wildlife species diversity, and reduces the quality of the habitat.

As a generalization, it can be said that forest harvesting causes a reduction in the functional and structural diversity of forest and wetland ecosystems. Often pathways or corridors for wildlife movement and genetic exchange of native plant material are truncated. Opening the canopy around wetland and aquatic sites can cause a reduction in the temperature buffering canopy of vegetation, which reduces both high summer temperatures and winter icing problems.

Conversion of old-growth to second-growth, for example, causes a loss of ecosystem structure and diversity which manifests itself as a reduction in the number and diversity of species supported in forest land.

Conversion of old-growth causes fragmentation of wildlife habitat and the phenomenon of island biogeography. Island biogeography dictates that some post harvest forest stands will be too small to support wildlife populations, particularly range and habitat necessary for reproduction.

Markets for species found in wetlands such as alder and cottonwood create impacts through compaction of soil; reduced reproductive ability in trees in wetland areas, due to the stress of flooding and predominantly vegetative (asexual) reproductive strategies; and invasion of exotic plant species such as reed canary grass, blackberry, and purple loosestrife.

Bog systems are particularly vulnerable to impacts from changing water quality or quantity. Changes of a few centimeters of water, or increases in nutrient of pH, can permanently and irretrievably adversely impact bog systems.

2.3.2 Impacts on wetlands from nonchemical impacts on recreation lands

Nonchemical impacts on recreation lands include physical modifications to those lands caused by such things as road building, concentrated use, misuse, and urbanization. These impacts can result in reductions in overall recreational opportunities, as well as ecological damages such as loss or degradation of wildlife habitat and damage to vegetation.

The most serious threat to wetlands from nonchemical degradation of recreation land is habitat loss and disruption from concentrated use of recreation land.

Road building in urban/rural, roaded and semi primitive recreation lands causes loss and degradation of wildlife habitat. Increased impermeable surfaces causes increased runoff, with an increase in pollutants such as oil and gasoline adversely impacting water quality. Road building is a key element in the conversion of semi primitive recreation land. Once road building occurs, wildlife is continuously disrupted from vehicle noise and increased access.

Resource extraction activities on roaded and semi primitive recreation lands causes loss and degradation of wetland habitat. The loss may be only temporary, if the environment is allowed to recover.

Urbanization/development and misuse of urban/rural, roaded, semi primitive and primitive recreation land causes degradation of wetlands.

2.3.3 Impacts on wetlands from nonchemical impacts on rangelands

At the time of European settlement, many streambanks were lined with woody vegetation, such as willow, aspen, alder, and cottonwood. Year-round, season-long livestock use allowed heavy animal concentrations along wetland areas, rather than on adjacent hillslopes. As a result, many of the wetland and riparian areas in eastern Washington are in a state of disrepair and degradation. Streams that were a perennial water source may no longer flow in late summer. Channels that once handled spring runoff and summer freshets easily are now unstable and eroding. Where channel gully erosion proceeded unabated, extensive deep gullies now remain as monuments to a lack of appreciation of how riparian wetlands function and maintain themselves (Elmore and Beschla, 1987).

Removal of vegetation through both grazing pressure and agricultural activities had several impacts on stream systems. Wetland plants such as willows, sedges, and rushes have strong root systems to hold banks. Their stems provide roughness and resistance to flow. This wetland vegetation maintains bank stability and filters sediment before reaching surface waters. Sediment accretion maintains the deep, narrow bank morphology which provides excellent fish habitat.

As a stream channels aggrade (i.e. channel elevation increases as sediment is deposited within and along the banks of the channel), water tables rise. Species composition and community structure of vegetation becomes dominated by typical riparian wetland species. An aggrading channel and a rising water table have many benefits. More water is stored during wet seasons, and slow release of this water may allow a stream to flow throughout the summer. The vegetation along the streambank provides valuable fish and wildlife habitat. In addition, increased forage production is provided for livestock.

Unregulated grazing before 1900 initiated streambank deterioration by wiping out vegetation and encouraging erosion. These conditions led to passage, in 1934, of the Taylor Grazing Act, which regulates grazing on the public domain. Since then, cover has returned to the range, usually as cheatgrass or crested wheatgrass. While they stabilize soil, these plants are not good wildlife food or habitat, and do not maintain streambank stability.

Dr. William Platts and his co-workers at the Forest Service Intermountain Forest and Range Experiment Station in Boise, Idaho have studies livestock/riparian problems for many years (Platts, 1987). After season-long grazing experiments, these changes were documented:

- Riparian vegetation was changed, reduced, or eliminated;
- Stream channels widened and eroded, and water table dropped;
- Fish habitat was lost as shade and cover disappeared and water temperature and sediment increased, reducing pool depth, aquatic invertebrates, and spawning gravel.
- Stream banks degraded, water flows became inconsistent, and eroded soil was deposited away from the initial site;
- Populations, types and numbers of fish, wildlife, aquatic invertebrates, and plants were altered or eliminated.

Grazing on federal lands is improving through improved grazing practices and rangeland recovery projects (Thomas, 1988). Range restoration projects include water gaps for livestock, pass-throughs for anglers, gap fences, and barriers built to keep livestock out of some riparian and wetland areas; conifers and junipers cut and cabled along badly-eroded streambanks to catch and deposit sediment for woody vegetation to grow in, and to reduce the effects of cattle trampling. Fish habitat has been improved in demonstration areas with instream structures, artificial shade, and cover and boulder replacement. Streamside vegetation has been planted. Check dams have been built and beaver been introduced.

Riparian wetlands have been severely degraded in Washington. In some areas, the stream has been plowed to the edge, and banks erode and headcut, costing the property owner loss of land. Most of the landscape in the eastern portion of the state has been so degraded, an assessment of pristine condition is a best professional guess (Evans, 1989). Impacts of grazing include decreased fish and wildlife habitat; decreased water quality through increased stream temperatures, siltation, erosion, and nutrient; increased flooding impacts; and decreased low flow augmentation of streams during dry periods of the year.

2.3.4 Impacts on wetlands from nonchemical impacts on agricultural lands

National estimates of wetland loss indicate that 87 percent of wetlands were lost due to drainage for agricultural conversion. Many wetlands have been drained and converted to agriculture. Many of the remaining wetlands have been degraded through off-site activities.

Soil erosion from farmland and other lands increases sediment, nutrient, and pesticide loadings in wetlands prior to entering surface waters. Sediment, nutrient, and pesticide loadings cause sedimentation problems on stream bottoms, affects aquatic plant and animal life, affects the quality of wetland and riparian habitats, reduces recreation opportunities, and may be related to human health affects.

2.4 Conclusions

The reports cited in the wetlands risk and degradation study identify two values for an existing wetland base: 938,000 acres (USFWS, 1989), and 400,000 acres (Hull & MacIvor, 1987). These do not represent upper and lower bounds, but rather the results of defining wetlands differently for different purposes. As currently defined, the remaining wetland base for Washington is presumed to be approximately 938,000 acres.

An interpolation of national loss rates of 0.40 percent per year (Shaw and Fredine, 1956), times the wetland base of 938,000 acres, indicates a yearly loss rate of 2,034 acres of wetlands per year. This national loss rate is based on 1956 data, and has not been field checked in Washington. Other estimates of yearly loss rates include the following:

Clean Water Act - 186 acres/year (Table 2.3)
Unregulated ----- 530 acres/year (Hull & MacIvor, 1987)
Total ----------- 716 acres/year

Another method for estimating wetland loss might be:

Rural/Suburban Counties - 530 acres/year (Hull & MacIvor, 1987)
Urban ------------------ 1800 acres/year (Snohomish County, 1989)
Total ------------------ 1530 acres/year

Estimates of wetland loss vary from 716 acres per year, to 1530 acres/year to the national estimate of 2,034 acres per year. These numbers are highly variable and are based on very rough estimates. Clearly, the numbers are not as significant as the message. Wetland loss is occurring, and documentation of the loss is unavailable.

Without knowing what types of wetlands are lost, how they are lost, and where they are being lost, it is extremely difficult to prevent or manage the state's wetland resource. Many wetland losses occur due to agriculture, small-scale farming, silviculture, small scale development, highway construction, or other activities which have been exempted from the regulatory process. More than twice the acreage of wetlands have been lost to draining rather than filling, and small, isolated wetlands contributed to a high percentage of wetland loss (Hull and MacIvor, 1987). Both small wetlands and impacts to wetlands other than fill are not covered under the Clean Water Act, the only legislation which specifically addresses wetland protection.

National and state estimates strongly indicate that wetlands are continuing to be lost at a rapid rate. While reliable trend analyses are difficult to develop, it is clear that a definite reduction of wetland acreage, values, and functions has occurred statewide. In addition, wetland loss is continuing to occur, with limited regulatory protection and increasing demand for development of remaining resources.

3. WETLANDS MANAGEMENT PROGRAMS

A variety of federal, state, and local laws and regulations affect construction and other activities in wetlands and adjacent areas in Washington. With the exception of the Wetlands Protection element of the Puget Sound Water Quality Management Plan, none of these laws focus on the protection of wetlands as their primary purpose. In addition, the types, sizes, and locations of wetlands included in the regulations vary from law to law. The Department of Ecology's Wetland Regulations Guidebook, published in July 1988, gives a complete description and analysis of the existing matrix of federal and state laws and regulations that protect wetlands in Washington. Section 3, Wetlands Management Programs, is quoted or closely paraphrased from the 1988 Washington Wetlands Study Report (Ecology, 1988a) except as noted. Additional information may be found in the Wetland Regulations Guidebook (Ecology, 1988b) and The Path Between Habitat and Development (Wildlife, 1987).

3.1 Federal and Washington State Management Programs

The primary laws currently used by federal, state, and local agencies to protect wetlands are summarized below:

3.1.1 Federal Clean Water Act

Wetlands management provisions of the Clean Water Act (CWA; 33 U.S.C 1251-1376) are contained in Section 404 (33 U.S.C. 1344). The Clean Water Act is a broad based law covering water pollution control in general; wetlands management is not the primary focus of the Act. Section 404 is enforced by the U.S. Army Corps of Engineers through its Department of the Army Permit which combines the provisions of Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899.

Intent. ". . . restore and maintain the chemical, physical, and biological integrity of the Nation's waters."

Jurisdiction. All wetlands meeting the Clean Water Act definition (see Section 1.2.2) are covered.

Regulated activities. The placement of fill in waters of the United States, including wetlands, as defined in the Act is covered.

Gaps in regulatory coverage. Section 404 only regulates filling, not dredging, draining, or land clearing. It exempts normal farming, ranching, and forestry practices. Corps regulations allow fills of less than one acre in isolated wetlands and may allow fills of 1 to 10 acres in isolated wetlands and headwaters streams of less than 5 cfs.

3.1.2 State Shoreline Management Act

The Washington Shoreline Management Act (SMA; Chapter 90.58 RCW) was adopted primarily to manage development on the state's shorelines. The Act is administered through Shoreline Master Programs adopted and enforced by local governments. The Department of Ecology has oversight authority over the local government actions.

Intent. To manage appropriate uses of the state's shorelines, as defined by the Act.

Jurisdiction. Shorelines of the State, including marine waters, lakes 20 acres or greater in size, streams with flows over 20 cfs, and all lands within 200 feet of Shorelines of the State (ordinary high water mark), plus associated marshes, bogs, and swamps are covered.

Regulated activities. Most wetland alterations are covered, but exact coverage depends on individual local Shoreline Master Programs.

Gaps in regulatory coverage. The Act excludes wetlands not "associated" with waters of the State, including isolated wetlands and riparian wetlands associated with lakes less than 20 acres and streams with flows less than 20 cfs. It exempts most agricultural and forest practices from permit requirements. Wetland protection is highly variable and is dependent upon the local Shoreline Master Program.

3.1.3 State Hydraulics Code

The Hydraulics Code (RCW 75.20.100) is jointly administered by the Washington departments of Fisheries and Wildlife through the Hydraulic Project Approval (HPA) permit process. In general, the Department of Fisheries assumes responsibility for marine shorelines and anadromous fish streams; the Department of Wildlife assumes responsibility for all other streams.

Intent. The intent of the Code is to protect fish and fish habitat.

Jurisdiction. All waters of the state, including marine waters, lakes, ponds, rivers, and sloughs, and wetlands are covered.

Regulated Activities. Most activities within the Ordinary High Water Mark are covered; exceptions are defined by Rule.

Gaps in regulatory coverage. Wetlands outside the Ordinary High Water Mark are excluded, as are isolated wetlands without fish life. The Code does not address impacts to wetland values and functions other than fish and fish habitat.

3.1.4 Forest Practices Act

The Forest Practices Act (FPA; Chapter 79.09 RCW) is enforced by the state Department of Natural Resources.

Intent. The Act is intended to protect public resources while promoting and maintaining a sound forest products industry.

Jurisdiction. Wetlands are considered Type 2 waters, as defined by the Act, when they have one acre or more of open water at low water. Wetlands are considered Type 3 waters, as defined by the Act, when they have less than one acre of open water at low water and an outlet to a stream containing anadromous fish, or if they have between 0.5 and 1 acre of open water at low water. Wetlands without open water are generally considered to be Type 5 waters.

Regulated activities. All forest practices including road construction are covered.

Gaps in regulatory coverage. The Act only regulates forest practices. It provides little or no protection for wetlands without open water (Type 4 or 5). It allows logging to the edge of wetlands classified as Type 2 or 3 waters. It is important to note that the Forest Practices Act was amended in 1987 to include certain provisions agreed to in the Timber, Fish and Wildlife (TFW) negotiations. As a result of the TFW agreement, a process is now in place that provides for detailed review of proposed forest practices and may result in greater protection of wetlands than is provided for in the forest practices regulations.

3.1.5 State Environmental Policy Act

The State Environmental Policy Act (SEPA; Chapter 43.21C RCW) is implemented mostly at the local government level. There is no central oversight or review authority for SEPA decisions.

Intent. SEPA requires full disclosure and consideration of possible adverse environmental impacts of a project and ways to mitigate or reduce adverse impacts.

Jurisdiction. SEPA review is required for any proposed action not categorically exempt by the Act; SEPA review must be completed before issuance of Shoreline Substantial Development Permits, Hydraulic Project Approvals, and many other state and local permits.

Gaps in regulatory coverage. SEPA is not a regulatory Act except when it is used to deny or condition a state or local permit based on significant adverse environmental impacts. SEPA includes no language specifically protecting wetlands.

3.1.6 Aquatic Lands Management Act

The Aquatic Lands Management Act (Chapter 79.90 RCW) provides for the management of state owned aquatic lands for a variety of uses. The Act is administered by the Department of Natural Resources.

Intent. The Act provides for the management of state owned lands for a variety of uses including encouragement of direct public use and access, fostering water dependent uses, ensuring environmental protection, and utilizing renewable resources.

Jurisdiction. Many uses of state owned aquatic lands, generally those requiring structures or other restrictions on public use, must receive a use authorization from the Department.

Gaps in regulatory coverage. The ALMA applies only to the state owned aquatic lands. Private lands are not affected.

3.2 Program Evaluation Summary

Cities and counties have other options available to them besides state and federal laws to protect wetlands. Included among these options are comprehensive plans and zoning ordinances; environmentally sensitive area ordinances; clearing, grading, and filling ordinances; and SEPA policies; and preservation program. Some cities, including Bellevue, Kirkland, and Olympia, and counties, including Island, King, Pierce, Snohomish, and Thurston, have adopted their own wetland protection programs. Grant County in eastern Washington is working on adoption of an ordinance.

Under the provisions of the Puget Sound Water Quality Management Plan, the Department of Ecology is developing wetland protection standards which will be used as guidance by local governments who are developing wetland protection programs. At some point in the future, these standards may be adopted as state rules for the Puget Sound basin. Hopefully, these standards will be used by local governments to provide improved wetland protection at the local level.

In summary, the current matrix of federal, state, and local laws and regulations, when taken together, do not provide adequate statewide protection for wetlands in Washington, even though the Puget Sound Water Quality Management Plan will offer a high degree of protection in the 12 counties included in the Puget Sound region. The principle gaps in statewide coverage include:

- Jurisdiction over isolated wetlands -- that is, wetlands not associated with Shorelines of the State or within the Ordinary High Water Mark of streams, lakes, and other waters of the state;
- Regulation of agricultural and forest practices;
- Regulation of activities in wetlands other than filling; and
- Lack of monitoring and enforcement of mitigation proposals.

3.3 Opportunities

There was no documentation found on opportunities created by successful application of wetlands management although such opportunities clearly exist.

4. EFFECT OF POPULATION GROWTH ON WETLANDS

Conventional wisdom indicates that an increase in population will lead to increased pressures on open space, including wetlands. Population in projected to continue to increase, with a 25 percent increase projected statewide in the next decade. Because of regulatory restrictions and time delays in developing wetland areas, upland alternatives are usually exhausted first. In rapidly growing areas, only wetlands or steep slope remain undeveloped. Because there is usually no protection offered for upland buffers, these wetlands are often isolated habitat islands in a developed landscape. As land becomes more scarce and population continues to grow, the pressure to develop remaining wetlands will become even more intense.

One case example is the Green River Valley. The following growth information is based on estimates from the Puget Sound Council of Governments. The Green River Valley contains the largest supply of vacant, zoned commercial and industrial land in the Seattle metropolitan area. The supply of zoned land is virtually exhausted in Seattle and is running low on the Eastside. A large portion of the vacant, industrially-zoned land in the Kent Valley contains wetland areas. The supply of land in the valley is expected to last only until the mid-1990s; therefore, only a two- to four-year supply is available. The market is extremely tight, land prices continue to escalate, and development pressure in this area is extremely high.

There are many problems with estimates of wetland losses by comparing data from past wetland resource base to the present. In the past wetland inventories were conducted for relatively narrow purposes, e.g. the early 1950s Circular 39 (Shaw and Fredine, 1956) inventory which was focused on waterfowl habitat. The early Soils Conservation Service maps were based on aerial photos and spot checked at a very large scale; forested wetlands were often missed in the data base, and no information was gathered for higher elevation areas. Thus, wetlands loss at that time was measured against a smaller base than are current wetland analyses. Any estimates based on wetland loss are extremely conservative.

Additionally, one must consider the factors regulating the rate of loss. In the past, particularly prior to the 1970s, there were few or no regulations controlling wetlands fill or drainage -- in fact, federal policy often encouraged such activity. Major wetland losses occurred through drainage for agriculture, grazing, mining, and forestry activities. Current losses occur through urbanization; industrial, residential and commercial development; and timber harvesting at a landscape scale to create significant cumulative adverse impacts. The differences in types of wetland loss also make quantification of changes over time or correlation with population very difficult. As the base area of wetland resources diminish, there are fewer wetlands to be lost in the future; this would tend to lower the rate of present and future loss.

The point is: lacking a stable baseline for comparison, it is difficult to compute meaningful loss rates for wetlands. The importance of conducting a statewide inventory and monitoring loss rates closely is a critical component of building an adequate data base for long-term wetland planning decisions. In addition, advanced planning for development through such activities as the Special Area Management Plans developed by the U.S. Army Corps of Engineers, Advanced Identification by the Environmental Protection Agency, and watershed management plans by state and local governments assist in maintaining wetland areas for wildlife and other wetland values and functions.

5. WETLANDS STATUS IN 2010

There are two clear trends in operation regarding wetlands: (1) a continued loss of wetlands of all kinds, and (2) a growing concern over their loss which is being reflected in tentative government action, e.g. the 1988 Washington Wetlands Study Report, and the proposed Wetlands Management Act of 1989.

If no regulatory action takes place, clearly then there will be a continued loss of wetlands at rates similar to or higher than now occurring. The secondary effects of this will principally be continued loss of fish and wildlife habitat leading to declines in populations and fewer opportunities for hunting, fishing, and passive observation; and continued loss of the hydrologic amenity values of wetlands in flood control and water quality improvement, leading to greater municipal costs for providing these benefits through engineered structures.

If a regulatory program similar to the proposed Wetlands Management Act of 1989 is adopted, then some reduction in the loss rate can be expected. There may also be revisions to the Clean Water Act to reduce the impacts of filling isolated wetlands. Local government may adopt wetland protection ordinances.

Assuming an existing (1989) wetlands base of 938,000 acres and a sustained annual loss rate of 800 acres (page 27), during the 21 years to 2010 an additional 16,800 acres of wetlands would be lost.

This is a minimal estimate of loss rate. Population growth and development pressures for both wastewater and storm water treatment; placement of fill for residential, commercial, and industrial projects; and silvicultural, agricultural, and roadbuilding activities will all continue or increase while the resource base remains finite.

Without regulatory protection or increased acquisition/presentation programs, loss and degradation of fish and wildlife habitat, water quality, and water quantity is expected to accelerate to 2010 in the state of Washington.

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THE STATE OF THE ENVIRONMENT REPORT

VOLUME II
Part 5

Food Fish and Shellfish Resource Characterization Report

ENVIRONMENT 2010

State of Washington
October, 1989

Introduction

Because of the short time frame and amount of material to review for writing this report, we have taken direct quotations from authors. For the most part, we are not citing individual Department of Fisheries employees. Therefore, if an author is not directly cited then one can conclude it was a WDF author. Outside authors quoted will be acknowledged in the text along with the references section.

Organization of this report is based on Department of Fisheries Management structure. Fisheries resources are broken into three programs representing salmon, shellfish, and marine resources; and further divided by geographic region.

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Washington Environment 2010
Summary of Fish and Shellfish Resource
Characterization Report

The Washington Department of Fisheries (WDF) is legislatively mandated to preserve, protect, perpetuate, and manage the food fish and shellfish resources in state waters. WDF is organized in a manner to manage three major natural resource groups. These are salmon resources (coastal, Columbia River, and Puget Sound), shellfish resources (coastal and Puget Sound), marine fish resources (coastal and Puget Sound) and nonanadromous resources (eulachon, shad, carp, and sturgeon).

There are five species of Pacific salmon in Washington State: chinook, coho, chum, pink, and sockeye. All species are anadromous, that is, they hatch in fresh water, migrate to salt water and then return to spawn in fresh water. Washington Pacific salmon are found in waters from California to Alaska and are caught in recreational, commercial, and Indian fisheries in Washington. They are also caught by fishers of Oregon, California, Alaska, and British Columbia. This leads to complex fishing regulations, treaties, and court mandated allocations to the various user groups.

Washington state shellfish can be separated into three groups according to their mode of life, namely, benethic shellfish living in the substrate (razor clams, hard shell clams, geoducks), epibenthic or bottom dwelling (Dungeness crab, sea urchins, and sea cucumbers) and those both epibenthic and pelagic or bottom dwelling and swimming in the water column off the bottom (shrimp). Shellfish are generally non-migratory, staying within Washington waters.

Marine fish can also be broken into three general groups: baitfish (Pacific herring, surf smelt), flat fish (Pacific halibut, flounders, sole) and ground fish (Pacific cod, walleye pollock, Pacific whiting). Like salmon, many marine fish migrate into and outside Washington waters making harvest management very complex.

In order to manage the food fish and shellfish resources, WDF measures the condition of each resource and determines the surplus available for harvest without damaging the basic stock. WDF then sets fishing seasons and regulations. The condition of the salmon resource is measured by sampling recreational and commercial catches, examining historical catch records, conducting spawning ground surveys to determine escapement levels and population estimates by tagging studies, making downstream counts of juvenile salmon and evaluating salmon hatchery releases.

The condition of the shellfish resources are measured by sampling commercial and recreational catch, examining historical catch records, conducting population estimates by tagging studies, and evaluating catch per unit of effort in the fisheries.

Marine fish stocks are also measured by population estimates and by long-term harvest records to determine allowable catch levels.

PACIFIC SALMON STATEWIDE (Sekulich and Edie 1989)

Using total Washington commercial harvest as an index, the salmon resource is relatively stable, with the last four 12-year averages ranging from 5.4 million to 6.3 million fish.

After the low of 5.4 million salmon for 1963-1974, the catches rebounded to 6.2 million, which approximates those during 1939-1962. In general, the salmon stocks are remaining stable or are improving.

The relative stability of harvest however, obfuscates the issues of wild stock/hatchery mix, abundance, selective run and stock depression, overcapitalization of the fleet and competition for the resource.

SHELLFISH COASTAL (Northup 1989)

Razor Clams

The razor clam population has been in a general state of decline for the last 10 years. The populations were further decreased by the onset of a previously unknown disease organism in 1983. Since that time, the populations have been very unstable and unpredictable, in what appears to be a continuous state of decline, with some exception.

Major fluctuations have occurred with population levels, survival of year classes (mostly related to results of disease) and successful spawning and recruitment of new year classes.

Dungeness Crab

As is typical of many crustacean species, Dungeness crab year-class strength (i.e., survival) is primarily determined by the environmental conditions encountered during the larval and early post-larval stages. Consequently, large fluctuations in abundance occur. Seasonal harvest by commercial fishery since 1950 has averaged 7.5 million pounds but has ranged from a low of 2.5 million pounds to a high of 18.4 million pounds. After eight consecutive seasons of below average catches, the fishery produced 16.25 million pounds last season and has produced more than 18.0 million pounds through April 1989.

The resource is healthy despite heavy fishing exploitation. Fishery regulations ensure protection of a breeding stock by prohibiting the harvest of all female and male crabs smaller than 6 1/4 inches in shell width; except six inches in Hood Canal.

The commercial fishery takes approximately 99 percent of the available resource each season on the coast.

Pink Shrimp

The abundance of pink shrimp fluctuates widely according to year class strengths. The resource has recovered somewhat from low catch per unit of effort (CPUE) averages which began in 1979 and persisted until a modest upturn in 1983. Landings, influenced by fishing effort, have been increasing since 1984. The number of vessels in the fishery has generally increased since 1973, but continues to be influenced by shrimp prices and abundance.

The ocean pink shrimp resource appears healthy, but probably poised for a decline in production. The landings of 1986, 1987, and 1988 exceed any other landing total by 30 percent or more, the catch per hour of towing is relatively low, and the fleet size large.

Oysters

Oyster culture is one of the major industries in southwest Washington and has increased in relative importance following declines in the timber and fishing industries. The broad tide lands and rich waters of Willapa Bay and Grays Harbor offer ideal conditions for culture of Pacific oysters. Oyster culture began in these bays with harvest of Olympia oysters during the mid-1800s. Pacific oyster culture began in the 1930s after introduction of Japanese oyster seed. Annual harvest from the bays reached 1.2 million gallons during World War II. Total Washington production peaked around 1955 and declined through the mid-1970s. In 1976, Willapa Bay and Grays Harbor production reached its historic low at only 263,000 gallons. This decline was due in part to competition from imported oysters. Recently, production has increased slightly and averages 350 to 400 thousand gallons per year from the coastal bays.

SHELLFISH PUGET SOUND AND STRAITS (Burge and Baumgarner 1989)

Dungeness Crab (TABLE 2)

Based on commercial landings since 1951, Puget Sound Dungeness crab production remains strong.

There has been some fluctuation in abundance, but these fluctuations do not indicate problems with reproductive potential. Table 2 shows total pounds landed, number of landings, and number of pounds averaged per landing for the years 1951 through 1988.

Sea Urchin (TABLE 3)

From 1971 through 1986, yearly harvest never exceeded 1.5 million pounds. The 1986-87 harvest was 3.4 million pounds; and in 1987-88, 4.5 million pounds were landed.

Over five million pounds were harvested during the latest season (1988-89), a record harvest. Eighty percent of the catch came from the San Juan Islands, while 20 percent was landed from the Strait of Juan de Fuca.

Sea Cucumbers (TABLE 4)

Over 1.9 million pounds were landed during the 1988 season, a record harvest. Catch per unit effort has remained stable as indicated by catch data shown in the Table, the 1988 harvest has apparently increased six-fold over the previous five-year average.

Geoduck (TABLE 5)

Five million pounds were harvested in 1988, representing about three percent of a total known resource base of 165 million pounds statewide. Figures for harvest are drawn from DNR and WDF fish ticket data as shown in the Table; total poundage available is based on WDF annual diver surveys made yearly. Many harvested beds have recovered to fishable levels within ten years, however, the rate of natural reproduction and recruitment can be much slower. Once a geoduck bed is completely harvested, it takes an average 30 years for geoduck densities to permit reharvest.

Geoduck harvest is managed for long-term sustainable harvest from geoducks found within the depths of 18 to 60 feet. Maximum sustainable yield is estimated at five million pounds per year, and only DNR geoduck tracts containing this amount are leased yearly. Thus, harvest has remained stable.

Spot Shrimp

Stock assessments have been made each year since 1977 to determine spot shrimp abundance and amount available for harvest.

Using new management techniques beginning in the late 1970s, spot prawn production has more than doubled and fluctuations in abundance have been stabilized.

Hardshell Clams (TABLE 6)

Historically, the native littleneck and butter clams have been harvested by two methods: the hydraulic harvester in the subtidal and by hand digging in the intertidal zone. The manila littleneck clams are harvested only by hand digging in the intertidal zone. Commercial harvest has shown a steady increase since 1980. This increase has occurred in spite of a decline in subtidal hydraulic harvest of all clams due to economic and shorelines permit problems. The increase is due entirely to greater harvest in the intertidal area in response to demand for manila clams. Other important factors limiting harvest in the recent 10-year period are closures due to pollution and red tide outbreaks in previously unaffected areas.

MARINE FISH PUGET SOUND (Schmitt 1989)

Groundfish (TABLE 7)

Major commercial species include whiting, dogfish, surfperch, lingcod, Pacific cod, pollock, rockfish, and flatfish.

For most of the major species in Puget Sound, the 1970s was a decade of rapidly increasing catches and effort. This was true for both the recreational and commercial fisheries. The catch by recreational bottomfish anglers and by commercial bottom trawlers kept pace with increasing effort. The recreational catch of major species by bottomfish-only fishers increased tenfold and the commercial catch more than doubled. This period of rapid fishery expansion in the 1970s was followed by an equally rapid decline in the recreational catch during the 1980s. However, effort in both fisheries remained high and catch rates fell. Although this trend is not common to every major species, it is shown for most of them. Although we do not know the reason for the decline for every species, we can identify the main reason for declines for some species and provide some reasonable speculation for other species.

The current stock condition and recent trends for each of the major groundfish species/species groups in Puget Sound is summarized in the Table 8.

In summary, catches of whiting, Pacific cod, flatfish and surfperch declined during the 1980s, at least partially as a result of reduced abundance. Regulation changes also contributed to the declines. Lowered market demand caused dogfish catches to decline and possibly lowered fisher demand may have contributed to the pollock catch decline. Pollock abundance may also be declining. Lingcod and rockfish in Puget Sound have been relatively stable during the 1980s, but there may be localized areas of depletion, compensatory changes in abundance of some rockfish species, or the recreational fishery may have shifted to new, relatively unexploited areas or stocks.

Pacific Herring (Figure 6)

Herring abundance in recent years has been fluctuating, but was stable overall in central and southern Puget Sound and Admiralty Inlet (the exception is in central Hood Canal, where spawner abundance appears to be very depressed). The sport-bait fishery that operates in these areas has been steadily taking 400-1,000 tons of herring per year for many years without much problem. In northern Puget Sound, the largest herring stock in the state (which spawns in the Cherry Pt. area of Whatcom County) has been experiencing extremely low abundance in recent years. Beginning in 1973, this stock supported a large and lucrative sac-roe fishery, however, recently the fishery has been either severely curtailed or suspended completely. The other smaller herring stocks in northern Puget Sound appear to have been doing well and increasing in recent years.

The current condition of the herring resource in Washington State is one of overall stability in central and southern Puget Sound. Herring are thought to form genetically discrete stocks that spawn on specific spawning grounds, therefore, some stocks can be stable or increasing, while others are in a depressed condition. Herring can be subject to fairly large fluctuations in abundance mainly due to the environmental conditions encountered during their first three months of life.

Surf Smelt

Commercial landings of surf smelt have averaged 107,000 pounds per year between 1971 and 1986. 1973 and 1974 were peak years having over 200,000 pounds landed each of those two years. Since 1975, the catches have stabilized to about 100,000 pounds per year. (Ward 1986)

COASTAL GROUNDFISH (Millikan 1989):

The current condition of Washington's coastal groundfish resource is generally healthy, with the exception of Pacific ocean perch stocks which are currently managed under a rebuilding program. The attached tables, reproduced from a recent Status of Stocks reports (PFMC 1987, 1988), document the best available estimates of the current condition, past trends, and future projections of the coastal groundfish resource. The areas pertaining to Washington's coast are the Vancouver and Columbia INPFC areas. As indicated in Table 9, stock condition was estimated to be either unknown, above MSY, or at MSY for all major Pacific coast groundfish stocks except for Pacific ocean perch. The same was true for the Vancouver and Columbia areas.

Catch trends for the commercially important groundfish species in the Columbia area is summarized in Table 10. In most cases, the year to year variability in catch is considerable and a clear trend is not evident. Furthermore, full blown assessments are not available for many stocks. While the abundance trend for most species is unknown, Dover sole and yellowtail rockfish were reported to be in decline. Such declines are not necessarily to be interpreted as an indication that stocks will continue to decline because stock biomass is expected to decline until equilibrium is reached at the MSY level.

Black rockfish and lingcod dominate the coastal recreational marine fish catch. Black rockfish landings have increased from 160,509 to 293,182 between 1981 and 1986; lingcod landings increased from 9,546 to 22,364 over the same period.

MISCELLANEOUS (NON-ANADROMOUS) (Ward 1986)

Sturgeon

During the late 1800s, the demand for caviar and smoked sturgeon increased greatly and made fishing for sturgeon a highly profitable enterprise. There was neither proper management nor regulation of the fishery at that time and disastrous overfishing resulted in almost complete elimination of the breeding stocks. Today it is uncommon to catch a sturgeon larger than 500 pounds in the Columbia. The commercial catch of white sturgeon in recent years has ranged from 1/3 to 1/2 million pounds in contrast with three to six million pounds taken in the 1890s. Both gill nets and set lines contribute to the commercial catch, which generally occurs incidental to salmon catches during open salmon season. Despite decreasing salmon seasons, lower Columbia River sturgeon harvests have increased steadily in recent years. Upper river stocks, however, are believed to have become severely depressed due to construction of dams and deterioration of access to spawning areas.

Eulacheon (Columbia River Smelt):

For as long as commercial statistics are available, the Columbia River catch has exceeded 1,000,000 pounds annually. The fish are taken commercially with fine mesh gill nets in the main Columbia, principally below Vancouver, and with dip nets in the Grays, Cowlitz, Kalama, Lewis, and Sandy Rivers, which are the main smelt producing tributaries. There is a large recreational fishery with dip nets.

Shad (Ward 1986)

Shad are a large underutilized resource in the Columbia River. The commercial fishery averages 44,000 pounds landed per year between 12971 through 1986.

HABITAT MANAGEMENT

The WDF has many "tools" to ensure stocks of food fish and shellfish and their habitats are maintained or enhanced. These include fish regulations, laws to protect habitat, and enforcement of these laws and regulations. WDF is in the final stages of formalizing its longstanding policy for habitat management. The policy, simply stated, contains an objective of achievement of a net gain of the productive capacity of the habitat of the food fish and shellfish resources of the state. This will be accomplished by pursuit of three goals: (1) maintain the productive capacity of all existing food fish and shellfish habitat (protection), (2) restore the productive capacity of habitats that have been damaged or degraded by natural causes or as a result of human activities (rehabilitation), and (3) improve the productive capacity of existing habitat and create new habitat (enhancement). Examples of recent "successes" using these "tools" include fish passage improvement at dams; major fishway and screening projects in eastern Washington; protection of salmon, shellfish, and marine fish habitat through administration of the Hydraulic code the State Environmental Policy Act and the Timber, Fish and Wildlife Agreement.

POPULATION IMPACTS

Numerous assumptions and disclaimers are necessary to predict how projected population increases in Washington will affect the fisheries resource in the year 2010. These are:

1. Complex fishery allocations and harvest management programs in existence will allow for adequate escapement of adults for optimum spawning population and egg take for hatcheries.

2. There will be no net loss of habitat for wild populations of salmon, marine fish, and shellfish.

3. There will be no loss of shellfish production by decertification from state, federal or local health agencies.

With these assumptions, an increase in human population will mean smaller allocations to user groups based on a finite food fish and shellfish resource population and habitat.

The only way to increase or maintain user group shares will be to maintain existing habitat, enhance existing habitat, restore habitat lost to dams and other obstructions and finally increase production through fish, shellfish hatchery type production.

Our future projection of fish and shellfish resources in year 2010 based on life histories, proper harvest regulations, current and historic catch records, proper enforcement of laws to maintain and enhance habitat are as follows:

SALMON COASTAL, PUGET SOUND AND COLUMBIA RIVER (Sekulich and Edie 1989)

Assuming habitat stability, catches for the 1987-2010 period are expected to average approximately the same as the previous 12 years, ranging from 5.4 million to 6.3 million salmon. Annual fluctuations related to short-term environmental and spawning escapement variations are obviously anticipated.

SHELLFISH COASTAL (Northup 1989)

For razor clams, lack of understanding about the current disease life history, the method of infection, and the exact relationship between infection intensity and subsequent levels of mortality make it difficult to impossible the projection of resource viability through 2010. Since the onset of the disease in 1983, there have been no patterns established that we can use to predict future razor clam populations with any reliability.

Abundance of Dungeness crab, ocean pink shrimp, hardshell clams, and oysters will continue to fluctuate as they have historically.

SHELLFISH PUGET SOUND (Burge and Baumgarner, 1989)

Abundance of Dungeness crab, sea urchins, sea cucumbers, spot shrimp, and hardshell clams will continue to fluctuate as they have historically. The management plan for geoduck limits harvest to five million per year. Within five years we expect to double the figure due to successful "seeding" of harvested geoduck beds with hatchery-reared juveniles.

MARINE FISH - PUGET SOUND (Schmitt 1989)

Conditions in the future will vary by species/species group and each is discussed in the following sections. However, in general, groundfish are becoming increasingly popular to both recreational and commercial harvesters. Species that are currently under-utilized may experience increased exploitation and other species that are currently fully utilized may become under-utilized. For example, the closure of much of Puget Sound to bottom trawling may result in under-utilization of many species, especially flatfish.

For surf smelt, preservation of existing spawning habitat is critical, as a minimum, to maintain present population.

Projections of future Pacific herring populations do not exist, however, fluctuations in abundance will continue to occur. In the judgment of professionals, even with conservative fisheries management, herring abundance may slowly decline overall due to environmental degradation of important habitat.

Table 1
WASHINGTON COMMERCIAL SALMON HARVEST
(source: 1986 Fisheries Statistical Report, p. 19)

YEAR	HARVEST OF SALMON	12 YEAR AVERAGES	
1939	6,795,000		
1940	3,417,000		
1941	7,267,000		
1942	5,500,000		
1943	3,184,000		
1944	1,980,000		
1945	8,821,000	6,282,33	1939-1950
1946	6,392,000		
1947	12,360,000		
1948	4,113,000		
1949	11,215,000		
1950	4,344,000		
1951	9,850,000		
1952	4,629,000		
1953	10,526,000		
1954	6,973,000		
1955	8,394,000		
1956	3,222,000	6,047,750	1951-1962
1957	6,843,000		
1958	7,385,000		
1959	6,389,000		
1960	2,102,000		
1961	3,762,000		
1962	2,498,000		
1963	9,311,000		
1964	2,314,000		
1965	3,801,000		
1966	3,906,000		
1967	8,099,000		
1968	3,144,000	5,410,083	1963-1974
1969	4,241,000		
1970	4,065,000		
1971	8,378,000		
1972	3,865,000		
1973	8,092,000		
1974	5,705,000		
1975	5,834,000		
1976	5,103,000		
1977	7,099,000		
1978	4,693,000		
1979	8,632,000		
1980	3,900,000	6,175,417	1975-1986
1981	7,687,000		
1982	6,218,000		
1983	4,235,000		
1984	3,851,000		
1985	10,332,000		
1986	6,521,000		

MARINE FISH COASTAL (Millikan 1989)

Because of a coordinated coastwide management regime, it is likely that the harvest of coastal groundfish stocks will continue to be maintained at levels here or below the Acceptable Biological Catch. These levels of catch are set and reviewed annually to ensure the long-term health of the fishery. Thus, the coastal groundfish resource may be expected to remain fairly stable over the long-term. In the case of Pacific ocean perch, however, it is unlikely that stocks will return to historic levels due to the level of bycatch of this species which occurs as part of the targeted fisheries.

Abundance of sturgeon, shad, and eulackion (Columbia River smelt) are appearing to remain stable.

In summary, the food fish and shellfish resources have remained reasonably stable and are expected to remain at these levels in the year 2010.

Table 2 - Puget Sound Dungeness Crab

Season	Pounds Landed	Number Landings	Landing
1951-1952	1,040,961	3,603	289
1952-1953	926,808	3,104	299
1953-1954	1,037,214	3,574	290
1954-1955	953,940	2,580	370
1955-1956	847,452	1,649	514
1956-1957	450,812	1,259	358
1957-1958	324,150	1,104	294
1958-1959	543,310	1,449	369
1959-1960	644,047	1,558	513
1960-1961	1,522,833	3,168	481
1961-1962	1,290,945	2,305	560
1962-1963	992,941	2,224	446
1963-1964	1,700,930	2,892	588
1964-1965	1,418,674	2,716	522
1965-1966	1,483,218	2,336	635
1966-1967	768,144	1,358	566
1967-1968	964,137	1,723	549
1968-1969	815,687	1,566	521
1969-1970	929,507	1,699	547
1970-1971	604,504	1,263	479
1971-1972	862,109	2,145	402
1972-1973	1,215,937	3,609	337
1973-1974	942,983	3,463	272
1974-1975	629,362	2,612	241
1975-1976	1,338,996	3,792	353
1976-1977	2,290,199	3,189	718
1977-1978	1,868,454	3,111	601
1978-1979	2,374,991	4,126	576
1979-1980	1,773,628	4,128	430
1980-1981	1,805,307	4,439	407
1981-1982	1,331,853	3,952	337
1982-1983	1,095,262	2,927	374

1983-1984	1,269,300	3,411	372
1984-1985			
1985-1986	1,293,583	3,618	358
1986-1987	1,324,600	3,806	348
1987-1988	1,467,500	4,355	337
1 1988-1989	1,647,300	3,434	479

1 October - December only

Table 3 Commercial Landing of Sea Urchins - (pounds and value in thousands)

Year	Urchins Pounds	Value
1971	2	0
1972	3	1
1973	15	4
1974	57	6
1975	31	2
1976	1,544	115
1977	903	76
1978	1,026	87
1979	1,002	104
1980	43	5
1981	268	29
1982	202	19
1983	412	43
1984	414	75
1985	642	126
1986	2,126	470
5 Yr. ave.	388	58
Table ave.	438	46

Table 4 Commercial Landing of Sea Cucumbers - (Pounds and Value in Thousands)

Year	Sea Cucumbers Pounds	Value
1971	8	1
1972	6	2
1973	10	2
1974	0	0
1975	3	1
1976	15	3
1977	63	13
1978	127	26
1979	236	34
1980	421	55
1981	276	40
1982	27	4
1983	376	66
1984	88	17
1985	324	53
1986	399	70
5 Yr. ave.	218	36
Table ave.	132	21

Table 5 Commercial Landing of Geoducks (Pounds and value in thousands)

Year	Geoducks Pounds	Value
1971	610	68
1972	493	44
1973	464	45
1974	803	67
1975	2,373	329
1976	5,366	938
1977	8,647	1,499
1978	7,090	1,279
1979	5,228	1,089
1980	3,910	692
1981	4,290	440
1982	5,303	2,386
1983	3,523	1,656
1984	4,421	515
1985	4,109	455
1986	2,854	1,855
5 Yr. ave.	4,329	1,090
Table ave.	3,775	767

Table 6 Washington Commercial Hardshell Clam Landings By Species and Gear in Thousands of Pounds

	Butter		Native		Manila		
Year	Hand Dug	Dredge	Hand Dug	Dredge	Hand Dug	Dredge	Total
1970	40	569	397	229	640	0	1,875
1971	34	432	452	175	762	0	1,855
1972	80	33	594	84	649	*1	1,741
1973	102	496	510	271	538	2	1,919
1974	12	348	322	325	790	*1	1,798
1975	16	307	349	197	966	*0	1,835
1976	22	210	434	113	1,111	0	1,890
1977	132	396	527	90	1,078	0	2,223
1978	43	194	418	56	1,840	0	2,551
1979	42	65	323	25	1,475	0	1,930
1980	72	334	455	67	1,466	0	2,394
1981	42	209	610	15	1,508	0	2,384
1982	30	158	414	5	1,477	2	2,086
1983	35	264	604	5	1,698	0	2,606
1984	9	179	506	89	2,497	0	3,280
1985	24	1	536	0	3,069	0	3,630
Five yr. ave.	38	229	518	36	1,729	0	2,550
Table ave.	47	300	461	116	1,233	0	2,158

Table 7 ANNUAL CATCHES (in pounds) OF ALL GROUNDFISH SPECIES IN PUGET SOUND

Year	Catch
1970	15,875,468
1971	12,685,552
1972	9,964,622
1973	9,533,816
1974	14,114,250
1975	11,027,009
1976	17,211,050
1977	17,495,001
1978	21,843,682
1979	27,981,689
1980	27,139,628
1981	22,794,596
1982	25,192,973
1983	25,981,893
1984	20,004,180
1985	15,367,575
1986	10,703,120
1987	9,573,076

Table 8. Current stock conditions and recent trend for the major species/species groups of groundfish in Puget Sound

Species	Condition	Trend
Flatfish	Healthy	Stable
Pacific cod	Low	Variable
Pacific whiting	Low	Stable
Walleye pollock	Unknown	Declining
Lingcod	Healthy	Stable
Rockfish	Unknown	Stable
Surfperch	Low	Stable
Dogfish	Healthy	Declining

Table 9 Puget Sound Herring Abundance Estimates by Spawning Ground, 1978-1988. Spawning Biomass in tons.

Area	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978
Quartermaster Harbor	750	924	1181	667	1386	909	1778	1777	1930	1941	1860
Agate Pass	1705	2538	1962	1415	1293	1651	1214	890	2139	1255	-
Port Susan	570	1216	934	1321	1555	1398	1391	-	-	-	-
Port Gamble	1358	2035	2050	2387	2685	2407	1463	1753	2309	1790	1984
Discovery Bay	853	1593	1566	1447	3144	2578	2356	3070	3220	-	1305
Fidalgo Bay	-	887	727	761	773	667	182	456	296	-	-
Skagit Bay	1340	1552	-	-	-	-	-	-	453	-	
Drayton Harbor	1965	-	1464	2325	772	766	1266	1008	-	-	-
Cherry Pt.	4311	3108	5671	5760	5901	8063	5342	6219	9329	9957	10973

*Excludes herring used in experimental spawn-on-kelp fisheries.

Table 10 Estimated commercial groundfish landings for the Columbia Area. 1980-1987. (Excludes joint venture and foreign catches.)

Species	Columbia Area							
	1980	1981	1982	1983	1984	1985	1986	1987
Roundfish								
Lingcod	1,447	1,386	1,442	1,877	1,247	1,257	734	905
Pacific Cod	293	123	81	59	89	30	36	794
Pacific Whiting	257	171	0	39	355	881	480	250
Sablefish	3,693	3,463	6,017	4,819	4,659	5,165	4,937	6,110
Total Roundfish	5,690	5,143	7,540	6,794	6,350	7,335	6,187	8,059
Rockfish								
Pacific Ocean Perch	1,491	986	531	1,205	924	756	714	559
Shortbelly	0	18	¼	0	1	11	2	0
Widow	15,366	20,615	10,871	4,648	5,864	5,104	6,142	9,304
Other Rockfish								
Bocaccio	367	649	525	723	253	476	272	234
Canary	2,612	1,669	3,045	2,821	1,145	1,078	892	1,475
Chilipepper	0	3	18	11	2	3	1	0
Thornyhead	140	55	76	716	726	876	521	378
Yellowtail	4,857	4,557	4,324	5,383	3,421	1,824	2,336	2,592
Remaining Rockfish	1,238	2,441	3,169	2,749	1,988	3,080	2,304	
Unspecified Rockfish	2,008	1,424	1,260	982	620	790	1,206	1,712
Total Rockfish	28,079	32,417	23,807	19,238	14,944	13,999	14,390	18,076
Flatfish								
Dover Sole	4,360	4,896	7,301	6,777	5,271	4,780	3,976	5,571
English Sole	760	711	825	692	357	513	641	705
Petrale Sole b/	1,085	968	991	1,001	703	617	720	979
Other Flatfish	1,461	1,563	2,094	1,598	1,157	1,182	892	1,058
Total Flatfish	7,666	8,138	11,211	10,068	7,488	7,091	6,229	6,313
Other Fish								
Jack Mackerel	0	0	0	0	0	0	0	0
Others	573	3,080	880	696	623	904	790	928
Total	42,008	46,778	43,438	36,796	29,405	29,326	27,610	35,376

a/ Remaining rockfish are all species of rockfish not specifically listed on this page.

b/ Except arrowtooth flounder which are recorded under other fish.

Data Source: Vancouver and Columbia area landings were extracted from WDF 1988 Status Reports to the Technical Subcommittee of the U.S.-Canada Groundfish Committee and PacFIN data. Eureka, Monterey, and Conception area landings were obtained from the PacFIN system.

Table 11. Comparisons of MSY, ABC, domestic landings, stock condition, and abundance trends for major Pacific coast groundfish stocks in the Columbia area, 1986-1988.

		Columbia						
		1986		1987	1988			
Species	MSY	ABC	Landing[a/]	ABC	Projected Landings[b/]	ABC	Stock Condition	Abundance Trend
Flatfish								
Dover Sole	8,413	11,500	3,976	11,500	5,293	11,500	Above MSY	Declining
English Sole	2,000	c/	641	c/	729	c/	Unknown	Unknown
Petrale Sole	1,100	1,100	720	1,100	1,117	1,100	Unknown	Unknown
Remaining Flatfish[d/]	At least ABC	3,000	892	3,000	1,069	3,000	Unknown	Unknown
Rockfish								
Bocaccio	e/	e/	272	e/	171	e/	Unknown	Unknown
Chilipepper	e/	e/	1	e/	1	e/	Unknown	Unknown
Canary	2,100	2,100	892	2,100	1,063	2,100	Unknown	Unknown
Yellowtail	3-3,173	2,600	2,336	2,600	2,888	2,600	At MSY	Declining
Remaining Rockfish[h/]	At least ABC	3,700	2,304	3,700	826	3,706	Unknown	Unknown
Sebastes Complex[f/]	NA	8,400	7,011	8,400	6,464	8,400	Unknown	Unknown
Pacific Ocean Perch	1,000-1,500	950	714	0	607	0	Unknown	Unknown
Shortbelly	g/	c/	2	c/	0	c/	Unknown	Unknown
Widow	g/	c/	6,142	c/	8,109	c/	Unknown	Unknown
Unspecified	NA	NA	1,236	NA	1,515	NA	Unknown	Unknown
Thornyhead	NA	NA	521	NA	513	NA	Unknown	Unknown
Other Species								
Jack Mackerel	At least ABC	c/	0	c/	0	c/	Unknown	Unknown
Lingcod	4,000	4,000	754	4,000	761	4,000	Unknown	Unknown
Pacific Cod	NA	900	36	900	711	900	Unknown	Unknown
Pacific Whiting	g/	c/	480	c/	240	c/	Unknown	Unknown
Sablefish	g/	c/	4,957	c/	5,627	c/	Unknown	Unknown
Others	At least ABC	7,000	790	7,000	1,110	7,000	Unknown	Unknown

a/ Landings for 1986 are from Table 3.
b/ Projected landings for 1987 are the sum of January through August 1987, and September through December 1986. Data was obtained from the PacFIN system on September 21, 1987.
c/ Species managed on a coastwide basis. A coastwide ABC estimate is included in Table 13.
d/ Remaining flatfish consists of all flatfish except Dover sole, English sole, petrale sole, and arrowtooth founder.
e/ These species are not common nor important in the areas footnoted. Rockfish ABCs are included in the "Remaining Rockfish" category.
f/ Sebastes complex consists of all rockfish except Pacific ocean perch, shortbelly, widow, and thornlyhead rockfish.
g/ Data not available to calculate MSY for this area. A coastwide MSY estimate is included in Table 18.
h/ Includes sharks, skates, rays, ratfish, morids, grenadiers, and arrowtooth flounder.

SECTION I: SUBCATEGORIES

Subcategories: Salmon, Shellfish, and Marine Fish Resources Managed and Protected under Chapter 75 RCW by Geographic Area (Management Unit)

1. Salmon (all anadromous salmonids under the genus *Oncorhynchus* as regulated under WAC 220-12-010 Food Fish)

   a. Coastal rivers and harbors

      - Spring chinook *Oncorhynchus tshawytscha*
      - Summer chinook *O. tshawytscha*
      - Fall chinook *O. tshawytscha*
      - Summer coho *O. kisutch*
      - Fall coho *O. kisutch*
      - Chum *O. keta*
      - Sockeye *O. nerka*

   b. Columbia River

      - Spring chinook *O. tshawytscha*
      - Summer chinook *O. tshawytscha*
      - Fall chinook *O. tshawytscha*
      - Fall coho *O. kisutch*
      - Sockeye *O. nerka*
      - Chum *O. keta*

   c. Puget Sound

      - Spring chinook *O. tshawytsha*
      - Summer/fall chinook *O. tshawytsha*
      - Pink *O. gorbuscha*
      - Chum *O. keta*
      - Coho *O. kisutch*
      - Sockeye *O. nerka*

2. Shellfish (All public shellfish regulated under WAC 220-12-020 Shellfish)

   a. Coastal (Columbia River to Cape Flattery)

      - Razor clams *Siliqua patula*
      - Coastal Dungeness crab *Cancer magister*
      - Ocean pink shrimp *Pandalus jordani*
      - Willapa/Grays Harbor
        Japanese Oysters - *Crassostrea gigas*
        Olympia Oysters - *Ostria lurida*
        - Oysters: private, commercial
        - Ghost shrimp: commercial
        - Hardshell clams: commercial

b. Puget Sound and Straits

- Dungeness crab *C. magister*
- Red sea urchins *Strongylocentrotus franciscanus*
- Green sea urchins *Strongylocentrotus droebachiensis*
- Sea cucumbers *Parastichopus californicus*
- Geoduck *Panope generosa*
- Spot shrimp *Pandalus platyceros*
- Hardshell clams various
- a. Ghost shrimp (*Callianassa sp.*
  b. Mud shrimp *Ubogebia pugettensis*

3. Marine Fish - (All marine fish except salmon regulated under WAC 220-12-010)

a. Puget Sound

- Ling cod *Ophiodon elongatus*
- Pacific cod *Gadus macrocephalus*
- Walleye pollock *Theragra chalcogrammus*
- Pacific whiting *Merluccius productus*
- Spiny dogfish *Squalus acanthias*
- Surfperch *Embiotocidae*
- Flatfishes (excluding halibut) Pleuronectidae and Bothidae
- Pacific halibut *Hippoglossus stenolepis*
- Rockfish *Sebastes sp.*
- Surf smelt *Hypomesus pretiosus*
- Pacific herring *Clupea harengus pallasi*

b. Coastal

- Lingcod *O. elongatus*
- Pacific cod *G. macrocephalus*
- Pacific whiting *M. productus*
- Flatfish *Pleronectidae*
- Rockfish *Sebastes sp.*
- Sablefish *Anoplopoma fimbria*
- Jack mackerel *Trachurus symmetricus*

4. Miscellaneous

a. Coastal (Willapa Bay and Grays Harbor)

- Green sturgeon *Acipenser transmontanus*
- White sturgeon *Acipenser medirostris*
- Shad *Alosa sapidissima*

b. Columbia River

- *Green sturgeon A. transmontanus*
- White sturgeon *A. medirostris*
- Shad *Alosa sapidissima*
- Eulashon (Columbia River smelt) *Thaleichthys pacificus*

c. Puget Sound (none or minor numbers of these fish)

- Sturgeon
- Shad
- Eulachon

SECTION II: GENERAL DESCRIPTION - ABUNDANCE/DISTRIBUTION/LIFE HISTORY

Pacific Salmon (Coastal Columbia River and Puget Sound)

The following discussion of salmon first describes some of the characteristics common to five species of Pacific salmon, then provides species specific information, followed by a discussion of variances between species.

Salmon is a valuable fisheries resource in the state of Washington. Five species of Pacific salmon are produced in Washington streams and caught by sport, commercial, and Indian fishers in salt and fresh waters of the state. Pacific salmon have been assigned to the genus *Oncorhynchus* (meaning hooked nose) and are distinguished from the Atlantic salmon, *Salmo*, chiefly because the latter may spawn more than once, while Pacific salmon always die after spawning. Pacific salmon are anadromous; that is, they hatch in fresh water, migrate to salt water, attain most of their growth there, and then return to the fresh water streams to spawn. They have a well-developed homing instinct, practically all of them returning to spawn in their streams of origin. Spawning occurs in well-percolated gravel beds in streams where the fish bury the eggs to protect them from predators and from the elements. The eggs hatch in the gravel and the young fish live there for a time subsisting on the yolk material from the egg, which remains attached to the fishes belly. When the yolk is exhausted, early the following spring, the young fish emerge from the gravel to rear as juveniles or migrate downstream.

The chinook salmon, *Oncorhynchus tshawytscha*, is the largest species of the Pacific salmon. It averages about 20 to 25 pounds when mature, and is important throughout its range from northern California to Asia. Mature fish are usually three to five years old (measured from the time the egg is fertilized). Other common names for chinook are king, spring, tyee, and blackmouth.

The main spawning migrations takes place in the late spring and early fall. The early run, called spring chinook, spawns in the late summer; fall chinook spawn as soon as they reach their spawning grounds in the autumn. There is also a run of summer chinook. Females commonly bear about 5,000 eggs. The young fall chinook, after emerging from the gravel, feed a short time in the streams and then descend to saltwater. The bulk of the young spring chinook tend to remain in the streams an additional year before going to sea.

In the ocean the chinook migrate far up and down the coastline but generally tend to go north of their streams of origin. Thus, Sacramento river fish are taken off the Washington coast and Columbia River fish off Alaska. Many chinook of Puget Sound origin remain in the Sound throughout most or all of their saltwater existence and grow at a slower rate than do those in the open ocean. Young chinook feed on small invertebrates in fresh and salt water while larger chinook feed mostly on fish, particularly herring.

Washington's most important chinook-producing river system is the Columbia, which supports a large gill net and an important sport fishery.

Other Washington streams are of less importance.

The chinook reared in Puget Sound rivers form the basis for an extensive sport fishery inside the sound where most are taken as immature blackmouth. Large sport fisheries have developed in recent years in various coastal areas in Washington, such as off Cape Flattery and Grays Harbor. Chinook are adapted to rear in salmon hatcheries.

Coho salmon, *Oncorhynchus kisutch*, are also known as silvers or silversides. Coho average about 8 to 10 pounds when mature, and are important from northern California to Asia. Mature fish are mostly three years old in Washington, but a few may be two years old. The spawning migration from the sea occurs chiefly in September and October but may extend into December. Coho salmon spawn in virtually every stream in Washington, but are most abundant in small lowland streams and main river tributaries. Females bear about 3,000 eggs.

The young, after emerging from the gravel in the spring, remain in the streams to feed for a little over a year before migrating to salt water. Their migrations in the ocean cover less area than those of chinook but there is a considerable interchange between Washington and adjacent waters. Many coho of Puget Sound origin remain in the Sound through part or all of their lives, and like the chinook, grow much slower than those migrating to the open ocean. Small invertebrates are the principal source of food for coho salmon in fresh and salt water, although they consume considerable quantities of small fish in their final summer. Coho are adapted for rearing in salmon hatcheries.

Pink salmon, *Oncorhynchus gorbuscha*, also commonly known as the humpback salmon, averages 5 to 6 pounds when mature. It is commercially important from Puget Sound to Asia. Pinks invariably mature at two years of age and the spawning migration from the sea takes place chiefly in August and September. Although spawning usually occurs near the mouths of tributary streams, pink salmon often go well up into the larger rivers. Females bear 1,500 to 2,000 eggs. The young pinks, after emerging from the gravel in the spring, go immediately to salt water. The adults are caught almost exclusively in odd years in the Puget Sound area. Large odd and even-year runs coexist in more northerly areas such as northern British Columbia and Southeast Alaska.

The Dungeness, Stillaguamish, Skagit, Snohomish, Puyallup, and Nooksack watersheds are Washington's chief producers of pink salmon. Adult pink salmon are taken by sports fishermen throughout Puget Sound and the popular sport fishing areas of LaPush and in the Strait of Juan de Fuca. Commercial catches vary depending on year class strength and the abundance of Canadian Fraser River pinks.

Pink salmon vary from other species in Washington State in their cyclic pattern. They appear only in odd-numbered years, when as many as 9,000,000 have been caught commercially on Puget Sound. By contrast, the even years produce only a few hundred. The more northerly the latitude, the more evenly they are distributed between the even and odd-numbered years. Pinks are rarely found as far south as the Columbia. Pink salmon are not adaptable to rearing in salmon hatcheries.

Chum salmon, *Oncorhynchus keta*, are also known as dog or fall salmon. When mature, they average about 10 to 12 pounds. They are commercially important from Oregon to northern Asia. Mature fish are usually four years old in Washington, but some may be three to five years old. The spawning migration takes place chiefly in October, November, and December. Females carry 2,500 to 2,800 eggs. The young chum, after emerging from the gravel in the spring, go almost immediately to salt water.

Chum salmon are taken by purse seines and gill nets on Puget Sound. There is also a good sport fishery for chum of Nisqually River origin. They are taken exclusively with gill nets in the Columbia River and coastal harbors. Salmon hatcheries have had limited success in rearing.

Sockeye salmon, *Oncorhynchus nerka*, is also known as the red salmon in Alaska and the blueback salmon in the Columbia River. Its landlocked form is called the kokanee, redfish, or silver trout. Sockeye average about five to seven pounds in Puget Sound and three to four pounds on the Columbia River. The landlocked forms usually weigh less than a pound when mature. Sockeye are commercially important from the Columbia River to Asia. Mature fish are from three to six years old but four years is the predominant age. Female carry about 3,000 eggs.

The spawning migration from the sea occurs chiefly in June, July, and August and spawning takes place in streams flowing into lakes or in the lakes themselves. When the fry emerge from the gravel in the spring, they make their way to the lakes where the majority remain for a little over a year, feeding on minute invertebrates. Lake Washington boasts a major sockeye run, the object of an important summer sport fishery when adult escapement levels have been met. When this occurs, there may also be a limited Indian net fishery.

The Fraser River in British Columbia is the most important contributor of sockeye salmon to Washington commercial fishermen. Sockeye headed for this river are taken by purse seines, reef nets, and gill nets fishing in the San Juan Islands and at Point Roberts. The Columbia River also has a sizeable run of this species. Several other Washington rivers have smaller runs of sockeye. The sockeye has rich, red flesh and for this reason is highly prized. The Fraser River sockeye runs are under the jurisdiction of the International Pacific Salmon Fisheries Commission, an organization sponsored jointly by the United States and Canada. Sockeye are not adapted for rearing in salmon hatcheries.

Variances in the Life History of Pacific Salmon

Portions of the life history of the five species of Pacific salmon vary considerably between species. Variances are evident in spawning time and area, stream and ocean residence, age, migration patterns, etc.

Salmon inhabit specific ecological niches which, between species, are somewhat different. For instance, few pink salmon are found in streams south of Puget Sound; the abundance of chum salmon decreases sharply south of Willapa Bay, and the largest contributor of sockeye salmon with which Washington fishermen are concerned is the Fraser River in British Columbia. Even the timing of migrations through major fishing areas in Puget Sound varies not only between species, but also between areas.

Some streams contain all five species of salmon indigenous to the state of Washington, while others may contain only a single species. The Skagit River in northern Puget Sound, containing all five species, is an example of a stream in which the habitat is most fully utilized. The salmon runs there tend to overlap one another but essentially the spring chinook migrate into the river earliest while chum enter the latest. Chronologically, the springs enter the Skagit in May and June and spawn in the upper main stream and tributaries in mid-September. Sockeye enter the river mainly in June and July, enter Baker Lake in July and August and spawn in November. Coho salmon are the most protracted in time of all salmon utilizing the Skagit. This species enters as early as July and as late as November. Spawning usually commences in October and extends to late December in minor tributaries throughout the watershed.

Summer chinook and pink salmon migrate concurrently, entering the river during August and early September. Spawning peaks occur at essentially the same time - near mid-September. Chinook, however, use heavier gravel and deeper areas than do pink salmon, although some overlap occurs in the main stem of the river. Pink salmon also utilize portions of major tributaries in which chinook salmon seldom spawn.

Chum salmon are the least protracted in time of the salmon entering the Skagit. Chum enter the river during October and November and spawn in side channels, sloughs, or slow water areas close to the mouth of the river in December and January. (Anonymous WDF 1977)

Shellfish: Coastal

Razor clams, *Siliqua patula*, occur from California to Alaska and are a major species of importance on the Washington open coast.

Razor clams reach sexual maturity at two years on Washington beaches and spawn first in April or May when the water temperature rises. Just prior to spawning, clams are fattest and in the best condition for eating. The spawn ripens in the foot or "digger" of the clam and fertilization follows the discharge of eggs and sperm into the open water. For the next six weeks the young clams drift in the surf zone and off-shore waters or settle to the bottom. Finally, they "set" by digging into the sand and adopt the adult mode of living. At this stage they are extremely delicate and heavy mortalities may be caused by winter storms which wash them in windrows high on the beach. High natural mortalities are usually compensated for by the tremendous reproductive capacity of the species, whose females will develop six to 10 million eggs annually. Additional spawning may occur through summer and fall, and sampling for set clams has shown considerable variation in the success of reproduction between beaches from year to year. This causes natural fluctuation in clam abundance.

Washington razor clams grow from a length of ½-inch their first fall to 3½ inches the next. Digging them as one-year-old clams is poor utilization because as two-year-olds they will average from four inches (Long Beach) to 4½ inches (Copalis) in length and weigh three times as much.

Five inch clams are three to five years of age. Although the life expectancy for Copalis clams is eight years, heavy digging pressure accounts for harvesting clams mainly two and three years old. Life expectancy is highest in Alaska, 11-15 years, but growth is slower.

Studies by the Department have shown that growth is slower during winter, often resulting in a dark-ring or annulus on the shell. Months of fastest growth are March, April, and May. The rapid growth of razor clams explains their ability to keep pace with intensive exploitation. (Anonymous, WDF 1982) Change refernece to Doug Simons.

The Dungeness crab, *Cancer magister*, ranges in waters from San Francisco, California to the Aleutian Islands in Alaska.

Mating occurs between hard-shelled male crabs and newly molted, soft-shelled female crabs. Along the Washington coast, mating occurs chiefly in May and June, although it has been noted in other months of the year. Eggs are fertilized in the fall when they are laid or extruded to become attached to the abdomen of the female. Large females may carry in excess of 2½ million eggs. As the embryos develop during the winter, the eggs darken from bright orange to to a dirty brown before hatching into larval crabs between January and March. In no way resembling an adult crab at first, the larvae swim freely in the sea and progress through a series of molts in which their appearance changes considerably. Dense swarms of crab larvae are often seen in the water in the spring and are fed on extensively by other marine organisms, including salmon. Finally accepting adult configuration, the juvenile crab, about a quarter of an inch in width, takes up bottom residence most commonly in June, on the coast and August in Puget Sound about 12 months after mating. Large numbers of young crabs are found in estuaries where they can tolerate dilutions of 2 parts fresh water to 1 part ocean water. The Grays Harbor and Willapa Bay estuaries are considered unique "nursery" areas for Dungeness crabs and certain fishes such as English sole, with which they share the bottom environment.

Large commercial fisheries, using crab pots, fish for Dungeness crab off the Pacific Coast and the northern part of Puget Sound. Recreational crabbing is very popular in north and central Puget Sound and in Hood Canal.

Shrimp (Pandalidae)

All of the important shrimp in Washington belong to the family Pandalidae and have similar life cycles.

The initial egg development occurs in the ovaries during late summer. In the fall, shortly after mating, the eggs are extruded to the underside of the abdomen where they are fertilized by a packet of sperm, and then attached to specialized pleopods (swimmeretts). The developing eggs are carried by the female until they hatch in the spring. The hatching period for the various species of shrimp begins at the end of February and lasts through May, with the peak occurring about the beginning of April.

The newly hatched larvae are small (3/16 inch), planktonic (living off the bottom, and unable to make headway against the currents), and bear only superficial resemblance to the adults. Within three months, they molt (shed shell in order to grow) five or six times, gradually taking on the adult appearance and habit of walking or at least resting on the bottom.

The shrimp continue to grow with each successive molt and usually mature as males within 18 months after hatching. They function as males one or two seasons before transforming during a series of summer molts into females for the next fall's mating season. The life cycle is variable, in that part of one year class may change to females one year with the remainder changing a year or two later. The shrimp then function as females for one or two seasons before dying of old age during the spring or summer after the last eggs hatch. Some individuals will skip the male phase entirely and spend their entire life as females. (Northup, 1989).

Two species are particularly important in Washington. The large spot shrimp *Pandalus platyceros* supports a very popular sport fishery in Hood Canal. The small ocean pink shrimp *Pandalus jordani* supports a large commercial shrimp fishery in waters up to 25 miles off the Pacific coast.

The Japanese oyster, *Crassostrea gigas*, was introduced to many areas on the Pacific Coast long ago and is now so well established in some places that it looks like part of the natural fauna. It is, as oysters go, a giant; the length of very large specimens may exceed 25 cm. Normally, the left valve, which is deeper than the nearly flat right valve fitting into it, is partially or almost completely cemented to a hard substrate. As this species tends to settle on shells of its own kind, sizable clumps are sometimes built up. The shells are often grotesquely twisted and deformed, and no two specimens are quite alike. The fluting of the external surface is almost always prominent.

When summer water temperatures are favorable for spawning and normal development of larvae, the Japanese oyster reproduces naturally. Many commercial growers, however, periodically restock their beds in spring by importing young oysters ("spat") that have settled on empty shells ("cultch"). These shells, on arrival, are strung out from racks or floats in suitable situations, usually muddy tidal flats. The Japanese oyster will tolerate a salinity considerably lower than that of normal sea water, so it grows well in estuaries. (Kozloff 1973)

The Olympia oyster, *Ostrea lurida*, although it is widely distributed in our region, and along the Pacific Coast in general, it is common nowhere. Moderately successful cultivation of this species is at the basis of a rather esoteric industry, and it yields an expensive delicacy. The native oyster lives on the undersides of rocks, except in muddy places, where it will usually be on the upper sides of rocks. It is small, the length rarely exceeds 5 cm. The shell may be gnarled and eroded, but it does not often show flutings like those on the Japanese oyster. Externally, it is grayish, and internally it is usually a shiny grayish green or grayish olive color, with a touch of mother-of-pearl. (Kozloff 1973)

Ghost shrimp, *Upogebia pugettensis* and *Callianassa sp.*, are burrowing shrimp indigenous to and very abundant in Willapa Bay and Grays Harbor.

Willapa Bay contains approximately 42,000 acres. Of this area it is estimated that 10-12,000 acres are suitable for ghost shrimp.

Ghost shrimp are shrimp-like crustaceans. They live in the sediments, constructing and maintaining extensive burrow complexes. These burrows range from 10 to over 20 inches (250 to 500 mm) deep and usually have two or more openings to the surface. Ghost shrimp are characterized by a pale pink body with a large, broad abdomen. Mature adults range from 2 to 4 inches (51 to 102 mm) in length.

Ghost shrimp feed by continually digging in sandy sediments and accumulating detrital particles on appendage hairs. Since ghost shrimp prefer clean, well-sorted sand rather than muddier substrates, they must process a large amount of sediment (Bird 1982).

The principle breeding period for ghost shrimp in the Pacific Northwest is late spring and early summer. The exact time depends on when the water warms. McCrow (1972) found that ghost shrimp become inactive and retreat to deeper (below 500 mm) burrows when exposed to low temperatures. Bird (1982) found that female ghost shrimp mature and produce eggs at about 24 months in Oregon estuaries. Growth rates ranged from 15.7 mm to 22.4 mm per year depending on location.

Ghost shrimp are also subject to predation which may limit their lower range on the beaches during the summer (Posey 1985). Posey found that the stagehorn sculpin (*Leptocottus armatus*) was an important predator in summer months.

Bird (1984) found high biomass of this population was about 1.7 kilograms per square meter (kg/m^2) (3.1 $pounds/yd^2$ or 15,004 lbs/acre). Other Oregon estuaries sampled by Bird had smaller populations. Ghost shrimp populations decrease with distance from the estuary entrance.

Hardshell clams - Minor numbers, see Puget Sound "hardshell clam" section.

Clam seed can be purchased from hatcheries in California and Washington. The Fisheries Department is now evaluating the feasibility of using such seed for restocking beaches in Washington.

Butter clams, native little necks, and manila clams do best in beach substrates composed of pea gravel and shell mixed with mud and sand. Beaches composed entirely of mud and sand rarely support usable quantities of clams. (Anonymous WDF 1968)

Puget Sound and Straits

Hardshell clams belong to the group of animals called bivalves, which includes clams, mussels, oysters, and scallops. The soft body parts of these animals are enclosed between two shells; hence, the word bivalve. Bivalves are closely related to limpets, abalone, snails, slugs, squids, and octopuses. These animals, including bivalves, are collectively called mollusks.

Most bivalves reproduce by discharging sperm and eggs into the water where fertilization occurs. Some will spawn only when the water temperature reaches a critical level. The fertilized eggs develop into microscopic larvae, which are carried about by water currents for various lengths of time (usually three to four weeks) before setting, depending on the particular species and water temperatures. The larvae feed on miroscopic organisms called plankton, and most species, after developing to the advanced stage, settle on and attach to gravel, shell, or sand grains, then burrow into the bottom. In contrast, oyster larvae cement themselves to hard, clean surfaces such as rocks and shells.

Since larval clams spend a considerable amount of time drifting about in the water before settling, the location where a particular larva ends up may be many miles from its parents. Many people assume that, if they transplant adult clams to their beach, they will soon populate the beach with clams. If the transplants survive and spawn, the resulting offspring will likely be scattered for several miles. A successful set of young clams on any particular beach depends on a mass spawning of adult clams in a very large area, and on setting and survival on the beach in large numbers.

Dungeness crab - See discussion of Dungeness crab in "Shellfish/Coastal" section.

The red sea urchin, *Strongylocentrotus franciscanus*, is the largest sea urchin occurring on our coasts. It lives at shallow depths, typically from 5-10 meters; though it may also be found intertidally or at depths up to 125 meters. It is usually found on rocky substrates in zones of brown seaweeds and where the currents are moderate to swift. It is distributed from Baja, California, northward to Alaska, across the Aleutian Islands to the Asiatic coast, and as far south as southern Hokkaido, Japan.

Because of its abundance, large size, and gonad color, the U.S. and Canadian sea urchin fisheries are almost entirely dependent on this species. However, despite its commercial importance, *S. franciscanus* has been little studied. Most of the parameters that would be useful to know for fishery management are unknown or can only be hinted at from inadequate data.

The species spawns largely during the colder months of the year. Spawning has been recorded in December and January at Corona Del Mar, February through March at Pacific Grove, April and May at John Hopkins Marine Station, March and April in Puget Sound, and possibly June and July near Vancouver Island. The larvae are planktonic for about two months before settling to the bottom. The juveniles apparently do not select habitats that differ greatly from the adults. They may be "hidden in crevices of amongst kelp holdfasts in the high subtidal zone." The adults and juveniles are often found within a few inches of each other. Assuming that this is the most usual habitat for the juveniles, it appears that larval recruitment is sporadic. Miller (1974) could find no indication of significant settlement from the intertidal zones to a depth of 12 meters in the summer of 1974. (Mottet 1976)

The green sea urchin, *Strongylocentrotus droebachiensis*, the distribution of the green sea urchin is circumpolar. In the eastern Pacific, it is found as far north as Point Barrow, Alaska and southward to Washington State where it is the dominant sea urchin in Puget Sound. It occurs in the Aleutian Islands and westward to Kamchatka, Korea, and Hokkaido, Japan. In the north Atlantic it may be found on the East Coast of the U.S. and Canada, and in Greenland, Iceland, and northern Europe. It lives at water depths up to 70 fathoms, but more commonly it is found in shallower water up to about the low mean tide line. It prefers rocky, gravelly, or shelly substrates, but it may also be found on sandy or rarely muddy bottoms.

S. droebachiensis is well adapted to cold temperatures, and its northern limitation in distribution is determined by actual freezing of coastal waters. When these urchins are acclimatized, their activity levels are almost normal at temperatures of only 0 C (32 F). Also, perfectly normal larvae can be produced from eggs which were fertilized and growth entirely at -1.0 C (about 30 F). However, the larvae are very intolerant of warm water temperatures, and this probably determines the southern range for this species. the upper limit for normal larval development is 10 C (50 F).

This species spawns during the winter or early spring. At Cape Cod, spawning may occur from December through April, and the maximum period of fertility is from mid-March to mid-April. After that time, a rapid spawn-out occurs. The males are ripe nearly two months earlier than the females, and they remain ripe about a month later. (Mottet 1976)

Two of Washington's newest fisheries are dive fisheries for sea urchins and sea cucumbers. Two species of urchins are harvested - red and green. The red sea urchin fishery has been established for several years, while the green sea urchin fishery is relatively new. To assure a sustainable red sea urchin fishery, a new management program was recently implemented which rotates harvest areas annually and protects both large and small urchins.

The rapidly expanding size of the urchin harvesting fleet, from 11 boats in 1983 to 97 in 1988, continues to be the fishery's major problem and threatens the future stability of the urchin fishery. The only alternative to drastic cuts in the harvest season is a limit on the size of the fishing fleet. The 1989 Legislature placed a limit of 45 boats on the fishery. A stable fleet size, continued dive surveys to monitor the resource, and life history/research should provide a sustained, orderly fishery.

In 1986, a new fishery began for green sea urchins which are found in more sheltered areas of Puget Sound. The green urchins are smaller than red urchins but have a relatively larger gonad which is the object of the fishery. Green sea urchin harvest developed largely in response to low market prices for red urchins and has remained relatively small, landing 444,000 pounds during the 1987-88 season. The rapid development of this fishery has necessitated new management approaches and additional efforts to acquire necessary biological and population statistics for management. (Anonymous WDF 1988)

Sea Cucumber support a minor new fishery. Life history was not readily available in summary form for Washington species.

A small dive fishery exists for sea cucumbers. In 1987, harvest was from the San Juan Islands and totaled 280,000 pounds, only slightly above the nine-year average of this fishery. Eighteen vessels participated in the dive fishery; a limited beam trawl fishery was allowed in certain deep water areas.

Price competition among new buyers is driving the price of cucumbers up, and the size of the fishing fleet is beginning to swell. This increasing pressure will require far more intensive management, including periodic population surveys, perhaps via underwater video, catch monitoring at the processing plant, and continued life history studies.

WDF implemented a new management program in 1987 to provide a stable, long-term sea cucumber fishery. This program restricts harvest to summer months and rotates harvest among four fishing areas annually.

Sea cucumbers have been counted during geoduck dive surveys since 1986. This year the increased numbers of young cucumbers indicates that periodic closures are allowing repopulation of harvested areas. Monthly research dives began in October 1987 to gain more information about sea cucumber life history and seasonal changes in body condition. (Anonymous WDF 1988)

The geoduck, *Panope generosa*, has been surveyed by WDF since 1967. Although geoduck have been observed from the low intertidal zone to depths exceeding 360 feet, these surveys were limited to depths suitable for commercial harvest (between -18 and -60 feet). At this depth, geoducks were found to be abundant throughout Puget Sound - WDF surveys discovered 19,545 acres of "major" geoduck beds containing 280 million pounds of geoducks (a "major" geoduck bed is larger than 5 acres with more than 0.4 m^2 geoducks per square meter). Of this acreage, 8,378 acres were considered suitable for commercial harvest. An additional survey conducted by DNR of beds between -60 and -360 feet discovered 64.5 million pounds of geoduck, indicating that geoducks found within 18-60 feet are only a small portion of the total geoduck population in Puget Sound.

Geoduck attain sexual maturity in 3 to 4 years, reach a harvestable size of about 1.5 pounds between age 4 and 10, and live from an average of 38 to 57 years, and have been known to live up to 130 years.

Rate of growth and ultimate size of geoduck varies depending on location: north Puget Sound geoduck average two pounds and reach harvestable size in 8 to 10 years; geoduck in some areas of south Puget Sound attain average weights exceeding 3.5 pounds and reach harvestable size in 4 years. (Goodwin 1973 and progress reports)

Spot Shrimp: See discussion of shrimp in "Shellfish/Coastal" section.

Ghost Shrimp: See discussion of ghost shrimp in "Shellfish/Coastal" section.

Marine Fish: Puget Sound

Adult Lingcod, *Ophiodon elongatus*, prefer rocky bottom habitats with high current velocities. They are voracious feeders, preying upon other fish and some invertebrates. Prior to spawning in the winter, mature males establish territories in shallow, rocky habitats. Mature females lay an adhesive egg mass in crevices. Males guard the eggs until hatching and are extremely vulnerable during this time to capture by hook and line and spear gears. After a two to three-month pelagic stage, larval lingcod inhabit sandy, estuarine areas for about six months before moving to the adult habitat. Most lingcod are sedentary, but some segments of the stocks may be migratory. (Schmitt, 1989)

Pacific Cod, *Gadus macrocephalus*, Pacific cod range from Santa Monica, California to Chukchi Sea and are common in Puget Sound. The semi-demersal adults spawn benthic eggs in winter and early spring. The eggs are demersal and the larvae are pelagic (Garrison and Miller, 1982).

Walleye Pollock, *Theragra chalcogramma*, range from central California to the Bering Sea. The adults are demersal and pelagic spawning pelagically in winter and spring. Both eggs and larvae are pelagic (Garrison and Miller 1982).

Walleye pollock are a white-fleshed codfish that are abundant in Alaskan waters and form the basis of the distant-water bottomfish fisheries. In Washington, pollock are not as abundant and are on the southern end of their geographic range. Pollock inhabit mid-water and near-bottom environments and feed on small fishes and crustaceans. Pollock form spawning aggregations from March to April in localized areas in depths of 60 to 80 fathoms. Pollock in southern Puget Sound are caught by fishers on charter boats and other recreational anglers. In northern Puget Sound, large schools that usually live in British Columbian waters occasionally move south of the border and become available to commercial trawlers during the winter. In other areas of Puget Sound, smaller quantities of pollock are landed incidentally in other commercial and recreational fisheries. (Schmitt 1989)

Pacific Whiting, *(Merluccius productus)*, also commonly known as hake, is one of the most abundant fishes in Puget Sound. This mid-water species forms dense spawning aggregations at specific locations in late winter. By far, the largest aggregation occurs in central Sound, especially at depths between 55 and 80 fathoms in Port Susan. Whiting may be found in shallow water at night during the summer. They feed on shrimps and small fishes. Puget Sound whiting is considered a discrete population from the coastal whiting.

The spawning aggregation in central Sound supports a large commercial pelagic trawl fishery, which accounts for nearly 100 percent of the whiting catch in Puget Sound. Occasionally, significant amounts of whiting have been taken by the bottom trawl fishery in the Gulf-Bellingham region. Whiting is also a popular target for a shore-based recreational fishery during the summer, although catches are insignificant compared to commercial catches. (Schmitt 1989)

Pacific whiting occur from California to Alaska and are common in Puget Sound. The adults are semi-demersal (near the bottom) and pelagic spawners during winter and spring. Eggs and larvae are pelagic (Garrison and Miller 1982).

The Spiny Dogfish, *(Squalus acanthias)*, is a very slow-growing and long-lived species of shark that is abundant in all regions of Puget Sound. They feed on a wide variety of fish and shellfish and may form feeding schools where food is abundant. Mature females produce 2 to 20 live young after a gestation period of about two years. Spiny dogfish in Puget Sound may be part of a larger population inhabiting inside marine waters of Washington and British Columbia. (Schmitt 1989)

Surfperch, Family Embiotocidae. Pileperch and striped seaperch are the primary surfperch species harvested in Puget Sound. They are abundant around pilings, reefs, and shore areas, and seldom occur deeper than 150 feet. Pile perch feed in schools on barnacles, small clams, and mussels associated with their habitat. Striped seaperch feed mainly on amphipods, polychaete worms, and crab larvae. Surfperch give birth to a relatively small number of fully-developed live young in late spring. Little is known of their migratory behavior, but surfperch tend to move into deeper waters in the fall, remain there during the winter, and return to shallow waters in the spring and summer.

The life history of surfperch makes them particularly susceptible to harvest by commercial drag seine and recreational anglers, and most of the harvest is by these gears. This vulnerability, extreme during the spring and summer months during the spawning period, has been a primary concern in the management of surfperch. The majority of the catch at this time of year is composed of females. (Schmitt 1989)

Flatfish - (Pleuronectidae and Bothidae): A variety of flatfish species inhabit Puget Sound, but seven species comprise most of the commercial catches. These seven species include English sole, starry flounder, rock sole, Dover sole, and sand sole, butter sole, and arrowtooth flounder. In addition, sanddabs are important to the shore-based recreational fisheries. Pacific halibut is also an important flatfish in Puget Sound but it is not managed by the Washington Department of Fisheries and therefore, is not included in this section.

All flatfish live on the bottom, although each species prefers a specific depth interval and/or substrate type. English sole is the most abundant species of flatfish in Puget Sound. It occurs over flat bottom, mainly at shallow depths during the summer and up to 70 fathoms during the winter. English sole feed on bottom-dwelling invertebrates. Males seldom appear in commercial landings because only a small percentage grow to marketable size. Mature females spawn pelagic eggs. Tagging studies in Puget Sound indicate that most English sole remain within the area of capture although migrations to other areas are common. Rock sole are abundant in northern areas and common elsewhere in Puget Sound. This species usually inhabits flat, soft bottom at depths less than 20 fathoms. Rock sole migrate very little and feed on invertebrates and small fish. Their eggs are demersal and adhesive. Starry flounder is the most abundant shallow-water flatfish in Puget Sound. This species occurs over soft bottom and prefers brackish bays. Adults feed on crustaceans, molluscs, and small fish. Starry flounder do not migrate extensively and mature females spawn pelagic eggs. Dover sole is common or abundant in all areas of Puget Sound, except Hood Canal. This species inhabits flat, sand, or mud bottom at depths greater than 50 fathoms, and feeds on burrowing invertebrates. Sand sole is common to abundant in most regions, and usually inhabits shallow, flat, sandy bottoms, and feeds mainly on fish, shrimp, and worms. It also spawns pelagic eggs. Little is known about the life history of other flatfish species in Puget Sound. (Schmitt 1989).

Pacific Halibut, *(Hippoglossus stenolepis)*, range from southern California to Norton Sound but are uncommon in Puget Sound. The demersal adults spawn in winter. The eggs and larvae are pelagic. (Garrison and Miller 1982)

A variety of rockfish species, *Sebastes sp.*, inhabit Puget Sound, but eight species comprise most of the commercial and recreational catches. These eight species include black, bocaccio, brown, canary, copper, quillback, yelloweye and yellowtail rockfish. Rockfish are generally found on or near rocky habitat. Copper, quillback, and brown rockfish are generally found in shallow water, near kelp or rocky habitat, whereas canary and yelloweye rockfish occupy rocky habitat at depths greater than 20 fathoms. Bocaccio occur in localized areas characterized by steep dropoffs to 50 fathoms, and black and yellowtail rockfish form pelagic schools around kelp or rocky habitats. Although the particular diet of each species differs, rockfish in Puget Sound feed on a variety of small crustaceans, molluscs, and fish. These rockfishes also show a diversity of life history patterns in Puget Sound. They are relatively long-lived, grow slowly, and bear live young (Schmitt 1989).

Surf smelt, *(Hypomesus pretiosus)*, range from southern California to the Gulf of Alaska and are common in Puget Sound. The adult are pelagic and spawn on sand, gravel beaches very high in the intertidal area. They spawn almost throughout the year in various areas of Puget Sound and Hood Canal. There is also spawning in the Straits of Juan de Fuca and a small population on the Washington coast near Kalalock.

The surf smelt is widely distributed in Puget Sound. It provides a popular sport fishery as it schools and spawns along the spawning beaches, in addition to providing a limited commercial harvest in localized areas. It also provides forage for salmon and other fish of sport and commercial importance.

Surf smelt deposit their eggs on the surface material in the upper intertidal zone of certain gravel beaches. This characteristic has made the species extremely vulnerable to man's encroachment onto beaches, and as a result, significant portions of important spawning beaches have been lost. Preservation of the rather unique and vulnerable spawning habitat of the species is the only assurance of continual reduction. (Anonymous WDF 1974)

Pacific herring, *(Clupea harengus pallasi)*, commonly occur throughout Puget Sound and support commercial fisheries primarily for bait and roe (eggs). The adults generally spawn in late winter to early summer, depending on geographic areas and different stocks. The adults are free swimming and have a schooling behavior. Herring in Puget Sound are near-shore spawners usually spawning on various marine vegetation (eelgrass, attached macroalgae) between the plus 3 foot to minus 20 foot tidal elevation (MLLW = 0.0'). The eggs hatch in a few days to about two weeks, depending on temperature and the larvae are pelagic (Aldirdice and Nelson, 1971).

Marine Fish: Coastal

The natural history of the following marine fish in coastal waters is similar to those previously described for Puget Sound: rockfish *Sebastes sp.*, surf perch - *Embiotocidae*, flatfish - *Pleuronectidae*, Pacific cod - *Gadus macrocephalus*, surf smelt - *Hypomesus pretiosa*, lingcod - *Ophiodon elongatus.*

Two marine fish/coastal species not covered in the Marine Fish/Puget Sound discussion, sablefish and jack mackeral, are described below.

Sablefish, *Anoplopoma fimbria*, range from Baja California to Berring Sea and are common in Puget Sound. The pelagic adults spawn at unknown depths but the time of year is not known in this area. The larvae are pelagic (Garrison and Miller, 1982).

Jack mackeral, *(Trachurus symmetricus)* are caught in the fisheries but little available life history information is available for Washington. In California spawning occurs between February and May. The eggs are pelagic (Hart, 1973).

Miscellaneous

White and green sturgeon, *Acipenser montanus and A. medirostris)*: occur in Washington. Both species range from northern California to northwestern Alaska, but white sturgeon center on the Columbia River. Small populations exist in Grays and Willapa harbors. The white sturgeon is one of the largest freshwater fishes in the world and the largest in North America. One specimen taken on the Pacific coast weighted 1,800 pounds. The green sturgeon is a smaller relative, reaching a maximum of seven feet and having inferior quality flesh.

The female sturgeon matures between 15 and 20 years of age. At this time they weigh approximately 100 pounds and are about six feet long. The males mature earlier and do not grow to the size of the females. Spawning occurs in late spring though not every year. The slow growth of these fish and relatively great age at maturity requires that they be more rigidly protected than some other commercial fish. Fishery regulations protect fish less than 36 inches and over 72 inches in total length, the latter because of their enormous egg-bearing potential.

Sturgeon are long-lived, slow growing, and slow to mature. White sturgeon, which have a life span of around 100 years, grow an average of three inches per year. Females do not generally mature until they reach nearly six feet in length (about 20 years of age), and the number of eggs carried increases with age and size. Males tend to mature somewhat earlier. Once initial spawning has occurred, sturgeon do not spawn annually, but at increasing intervals over time.

Two of North America's 23 sturgeon species, the green and the white sturgeon, are native to the Columbia River. These prehistoric creatures evolved 100-200 million years ago and have remained relatively unchanged since that time.

The green sturgeon is primarily a marine species, inhabiting the brackish waters of the estuary and the lower reaches of the Columbia River.

The Columbia River supports the largest of the Pacific coast white sturgeon stocks, except above Bonneville Dam where dams have created landlocked and often remnant populations.

The white sturgeon, the largest of the North American sturgeons, is found along most of the Pacific coast in both marine and fresh waters. (WDF I and E section 1989)

American Shad, *(Alosa sapidissima)*, are an introduced species native to the Atlantic Coast to the Pacific Coast in the late 1800s. Averaging about 30 inches long, shad are anadromous (spawn and incubate eggs in fresh water; live much of their life in salt water) like Pacific salmon.

Shad spawn at night and the fertilized egg sinks to the bottom where they incubate from three to six days. After hatching, the young drift downstream.

Shad are most abundant in the Columbia River between May through July and are an under-utilized species of food fish in Washington State. There is also a small population in the Chehalis River. (WDF E and I section 1989)

Eulachon (Columbia River Smelt), *Thaleichthys pacificus*, locally is called eulachon, holligan, oolichon, or candlefish. Their oil once was used by Indians for candles.

Most smelt spawn and die at the age of three years, although recent studies indicate that 20 to 30 percent of a run may be composed of four-year-old fish. The eggs are deposited and fertilized in the water by mass spawning over a river bottom of fine pea-sized gravel. The eggs adhere to the bottom, and hatch into minute, almost invisible, fry after an incubation period of about 30 days. The fry are carried by the river current seaward and are fed en route by the yolk material stored adjacent to the stomach. In the ocean, the smelt feed on minute organisms which they strain from the waters by means of filamentous gills, and in turn are fed upon by rockfish, cod, sharks, and other fishes.

Upon reentering fresh water as adults, the female smelt are silvery, smooth bodied fish capable of carrying more than 25,000 eggs. The males exhibit an external roughness comparable to fine sandpaper, and are normally dark green on the back. Smelt migrate in schools at speeds up to 25 to 35 miles per day. (WDF I and E section 1989)

SECTION III: KEY INDICATORS

The definition of "Key Indicator," in the context of this report, is limited to the unit-of-measure used to measure species abundance and/or population strength in the "Historical/Current Status," and "Future Status" sections of this report.

Several methods, in addition to these described below (such as stream surveys and tagging studies), are used as tools by fisheries personnel to determine health of the fisheries resources.

Salmon: Coastal, Puget Sound and Columbia River

For this section, fish abundance was estimated using Washington commercial harvest as an index and general knowledge of the authors (Sekulich and Edie 1989)

Shellfish Coastal

Razor clams population levels, survival, spawning success, and recruitments are measured by taking multiple population censuses each year in conjunction with monitoring (since 1983) the level of a newly discovered disease organisms known as NIX. Fisheries also monitors the recreational fishery very closely to determine levels of harvest. Often, the population shows what we consider abnormal losses of clams that exceed harvest and natural mortality. Fisheries also monitors the presence and relative number of juvenile clams that recruit onto the intertidal beaches. Lack of such setting is usually indicative of a year class failure for reasons not understood.

The historical trends used are the comparative population levels, the total harvest per year and our inability to improve recreational opportunity through longer seasons or larger limits. Since 1983, the levels of the NIX infection correlated with the subsequent loss of clams, have also been used. (Northup 1989)

Pink Shrimp: Key indicators used to characterize the ocean pink shrimp status are sex, total landings, catch per hour of towing (CPUE), and level of effort (vessels in the fishery).

Oyster production: Indicators of the status of the Pacific oyster resource of Willapa Bay and Grays Harbor is the pounds of oysters landed.

Hardshell clams are measured by commercial landings.

Ghost Shrimp: Rough estimates of ghost shrimp abundance were derived from burrow counts on the coast and actual counts in Puget Sound.

Shellfish Puget Sound and Straits

Dungeness Crab: Condition of the resource is based on pounds landed in the commercial fishery and pounds per landing and crab condition (molt softshell).

Sea Urchins: Catch data (fish tickets and harvest logs) were used to represent current sea urchin abundance along with pre-season diving surveys.

Sea Cucumbers: Indicators of resource strength include catch per unit effort data from harvest logs and sea cucumber counts from urchin and geoduck dives.

Geoduck: Key indicators for geoduck are catch data and total poundage available along with pre-season dive surveys.

Spot Shrimp: Key indicator is pounds per pot, a relative index of stock abundance obtained from Washington Department of Fisheries test fishing.

Hardshell Clams: The estimate of the current status of hardshell clams is based on commercial hardshell clam landings.

Marine Fish Puget Sound

Lingcod: The catches and catch rates by recreational anglers, as well as commercial catch numbers, are indicative of lingcod stock condition in most regions. Ling cod tagging programs are also used for population information.

Pacific Cod: Stock condition for Pacific cod is measured by the landed catch from commercial and recreational fisheries. Limited tagging.

Walleye Pollock: Since the walleye pollock stock in northern Puget Sound is primarily a Canadian stock, it is not assessed by Fisheries. For the southern Puget Sound stock, total catch from all fisheries is used as an index of stock abundance.

Pacific Whiting: Fish abundance is estimated by analyzing data collected during weekly research surveys.

Spiny Dogfish: Fish abundance is estimated by using commercial catch data, and Canadian stock assessments that utilize catch and effort data from Washington's inside waters.

Surfperch: Estimates of fish abundance are based on catch rate.

Flatfish: The condition of the flatfish resource is usually measured by the catches and catch rates of key species in the commercial bottom trawl fishery. English sole, starry flounder, rock sole, and Dover sole are the key species assessed. In addition to the fishery measures, stock abundance in Puget Sound is currently being measured on research trawl surveys.

Rockfish: Currently, WDF relies primarily on fishery catch and effort trends to generally monitor stock condition along with some tagging effort.

Pacific Herring: The herring resource is measured by monitoring the abundance of spawning fish in a stock, usually referred to as spawning biomass, which is the key indicator in herring management. In Washington State herring abundance is estimated on specific spawning grounds during the spawning season (January-June) using two methods; nearshore spawn (egg) deposition surveys, and hydroacoustic-trawl surveys of prespawner holding areas. Occasionally, Fisheries attempts to estimate the abundance of juvenile herring, however, it is difficult to quantify due to migration and mixing of herring stocks in the juvenile stage. In Washington State monitoring spawner herring abundance is relatively new, having been done only since 1972. (Schmitt 1989)

Surf smelt: Spawning ground surveys and landings.

Marine Fish - Coastal (includes all coastal groundfish managed by Fisheries): Washington's coastal groundfish are managed under a coastwide management process through the Pacific Fishery Management Council (PFMC). As part of this process, stock assessments are conducted by state and federal personnel. The results of these assessments, with recommendations for management, are reported annually in a PFMC "Status of Stocks" document (PFMC 1988).

We measure the condition of the coastal groundfish resource by conducting stock assessments of the species most abundant in the commercial catch. The sophistication of these assessments varies by species depending largely on the amount and quality of biological information available. The least sophisticated assessments are conducted by simply examining catch and catch per unit effort trends over time. More sophisticated assessments incorporate knowledge of the population age structure. The goal in stock assessments is to provide an estimate of Maximum Sustainable Yield (MSY) from which managers set in Acceptable Biological Catch (ABC). (Millikan 1989)

SECTION IV: HISTORICAL AND CURRENT STATUS

Salmon: Coastal, Puget Sound and Columbia River (Sekulichand Edie 1989) The salmon resource is relatively stable, with the last four 12-year averages ranging from 5.4 million to 6.3 million fish (Table 1). This general conclusion is based upon the harvest data shown in Table 1, below. Harvest data however, obfuscates some of the more interesting issues and trends in salmon resource management.

First, it must be recognized that harvest is the most reliable indice of the health of the resource, but it is only a surrogate for abundance. Unfortunately, the science of estimating abundance (the total number of fish existing at any one time) is subject to a number of variables and therefore must be considered imprecise. Assumptions about harvest distribution, mortality, and escapement all may alter the final abundance estimate, particularly at the stock level. All estimates of abundance used in this section are subject to these variables and should be weighed accordingly.

In addition to the problems inherent in abundance estimating, insufficient data is a major concern for proper management of a number of fisheries. This is true because management of the salmon resource is based upon allocations. If adequate data on fish populations does not exist, allocation decisions may be flawed, with potentially disastrous results for the fishery. Despite the crucial role data plays in the management of the fisheries resource, professional managers and environmental advocates report that the Washington State Legislature has been reluctant to fund basic data enhancement initiatives.

While harvest data suggest that the total population of salmon remains stable, variations do exist at the species and run level. Abundance estimates for Skagit River coho, for example, reveal an 81 percent increase when the years 1985 and 1988 are compared. In contrast, comparison of the same years for Hood Canal coho reveals a 49 percent decline in abundance (Pat Patillo, WDF, 1989). While it is not perfectly defensible to draw conclusions based upon the comparison of two years data, in the case of the Skagit the increase was accomplished in spite of low escapement and other adverse factors.

The public's perception of salmon abundance has been dramatically impacted by court decisions which have altered the location of the salmon harvest. Federal court decisions forced a reduction in the harvest of salmon along the Washington coast. This, in turn, had the effect of bringing large numbers of sexually mature salmon to waters inside Puget Sound. Sexually mature salmon are less susceptible to hook and line fishers when close to their river of origin.

The total harvest of salmon, however, remains stable or rising. The point of harvest has shifted to Puget Sound, where native Americans have better access to fish to fill their treaty allocations, using primarily net gear. This represents a significant change in Washington State fisheries economics and coastal sportfishers were among the most heavily impacted.

In recent years the issue of overfishing has come to the forefront of concern for salmon fisheries managers. The fact is that overfishing is not currently taking place in Washington waters. What is taking place, however, is the overcapitalization of the fishing fleet (e.g. too many boats and too much sophisticated electronic equipment). This overcapitalization means that the threat of overfishing is always present for fishery managers.

In the future, Washington's salmon fishing community could face resource competition from Alaska fishers and from salmon taking on the high seas.

Under terms of federal law, U.S. fishers have the first right to fish in U.S. waters. This allocation is made without regard to state of origin. As a result, it is possible for the highly efficient Alaska on-water processors to appear off Washington's coast and take fish from the territorial waters of the U.S.

Recent information indicates an additional concern as a result of the high seas drift net fishery operating in the North Pacific. Currently, the U.S. and the USSR are working together to prevent the taking of salmon by the drift net fishers.

As shown in Table 1, after the low of 5.4 million for 1963-1974, the salmon catches rebounded to 6.2 million, which approximates those during 1939-1962. Thus, harvest data do suggest a stable salmon resource.

Shellfish Coastal (Northup 1989)

Razor Clams: The razor clam population has been in a general state of decline for the last 10 years. The populations were further decreased by the onset of a previously unknown disease organism in 1983. Since that time, the populations have been very unstable and unpredictable, in what appears to be a continuous state of decline, with some exception.

Major fluctuations have occurred with population levels, survival of year classes (mostly related to results of disease) and successful spawning and recruitment of new year classes.

Dungeness Crab: As is typical of many crustacean species, Dungeness crab year-class strength (i.e., survival) is primarily determined by the environmental conditions encountered during the larval and early post-larval stages. Consequently, large fluctuations in abundance occur. Seasonal harvest by the commercial fishery since 1950 has averaged 7.5 million pounds but has ranged from a low of 2.5 million pounds to a high of 18.4 million pounds. After eight consecutive seasons of below-average catches, the fishery produced 16.25 million pounds last season and has produced more than 18.0 million pounds through April 1989.

Table 1
WASHINGTON COMMERCIAL SALMON HARVEST
(source: 1986 Fisheries Statistical Report, p. 19)

YEAR	HARVEST OF SALMON	12 YEAR AVERAGES	
1939	6,795,000		
1940	3,417,000		
1941	7,267,000		
1942	5,500,000		
1943	3,184,000		
1944	1,980,000		
1945	8,821,000	6,282,33	1939-1950
1946	6,392,000		
1947	12,360,000		
1948	4,113,000		
1949	11,215,000		
1950	4,344,000		
1951	9,850,000		
1952	4,629,000		
1953	10,526,000		
1954	6,973,000		
1955	8,394,000		
1956	3,222,000	6,047,750	1951-1962
1957	6,843,000		
1958	7,385,000		
1959	6,389,000		
1960	2,102,000		
1961	3,762,000		
1962	2,498,000		
1963	9,311,000		
1964	2,314,000		
1965	3,801,000		
1966	3,906,000		
1967	8,099,000		
1968	3,144,000	5,410,083	1963-1974
1969	4,241,000		
1970	4,065,000		
1971	8,378,000		
1972	3,865,000		
1973	8,092,000		
1974	5,705,000		
1975	5,834,000		
1976	5,103,000		
1977	7,099,000		
1978	4,693,000		
1979	8,632,000		
1980	3,900,000	6,175,417	1975-1986
1981	7,687,000		
1982	6,218,000		
1983	4,235,000		
1984	3,851,000		
1985	10,332,000		
1986	6,521,000		

Table 12 below presents the numbers of fish compared to the potential, according to best professional judgment, and postulates recent and future trends.

Table 12 - Salmon Potential

	Nos. of fish compared to potential	Recent & future trends
Coastal Rivers and Harbors		
spring chinook	Low	Improving
summer chinook	Low	Improving
fall chinook	Mod. to high	Improving
summer coho	High	Stable
fall coho	Very low to high	Stable
sockeye	Low to mod.	Stable
chum	High	Stable
Columbia River		
spring chinook	Very low to high	Stable to improving
summer chinook	Low	Stable
fall chinook	Mod. to high	Stable
sockeye	Low to mod.	Improving
chum	Negligible	Stable

	Nos. of fish compared to potential	Recent & future trends	Comments
Puget Sound			
spring chinook	Very low to low	Improving	2-3% of Puget Sound chinook
summer/fall chinook	Moderate to high	Stable	
pink	Low to high	Improving	
chum	Moderate to high	Improving	Inversely related to pink
coho	Moderate to high	Stable to improving	
sockeye	Low to moderate	Variable	Freshwater and marine factors have significant influence

Shellfish Coastal (Northup 1989)

Razor Clams: The razor clam population has been in a general state of decline for the last 10 years. The populations were further decreased by the onset of a previously unknown disease organism in 1983. Since that time, the populations have been very unstable and unpredictable, in what appears to be a continuous state of decline, with some exception.

Major fluctuations have occurred with population levels, survival of year classes (mostly related to results of disease) and successful spawning and recruitment of new year classes.

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Table 13
WASHINGTON COAST COMMERCIAL DUNGENESS CRAB FISHERY
DATA
1967-1988

Season	Lbs. Landed	No. of Vessel	No. of Landings	lbs per Boat
1967-68	10,789,893	70	4,163	154,141
1968-69	18,433,896	97	5,474	190,040
1969-70	17,745,643	138	7,376	128,592
1970-71	12,552,037	*	5,721	*
1971-72	9,199,701	173	6,200	53,177
1972-73	4,339,221	147	5,153	29,519
1973-74	3,633,958	129	4,378	28,170
1974-75	5,199,105	127	4,850	40,938
1975-76	8,516,055	138	5,580	61,711
1976-77	11,673,995	141	5,599	82,794
1977-78	7,368,660	135	5,616	54,583
1978-79	7,979,403	135	5,493	59,107
1979-80	6,546,544	123	4,556	53,224
1980-81	2,689,142	105	3,470	25,611
1981-82	2,564,766	95	3,524	26,998
1982-83	3,972,555	102	4,693	38,947
1983-84	4,696,701	123	5,323	38,185
1984-85	2,921,078	110	4,319	26,555
1985-86	3,946,552	100	4,145	39,466
1986-87	3,183,112	104	4,021	30,607
1987-88	16,250,000	140		116,071
1988-89	*18,500,000	200		92,500

*This is preliminary through April 1989.

The resource is healthy despite heavy fishing exploitation and the activities of man in the estuarine environment. Fishery regulations ensure protection of a breeding stock by prohibiting the harvest of female and male crabs smaller than 6¼ inches in shell width except that six inch males may be taken in Hood Canal.

The commercial fishery takes approximately 99 percent of the available resource each season.

Pink Shrimp: The abundance of pink shrimp fluctuates widely according to year class strengths. The resource has recovered somewhat from low CPUE averages which began in 1979 and persisted until a modest upturn in 1983. Landings, influenced by fishing effort, have been increasing since 1984. The number of vessels in the fishery has generally increased since 1973, but continues to be influenced by shrimp price and abundance.

The ocean pink shrimp resource appears healthy, but probably poised for a decline in production. The landings of 1986, 1987, and 1988 exceed any other landing total by 30 percent or more, the catch per hour of towing is relatively low, and the fleet size large (see Table 14).

Oysters: Oyster culture is one of the major industries in southwest Washington and has increased in relative importance following declines in the timber and fishing industries. The broad tidelands and rich waters of Willapa Bay and Grays Harbor offer ideal conditions for culture of Pacific oysters. Oyster culture began in these bays with harvest of Olympia oysters during the mid-1800s. Pacific oyster culture began in the 1930s after introduction of Japanese oyster seed. Annual harvest from the bays reached 1.2 million gallons during World War II. Total Washington production peaked around 1955 and declined through the mid-1970s. In 1976, Willapa Bay and Grays Harbor production reached its historic low at only 263,000 gallons. This decline was due in part to competition from imported oysters. Recently, production has increased slightly and averages 350 to 400 thousand gallons per year from the coastal bays.

As oyster production declined, growers reduced their operations and concentrated on the most productive grounds. Currently the center of the industry is the 2,500 or so acres of fattening ground. Consequently, large areas of potential culture ground remains available. Although productivity in Willapa Bay has generally declined (Westley 1962), significantly increased production is possible if market conditions improve.

Oyster culture has traditionally been Willapa Bay's principal marine fishery. Native oysters covered intertidal and shallow subtidal areas before 1850. These stocks were drastically reduced by over harvesting and competition from introduced species (Hedgpeth and Obrebski 1981, COE 1976, Shotwell 1977).

Table 14
WASHINGTON OCEAN PINK SHRIMP FISHERY
LANDINGS, CPUE, VESSELS, AND FOUR YEAR AVERAGE

Year	Landings lbs.	CPUE lbs/hr	Vessels	Four Year Average Landings	Four Year Average CPUE	Four Year Average Vessels
1957	2,384,000	737	12	3,409,750	494.5	18.5
1958	6,531,000	470	33			
1959	2,943,000	462	18			
1960	1,781,000	309	11	3,409,750	494.5	18.5
1961	1,437,000	433	8			
1962	1,367,000	362	10			
1963	965,000	466	5			
1964	314,000	384	3	1,020,750	411.3	6.5
1965	23,000	168	2			
1966	283,000	598	2			
1967	1,029,000	628	4			
1968	1,164,000	628	3	624,750	505.5	2.8
1969	1,425,000	630	14			
1970	925,000	557	7			
1971	678,000	495	4			
1972	1,582,000	944	6	1,152,500	656.5	7.8
1973	5,271,000	738	11			
1974	9,325,000	637	17			
1975	10,167,000	610	20			
1976	9,261,000	590	21	8,506,000	643.8	17.3
1977	11,803,000	639	21			
1978	12,297,000	486	32			
1979	12,135,000	284	49			
1980	12,629,000	210	88	12,216,000	404.8	47.5
1981	10,055,000	196	66			
1982	4,999,000	150	35			
1983	5,656,000	105	56			
1984	3,423,000	140	20	6,033,250	147.8	44.3
1985	9,118,000	338	27			
1986	17,446,000	318	65			
1987	15,893,000	291	56			
1988	18,200,000		53	15,164,250	315.7 *	50.3

* 1988 CPUE Not Included

Current Status (coastal): Presently, only the Pacific oyster from Japan is commercially cultivated extensively. For many years, Japan was the only source of oyster seed, but local sources have been developed in the Northwest. A number of oyster hatcheries operated in Willapa Bay, and hatchery-reared foreign and domestic seed is being tested for growth and disease resistance (Wilson 1984, Weigardt 1984). Also, Fisheries manages 10,000 acres of oyster reserves in Willapa Bay that provide natural oyster seed. The Fisheries shellfish laboratory at Nahcotta on the Long Beach Peninsula manages and conducts research on oysters and other shellfish species.

The major change in the oyster industry occurring in the past ten years has been the development by private industry of the oyster hatchery and remote spat setting. This means oyster growers are no longer dependent upon Japan as their primary seed source and provides stability that natural seed production does not.

Approximately 37,000 acres, 85 percent of the tidelands in the bay, are classified as oyster lands by Pacific County. Of this, only 2,500 acres produces market quality oysters to support the industry (Tufts 1985). The industry and Pacific County classify this ground as high quality "growing" and "fattening" ground. It is the only area where oysters will fatten to market standards. Some oyster seed is planted on this ground and grown to market size. Also, one or two year old oysters are moved here from other ground to fatten prior to harvest. The annual Willapa Bay oyster production requires harvest of 800 to 1000 acres of fattening ground each year.

Oyster production from Willapa Bay is compared with the total Washington production from 1975 through 1984 in Table 15. Willapa Bay produces about 50 percent of Washington's total oyster harvest.

Table 15. Willapa Bay Pacific Oyster Landings.
(Landings and values of oyster meats in thousands)

		Landings		
Year	Pounds	Gallons	Value	Percent of Total
1975	2,301	263	$2,867	48
1976	2,459	281	3,167	45
1977	2,997	344	4,317	49
1978	3,328	380	5,540	58
1979	3,080	352	5,924	50
1980	2,820	322	5,593	54
1981	3,135	358	5,513	55
1982	3,091	353	5,535	51
1983	2,351	269	4,932	42
1984	2,651	303	5,845	42
10 yr. Average	2,849	326	4,923	49

Date provided by WDF.

Grays Harbor: In contrast to the 35,000 acres designated as oyster lands in Willapa Bay, about 600 acres are used in Grays Harbor for oysters (T. Hayes 1984, Morris 1984). Of this about 50 percent is owned by a single company. This 600 acres is less than 2 percent of the total tidelands in Grays Harbor. Table 16 summarizes the production of oysters in Grays Harbor from 1977 to 1982.

Table 16. Grays Harbor Pacific Oyster Landings and Values. (Landings and values in thousands.)

	Landings			
Year	Pounds	Gallons	Value	Percent of Total
1975	319	36	$392	7
1976	478	55	620	9
1977	367	42	527	6
1978	490	56	816	9
1979	440	50	842	7
1980	261	30	521	5
1981	639	73	1,124	11
1982	725	83	1,301	12
1983	779	89	1,463	13
1984	551	63	1,215	9
10 yr. average:	506	58	832	9

Date provided by WDF.)

Ghost Shrimp - Commercial (Coastal): Ghost shrimp in Willapa Bay were ignored until the late 1950s when the population greatly increased after an El Nino. The increase in numbers was so great that Fisheries started its pest/predator program in the early 1960s to reclaim oyster land lost to ghost shrimp activity.

The current condition of the ghost shrimp resource in Willapa Bay is unknown. All commercial harvesting has occurred within the past 10 years by a very small number of individuals. This fishery has not been regulated or monitored during that time thus historical catch and effort figures are not available. Current harvest levels are also unknown at this time but will be determined in 1989 when DNR/WDF establishes a lease/permit system with required harvest logbooks.

Generally it can be assumed that the resource is healthy and may even be increasing in size. One way this can be illustrated is from the increased number (acreage) of ghost shrimp control permits applied for by oyster growers in the years since the 1983 El Nino.

Burrow counts during pre-inspection of Carbaryl spray tracts suggest an increase in overall abundance. Counts on pretreated tracts in 1980-83 ranged from 3-24 burrows per square meter, while counts done after El Nino (in 1984-85) ranged from 20-280 burrows per square meter.

A WDF survey in September 1988 showed shrimp densities in two different areas of Willapa Bay to range from 65-100 per square meter.

After the 1957-58 El Nino, burrowing shrimp populations in Willapa Bay and Grays Harbor significantly expanded. Ghost and mud shrimp burrow tunnels in oyster beds and generate large amounts of silt. Oysters planted in heavily populated beds sink into the mud or are smothered by the silt. The expanded burrowing shrimp population threatened the multi-million dollar oyster culture industry in the bays with reduced production.

The Washington Department of Fisheries (WDF) considered and experimented with a variety of measures to reduce and control the burrowing shrimp population. The carbamate insecticide Sevin (carbaryl) was selected for use. The WDF also established procedures to regulate the use of Sevin under the authority of the Washington Department of Agriculture (WDA).

Beginning about 1976, WDF prepared declarations of nonsignificance each year for the burrowing shrimp control program. Recently questions and concerns have been expressed about the use of a pesticide in the marine environment. Because of this, WDF and the Washington Department of Ecology (Ecology) determined that an environmental impact statement (EIS) should be prepared on the program.

Hardshell Clams: Table 17

Commercial Landings of Willapa Harbor Hardshell Clams in Thousands of Pounds

Year	Hardshell Clams
1971	17
1972	22
1973	27
1974	12
1975	1
1976	65
1977	0
1978	56
1979	33
1980	38
1981	37
1982	25
1983	32
1984	21
1985	136
1986	141
Five yr. ave.	50
Table ave.	35

Shellfish Puget Sound and Straits (Burge and Baumgarner 1989)

Dungeness Crab: Based on commercial landings since 1951, Puget Sound Dungeness crab production remains strong.

There has been some fluctuation in abundance, but these fluctuations do not indicate problems with reproductive potential. See Table 2, below, for total pounds landed, number of landings, and number of pounds averaged per landing for the years 1951 through 1988.

Table 2 - Puget Sound Dungeness Crab

Season	Pounds Landed	Number Landings	Landing
1951-1952	1,040,961	3,603	289
1952-1953	926,808	3,104	299
1953-1954	1,037,214	3,574	290
1954-1955	953,940	2,580	370
1955-1956	847,452	1,649	514
1956-1957	450,812	1,259	358
1957-1958	324,150	1,104	294
1958-1959	543,310	1,449	369
1959-1960	644,047	1,558	513
1960-1961	1,522,833	3,168	481
1961-1962	1,290,945	2,305	560
1962-1963	992,941	2,224	446
1963-1964	1,700,930	2,892	588
1964-1965	1,418,674	2,716	522
1965-1966	1,483,218	2,336	635
1966-1967	768,144	1,358	566
1967-1968	964,137	1,723	549
1968-1969	815,687	1,566	521
1969-1970	929,507	1,699	547
1970-1971	604,504	1,263	479
1971-1972	862,109	2,145	402
1972-1973	1,215,937	3,609	337
1973-1974	942,983	3,463	272
1974-1975	629,362	2,612	241
1975-1976	1,338,996	3,792	353
1976-1977	2,290,199	3,189	718
1977-1978	1,868,454	3,111	601
1978-1979	2,374,991	4,126	576
1979-1980	1,773,628	4,128	430
1980-1981	1,805,307	4,439	407
1981-1982	1,331,853	3,952	337
1982-1983	1,095,262	2,927	374
1983-1984	1,269,300	3,411	372
1984-1985			
1985-1986	1,293,583	3,618	358
1986-1987	1,324,600	3,806	348
1987-1988	1,467,500	4,355	337
1 1988-1989	1,647,300	3,434	479

1 October - December only

Sea Urchin: From 1971 through 1986, yearly harvest never exceeded 1.5 million pounds. The 1986-87 harvest was 3.4 million pounds; and in 1987-88, 4.5 million pounds were landed.

Over five million pounds were harvested during the latest season (1988-89), a record harvest. Eighty percent of the catch came from the San Juan Islands, while 20 percent was landed from the Strait of Juan de Fuca.

Table 3 shows the number of sea urchins landed from 1971 through 1986.

Table 3
Commercial Landing of Sea Urchins - Pounds and Value in Thousands

Year	Urchins Pounds	Value
1971	2	0
1972	3	1
1973	15	4
1974	57	6
1975	31	2
1976	1,544	115
1977	903	76
1978	1,026	87
1979	1,002	104
1980	43	5
1981	268	29
1982	202	19
1983	412	43
1984	414	75
1985	642	126
1986	2,126	470
5 Yr. ave.	388	58
Table ave.	438	46

Sea Cucumbers: Over 1.9 million pounds were landed during the 1988 season, a record harvest. Catch per unit effort has remained stable.

As indicated by catch data shown in Table 4, the 1988 harvest has apparently increased six-fold over the previous five-year average.

Table 4
Commercial Landing of Sea Cucumbers (Pounds and value in thousands)

	Sea Cucumbers	
Year	Pounds	Value
1971	8	1
1972	6	2
1973	10	2
1974	0	0
1975	3	1
1976	15	3
1977	63	13
1978	127	26
1979	236	34
1980	421	55
1981	276	40
1982	27	4
1983	376	66
1984	88	17
1985	324	53
1986	399	70
5 Yr. ave.	218	36
Table ave.	132	21

Geoduck: Five million pounds were harvested in 1988, representing about 3 percent of a total known resource base of 165 million pounds statewide. Figures for harvest are drawn from DNR and WDF fish ticket data as shown in Table 5; total poundage available is based on WDF diver surveys made yearly. Many harvested beds have recovered to fishable levels within ten years, however, the rate of natural reproduction and recruitment can be much slower; once a geoduck bed is completely harvested, it takes an average 30 years before geoduck densities and size permit reharvest.

Geoduck harvest is managed for long-term sustainable harvest from geoducks found within the depths of 18 to 60 feet. Maximum sustainable yield is estimated at five million pounds per year, and only lands containing this amount are leased yearly. Thus, harvest has remained stable.

Table 5
Commercial Landing of Geoducks (pounds and value in thousands)

Year	Geoducks Pounds	Value
1971	610	68
1972	493	44
1973	464	45
1974	803	67
1975	2,373	329
1976	5,366	938
1977	8,647	1,499
1978	7,090	1,279
1979	5,228	1,089
1980	3,910	692
1981	4,290	440
1982	5,303	2,386
1983	3,523	1,656
1984	4,421	515
1985	4,109	455
1986	2,854	1,855
5 Yr. ave.	4,329	1,090
Table ave.	3,775	767

Spot Shrimp: Stock assessments have been made each year since 1977 to determine spot shrimp abundance and amount available for harvest.

Using new management techniques beginning in the late 1970s spot prawn production has more than doubled and fluctuations in abundance have been stabilized.

Table 18
Spot Shrimp Stock Trends

Year	*CPUE lbs	CPUE no.
1977	2.10	31
1978	4.30	84
1979	3.80	73
1980	4.60	75
1981	5.90	108
1982	6.02	132
1983	6.64	146
1984	6.03	141
1985	6.63	154
1986	6.20	140
1987	5.07	116
1988	5.54	115

*CPUE is the catch per unit effort
(unit is pounds in shrimp pot)

Hardshell Clams: Historically, the native littleneck and butterclams have been harvested by two methods: the hydraulic dredge in the subtidal and by hand digging in the intertidal zone. The manila littleneck is harvested only by hand digging in the intertidal zone. Commercial harvest has shown a steady increase since 1980 (see Table 6). This increase has occurred in spite of a decline in subtidal hydraulic dredge harvest of all clams due to economic and shorelines permit problems. The increase is due entirely to greater harvest in the intertidal area in response to demand for manila clams. Other important factors limiting harvest in the recent 10-year period are closures due to pollution and red tide outbreaks in previously unaffected areas.

Table 6
WASHINGTON COMMERCIAL HARDSHELL CLAM LANDINGS
BY SPECIES AND GEAR IN THOUSANDS OF POUNDS

	Butter		Native		Manila		
Year	Hand Dug	Dredge	Hand Dug	Dredge	Hand Dug	Dredge	Total
1970	40	569	397	229	640	0	1,875
1971	34	432	452	175	762	0	1,855
1972	80	33	594	84	649	1	1,741
1973	102	496	510	271	538	2	1,919
1974	12	348	322	325	790	1	1,798
1975	16	307	349	197	966	0	1,835
1976	22	210	434	113	1,111	0	1,890
1977	132	396	527	90	1,078	0	2,223
1978	43	194	418	56	1,840	0	2,551
1979	42	65	323	25	1,475	0	1,930
1980	72	334	455	67	1,466	0	2,394
1981	42	209	610	15	1,508	0	2,384
1982	30	158	414	5	1,477	2	2,086
1983	35	264	604	5	1,698	0	2,606
1984	9	179	506	89	2,497	0	3,280
1985	24	1	536	0	3,069	0	3,630
Five yr. ave.	38	229	518	36	1,729	0	2,550
Table ave.	47	300	461	116	1,233	0	2,158

Marine Fish Puget Sound (Schmitt 1989)

Groundfish, General Discussion: Puget Sound is divided into seven groundfish management regions.

For most of the major species in Puget Sound, the 1970s was a decade of rapidly increasing catches (Table 7) and effort. This was true for both the recreational and commercial fisheries. The catch by recreational bottomfish anglers and by commercial bottom trawlers kept pace with increasing effort. The recreational catch of major species by bottom-fish-only anglers increased tenfold and the commercial catch more than doubled. This period of rapid fishery expansion in the 1970s was followed by an equally rapid decline in the commercial catch and a somewhat lesser decline in the recreational catch during the 1980s. However, effort in both fisheries remained high and catch rates fell. Although this trend is not common to every major species, it is shown for most of them. Although we do not know the reason for the decline for every species, we can identify the main reason for declines for some species and provide some reasonable speculation for other species.

Major commercial species include whiting, dogfish, surfperch, lingcod, Pacific cod, pollock, rockfish, and flatfish. Commercial fisheries for whiting and surfperch are primarily single species fisheries. It is clear that whiting catches were dramatically reduced in the 1980s as a result of declining abundance. For surfperch, declining abundance is the prime concern although shoreline development limiting access to fishing grounds, loss of experienced fishermen from the fishery, and market demand may all contribute to the decline in catch during the 1980s. Dogfish are taken in several commercial fisheries and poor market demand is the main reason for declining catches.

The other major commercial species are taken primarily in the multi-species bottom trawl fishery. The trawl catches of lingcod, rockfish, and pollock are minor in comparison to the remaining major species, although each declined during the 1980. The catch of pollock is mainly tied to the sporadic movement of fish between northern Puget Sound and Canadian waters.

Table 7. Annual catches (in pounds) of all ground fish species in Puget Sound, 1970 - 1987.

Year	Catch
1970	15,875,468
1971	12,685,552
1972	9,964,622
1973	9,533,816
1974	14,114,250
1975	11,027,009
1976	17,211,050
1977	17,495,001
1978	21,843,682
1979	27,981,689
1980	27,139,628
1981	22,794,596
1982	25,192,973
1983	25,981,893
1984	20,004,180
1985	15,367,575
1986	10,703,120
1987	9,573,076

Lingcod and rockfish are managed with a recreational emphasis in most areas and regulation changes to reduce commercial harvest have contributed to the declining catches of these species.

Flatfish and Pacific cod are the primary target species for the bottom trawl fisheries, and catches of these species dropped by about half during the 1980s while effort remained fairly constant. Declining abundance of Pacific cod in some areas prompted closures to the trawl fishery in those areas in recent years. Over harvest of juvenile flatfish resulted in the establishment of a minimum size limit for some species. Other regulations to restrict trawling have been enacted for reasons other than declining abundance of targeted bottomfish. These regulation changes cannot entirely account for the declining catches and catch rates of these species. Pacific cod recruitment is probably affected by environmental conditions, especially water temperature, and the declining catch rates of Pacific cod probably result from low recruitment during warm water years. Thus, regulation changes and declining abundance apparently coupled to produce reduced catches and catch rates of Pacific cod and flatfish during the 1980s.

Major recreational species for boat-based bottom fish anglers include lingcod, Pacific cod, pollock, and rockfish. In comparison to commercial fisheries, recreational catches are much smaller for most major species and trends are more difficult to evaluate.

Most of the decline in recreational catches (by weight) can be attributed to reduced catches of pollock. During the late 1970s and early 1980s, pollock was the most abundant species in the catch, but recent pollock catches were lower than those for the late 1970s and early 1980s most other species. The reasons for the decline are not known, but may partially result from reduced angler demand for bottomfish, in general. Demand has declined somewhat, perhaps because of concern over potential health risks of eating bottomfish from Puget Sound, especially those near urban and industrialized areas. Most of the pollock are taken from South Sound, near Tacoma. Pollock abundance has also probably declined as well.

Lingcod and rockfish catches do not show declines during the 1980s, but rather have closely followed effort changes. Lingcod has been intensively managed during the 1980s to rebuild the population from the low levels of the late 1970s.

Although the Puget Sound catch of all rockfish species combined has held up under relatively high effort, the condition of each species is not known. Some species may have declined while others increased and there may be areas of localized depletion. Similarly, Pacific cod catches and catch rates have declined dramatically in some areas of Puget Sound, such as Agate Passage in Central Sound, but overall, have remained fairly stable during the 1980s.

In summary, catches of whiting, Pacific cod, flatfish, and surfperch declined during the 1980s, at least partially as a result of reduced abundance. Regulation changes also contributed to the declines. Lowered market demand caused dogfish catches to decline and possibly, lowered angler demand may have contributed to the pollock catch decline. Pollock abundance may also may be declining. Lingcod and rockfish in Puget Sound have been relatively stable during the 1980s, but there may be localized areas of depletion, compensatory changes in abundance of some rockfish species, or the recreational fishery may have shifted to new, relatively unexploited areas or stocks.

The current stock condition and recent trends for each of the major groundfish species/species groups in Puget Sound is summarized in Table 8 below.

Table 8. Current stock condition and recent trend for the major species/species groups of groundfish in Puget Sound.

Species	Condition	Trend
Flatfish	Healthy	Stable
Pacific cod	Low	Variable
Pacific whiting	Low	Stable
Walleye pollock	Unknown	Declining
Lingcod	Healthy	Stable
Rockfish	Unknown	Stable
Surfperch	Low	Stable
Dogfish	Healthy	Declining

Puget Sound Lingcod: Lingcod are caught by a variety of gears in Puget Sound and the dominant gear varies by region. Most of the catch in the Gulf-Bellingham region is taken incidentally to the trawl fishery. In the neighboring San Juan Islands, recreational anglers have taken over 90 percent of the total harvest. Scuba divers may also harvest significant quantities of lingcod. Jig, troll, and set line gears account for the majority of the harvest in the Juan de Fuca and West Juan de Fuca regions. Recreational landings of lingcod now dominate the catches in Hood Canal, Central Sound, and South Sound regions.

Over the last 18 years, Puget Sound lingcod catches have been stable, averaging over 300,000 pounds per year (Table 19). However, catches in individual management regions have shown some trends. In the Gulf-Bellingham region, lingcod catches since 1982 have averaged nearly 150,000 pounds, about double the catches in earlier years.

Lingcod catches in Puget Sound have been affected by regulation changes and closures over the last 18 years. During the mid-1970s, declining catches and resultant concern over the lingcod resource in Puget Sound prompted a closure to all harvest of lingcod in 1978 in all areas south of Admiralty Inlet. In the other areas, fishing was still allowed although it was more restricted. In 1982, closed areas were expanded to include Admiralty Inlet, and in 1983, the closed areas were reopened to recreational fishing during reduced seasons. Thus, a decline in Central Sound lingcod catches in recent years partially reflects the effects of the commercial closure in 1982.

The lingcod stocks in Puget Sound appear to be stable and generally in healthy condition. The catches and catch rates by recreational fishers are indicative of stock condition in most regions, and these measures are closely monitored in the most popular fisheries.

Table 19. Annual catches (in pounds) of lingcod in Puget Sound, 1970-1987.

Year	Catch
1970	340,911
1971	242,477
1972	283,607
1973	291,600
1974	274,537
1975	250,891
1976	216,263
1977	241,186
1978	225,027
1979	199,245
1980	344,451
1981	335,024
1982	449,471
1983	389,273
1984	423,825
1985	343,525
1986	372,751
1987	339,371

Pacific Cod: The Pacific cod resource in Puget Sound is stable with total catches averaging 2.11 million pounds in the last five years (1983-1987) ranging only between 1.99 million pounds and 2.87 million pounds.

Because cod are a species adapted to colder waters, their survival and population levels are subject to changes in the environment on the warmer southern extremes of their geographic range.

While the overall Puget Sound cod catch is stable, individual regions have different catch patterns. Most of the cod in Puget Sound are caught in the Straits of Georgia and Juan de Fuca which support the generally stable commercial trawl fisheries. Some of the other regions that have supported commercial and recreational fisheries have shown striking reductions in cod catches in recent years. Some of these fisheries have been curtailed or closed. Port Townsend Bay once supported trawl and setnet fisheries but now lack sufficient quantities of fish for commercial exploitation. This area is now closed to commercial fishing. Commercial catches in the San Juan Islands also declined at approximately the same time as Port Townsend and cod catches have remained low. A popular recreational fishery for cod has existed at Agate Passage in central Puget Sound for many years but in recent years has shown low catches and poor angler success. These low catches prompted a reduction in the sport bag limit of cod from 15 fish to 10 fish.

Periods of low catches occur at the same time in major catch areas in Washington and British Columbia. Low catch years occurred in 1961, 1973, and in the period between 1984-1986. The 1961 and recent low catch years may be associated with the El Nino events that took place in 1958 and 1982 by possibly influencing the survival of young fish.

In Puget Sound, five major phases of cod catches occurred between 1942 and 1983. Annual catches, in pounds, of Pacific cod in Puget Sound, 1970-1987, are shown in Table 20. Each of these phases can be distinguished by a two- to three-year period when annual catches are depressed alternating with a two- to eleven-year period when catches were consistently higher. Low catch years were 1947, 1955, 1961, 1973, and 1986. The catch in each successive high catch period has increased over the previous high catch period. The annual catches between 1975 and 1981 exceeded all of the previous annual catches. The historical peak catch occurred in 1980 when 3.5 million pounds of cod were landed. After 1981, catch levels have been variable, ranging between 1.7 million pounds in 1986 and 2.9 million pounds in 1984. While catches in recent years are low relative to the recent period of high catches, the catch levels have been comparable to the first four periods of high catch. Two million pounds of cod were landed in 1987.

Table 20. Annual catches (in pounds) of Pacific cod in Puget Sound, 1970 - 1987.

Year	Catch
1970	1,583,242
1971	1,670,556
1972	2,016,746
1973	1,340,394
1974	2,050,089
1975	2,955,220
1976	3,347,057
1977	3,052,240
1978	2,996,805
1979	2,863,232
1980	3,500,946
1981	3,031,615
1982	2,002,903
1983	1,934,218
1984	2,871,661
1985	2,050,052
1986	1,726,846
1987	1,988,463

<u>Walleye Pollock</u>: The walleye pollock stock in southern Puget Sound is depressed relative to previous years. Annual catches, in pounds, of

walleye pollock in Puget Sound, 1970-1987, are shown in Table 21. Since the stock in northern Puget Sound is primarily a Canadian stock, we do not assess this stock. For the southern Puget Sound stock, total catch from all fisheries is used as an index of stock abundance.

The Puget Sound pollock catch in recent years has ranged from only 12,000 pounds in the early 1970s to a peak catch of 1.9 million pounds in 1981. Catches increased in the late 1970s when new commercial markets for pollock were developed and Canadian stocks became available to trawlers in the Gulf-Bellingham region. When the pollock are available in this region, commercial fisheries have accounted for 60 percent to 80 percent of the total Puget Sound pollock catch.

Since 1976, recreational fishers in southern Puget Sound have had an increased interest in fishing for pollock. Catches in southern Puget Sound increased from less than 60,000 pounds before 1976 to a peak recreational catch of half a million pounds in 1979. Since then, the recreational catch of pollock in southern Puget Sound has decreased in each successive year to less than 130,000 pounds in 1987. The number of trips taken by anglers has not decreased significantly during this period. The total harvest by all fishers in all regions in Puget Sound was 207,000 pounds in 1987.

Insufficient information exists to judge whether the increase in the pollock catch in southern Puget Sound was due to a coincidental increase in the pollock resource or just increased desirability of pollock by fishers. It is correspondingly difficult to determine whether the decrease in pollock catch is a result of overfishing or decreased recruitment and survival of young fish or a lack of interest by recreational anglers.

Table 21. Annual catches (in pounds) of walleye pollock in Puget Sound, 1970-1987.

Year	Catch
1970	76,962
1971	14,460
1972	12,084
1973	60,748
1974	109,328
1975	102,604
1976	213,796
1977	386,263
1978	1,574,579
1979	1,544,196
1980	1,221,638
1981	1,989,523
1982	653,007
1983	484,607
1984	309,800
1985	222,768
1986	275,540
1987	207,359

Herring Catch

Pacific Whiting: Historically, whiting in Central Sound has ranked first in catch among all bottomfish species in Puget Sound. The 8.7 million-pound catch in 1970 preceded a gradual decline to about 3.5 million pounds during the mid-1970s. This slump was followed by a rapid increase to a peak catch of 15 million pounds in 1983. However, catches plummeted to only 0.7 million pounds in 1987.

Exploitation rates during the 1980s were very high (Table 22). During the fall 1983 - spring 1984 fishing season, 42 percent of the adult stock was harvested. As the adult stock declined, exploitation rates were significantly lowered by regulation. The low 4 percent rate for the 1987-1988 season partially reflects poor market demand for small whiting, which were more common in catches that season. Increased predation by marine mammals has increased natural mortality rates of whiting in Puget Sound. Poor survival of young whiting may also have contributed to the decline in adult abundance.

The Pacific whiting resource and commercial fishery is more intensively managed than any other fishery for bottomfish in Puget Sound. During the spawning season, research surveys are conducted weekly to measure fish abundance. The allowable harvest, if any, is determined from the survey results and criteria specified in the management plan for this fishery, then the fishing industry is notified each week if fishing is allowed and under what conditions.

The current status of Pacific whiting in Puget Sound is very low, barely sufficient to allow a commercial harvest. For the past few years, harvests have been severely restricted to allow the stock to rebuild however the stock has remained at a low level (Table 23).

Table 22. Annual catches (in pounds) of Pacific whiting in Puget Sound, 1970 - 1987.

Year	Catch
1970	8,732,206
1971	7,514,258
1972	4,187,241
1973	2,485,259
1974	5,202,622
1975	3,362,804
1976	3,748,103
1977	3,637,951
1978	6,393,634
1979	9,795,469
1980	10,310,268
1981	9,445,594
1982	13,405,452
1983	15,144,768
1984	8,801,430
1985	7,738,455
1986	3,324,978
1987	672,707

Table 23. Adult biomass, commercial catch, and exploitation rate for Pacific whiting, 1983-1988.

Season	Biomass (millions of pounds)	Catch (millions of pounds)	Exploitation Rate(%)
1983-84	27.1	11.4	42
1984-85	16.0	6.5	41
1985-86	16.0	4.3	27
1986-87	11.9	1.5	13
1987-88	12.8	0.5	4

Spiny Dogfish: Significant quantities of spiny dogfish have been landed commercially by bottom trawls, set nets, and set lines in all management regions except West Juan de Fuca. Very few spiny dogfish are landed by recreational anglers, but many are caught, often killed, and returned to the waters by anglers.

Between 1970 and 1974, less than 130,000 pounds of dogfish were landed from Puget Sound. As a result of opening markets and restrictions on salmon fisheries, dogfish landings increased tenfold in 1974 and continued to increase to a peak landing of 8.6 million pounds in 1979 (Table 24). Over the 14 years of significant landings, catches have averaged over four million pounds, but in recent years catches have averaged only 2.86 million pounds. Long-term decreases in catches have occurred in all management regions except the West Juan de Fuca region, which has had significant catches only since 1983. Catches between 1982 and 1986 decreased in most regions except South Sound and West Juan de Fuca where no trend is evident.

Canadian stock assessments which utilize catch and effort data from Washington's inside waters, indicate that the dogfish population has been decreasing since 1970. Recent biomass estimates for the combined areas indicate that there are 152 million pounds of dogfish. The decrease in the biomass has stabilized.

The 1987 catches of spiny dogfish in all regions except the West Juan de Fuca region increased over 1986 catches and have approached or exceeded the average catches during the past five years in most management regions.

Table 24. Annual catches (in pounds) of spiny dogfish in Puget Sound, 1970 -1987.

Year	Catch
1970	128,552
1971	47,903
1972	42,751
1973	15,966
1974	1,681,419
1975	1,130,184
1976	5,735,354
1977	5,310,916
1978	5,866,875
1979	8,594,823
1980	6,663,647
1981	4,003,927
1982	4,320,316
1983	3,867,500
1984	3,458,266
1985	2,165,161
1986	1,665,349
1987	3,151,244

Surfperch: During the 1970s the total harvest of surfperch consistently exceeded 200,000 pounds annually. However, during the 1980s, the catch declined steadily to only 100,000 pounds by 1987. Effort by the drag seine fishery was relatively constant during the 1970s, but declined somewhat during the 1980s. As a result, catch rates were relatively constant during the 1970s, but stabilized at approximately half that level during the 1980s. (Table 25)

The cause of the decline in catch and catch rate is uncertain although several possibilities have been suggested: overfishing, shoreline development, changes in fish behavior, loss of experienced fishers, and increased marine mammal predation. During the mid-1980s concern over the condition of the surfperch resource prompted more restrictive regulation of the commercial drag seine fishery and in 1988, more restrictive regulations were also applied to the recreational fishery.

Pile perch and striped seaperch are managed as a unit, although the catch rate of pile perch in the commercial drag seine fishery is considered most indicative of stock condition. The catch and catch rate of striped seaperch fluctuates widely with market demand. Over 90 percent of drag seine catch and effort for pile perch occurs in Hood Canal, Central Sound, and South Sound.

Table 25. Annual catches (in pounds) of surfperches in Puget Sound, 1970 - 1987.

Year	Catch
1970	234,849
1971	224,890
1972	215,116
1973	299,954
1974	267,796
1975	245,112
1976	280,523
1977	232,193
1978	200,332
1979	218,006
1980	188,062
1981	159,958
1982	146,642
1983	140,066
1984	130,787
1985	124,060
1986	174,652
1987	104,759

Flatfish: Flatfish are harvested primarily by the commercial bottom trawl fishery. Because this fishery harvests more than one species, flatfish are generally managed as a unit, although minimum size limits apply to some species.

During the 1970s, catches of flatfish were variable, but generally increased from a low of 2.1 million pounds in 1972 to a high of 3.8 million pounds in 1977. Thereafter, catches steadily declined to a low of 1.6 million pounds in 1987. Most of this catch has been taken by the bottom trawl fishery, and effort in this fishery rose during the 1970s and remained high during the 1980s. Catch rates in this fishery also rose during the 1970s but, unlike effort, fell during the 1980s. Part of the decline in catch and catch rate is due to regulation changes, so that the catch rate in recent years may be near that observed during the early 1970s. Annual catches of flatfish from 1970-1987 are shown in Table 26.

At present, flatfish appear to be in healthy and stable condition, with some localized exceptions. Recent declines in the trawl catches and catch rates are partially attributable to increasingly restrictive regulations since the early 1980s. Most of the catch comes from the Gulf-Bellingham and Central Sound regions, although catches from South Sound were also significant until recently. English sole in South Sound are commonly infected with a blood worm that makes them suitable only for the animal food market. Market demand for wormy sole has been poor in recent years.

Table 26. Annual catches (in pounds) of flatfishes (excluding Pacific halibut) in Puget Sound, 1970 - 1987.

Year	Catch
1970	2,621,127
1971	2,286,107
1972	2,087,255
1973	3,145,051
1974	3,001,389
1975	2,387,490
1976	3,006,417
1977	3,759,001
1978	3,749,973
1979	3,257,523
1980	3,247,630
1981	2,747,110
1982	2,960,684
1983	2,878,164
1984	2,551,071
1985	1,759,401
1986	1,676,352
1987	1,573,260

Rockfish: Rockfish are caught in nearly every fishery, and sport anglers typically harvest one-half to three-quarters of the total Puget Sound catch. Rockfish are important to the bottomfish fisheries in every management region, with catches exceeding 100,000 pounds at some time in every region, except Hood Canal.

All rockfish species in Puget Sound are managed as a unit, primarily because each fishery harvests more than one species. Rockfishes are one of the most difficult groups of bottomfish to assess and one of the most difficult to rebuild if in poor condition. Currently, we rely primarily on fishery catch and effort trends to generally monitor stock condition.

Historically, rockfish catches in Puget Sound climbed from the 247,000 pounds taken in 1970 to a peak of over 910,000 pounds harvested in 1980 (Table 27). Then catches fell to a fairly constant level, averaging 564,000 pounds annually since 1981. Rockfish catches in most management regions showed a similar trend, especially in regions where catches were largest: Juan de Fuca, Central Sound, and South Sound. Part of the decline in rockfish catches during the 1980s is attributable to regulation changes to significantly reduce the incidental rockfish catch by commercial trawl gear. In general, effort in the sport and commercial fisheries paralleled their respective catch trends.

The current status of the rockfish stocks in Puget Sound is unknown. In recent years, rockfish catches and effort in the recreational fishery, the major harvester, have been fairly stable. This apparent stability suggests that the rockfish stocks may be able to sustain current harvest levels. However, localized depletions can occur and we have little information on the size of rockfish in the catches. If the average size has declined, then the rockfish stocks may be in poor condition.

Table 27. Annual catches (in pounds) of rockfishes in Puget Sound, 1970 - 1987.

Year	Catch
1970	247,152
1971	181,984
1972	306,935
1973	395,348
1974	438,795
1975	346,796
1976	364,379
1977	548,655
1978	537,573
1979	689,301
1980	910,400
1981	620,663
1982	524,239
1983	578,187
1984	639,575
1985	406,264
1986	620,044
1987	732,016

<u>Pacific herring</u>: Herring abundance in recent years has been fluctuating, but was stable overall in central and southern Puget Sound and Admiralty Inlet (the exception is in central Hood Canal, where spawner abundance appears to be very depressed). The sport-bait fishery that operates in these areas has been steadily taking 400-1,000 tons of herring per year for many years without much problem. In northern Puget Sound, the largest herring stock in the state (which spawns in the Cherry Pt. area of Whatcom County) has been experiencing extremely low abundance in recent years. Beginning in 1973, this stock supported a large and lucrative sac-roe fishery, however, recently the fishery has been either severely curtailed or suspended completely. The other smaller herring stocks in northern Puget Sound appear to have been doing well and increasing in recent years.

The current condition of the herring resource in Washington State is one of overall stability in central and southern Puget Sound, and one of decline in northern Puget Sound. Herring are thought to form genetically discrete stocks that spawn on specific spawning grounds, therefore, some stocks can be stable or increasing, while others are in a depressed condition. Herring can be subject to fairly large fluctuations in abundance, mainly due to the environmental conditions encountered during their first three months of life.

Table 9 shows herring abundance estimates by spawning ground.

Surf smelt. Commercial landings of surf smelt have averaged 107,000 pounds per year between 1971 and 1986. 1973 and 1974 were peak years having over 200,000 pounds landed each of those two years. Since 1975 the catches have stabilized. (Ward 1986)

Table 9

Puget Sound Herring Abundance Estimates by Spawning Ground, 1978-1988
Spawning Biomass (tons)

Area	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978
Quartermaster Harbor	750	924	1181	667	1386	909	1778	1777	1930	1941	1860
Agate Pass	1705	2538	1962	1415	1293	1651	1214	890	2139	1255	-
Port Susan	570	1216	934	1321	1555	1398	1391	-	-	-	-
Port Gamble	1358*	2035*	2050	2387	2685	2407	1463	1753	2309	1790	1984
Discovery Bay	853	1593	1566	1447	3144	2578	2356	3070	3220	-	1305
Fidalgo Bay	-	887	727	761	773	667	182	456	296	-	-
Skagit Bay	1340	1552	-	-	-	-	-	-	453	-	-
Drayton Harbor	1965	-	1464	2325	772	766	1266	1008	-	-	-
Cherry Pt.	4311*	3108*	5671	5760	5901	8063	5342	6219	9329	9957	10973

*Excludes herring used in experimental spawn-on-kelp fisheries.

Coastal Groundfish (Millikan 1989): The current condition of Washington's coastal groundfish resource is generally healthy, with the exception of Pacific ocean perch stocks which are currently managed under a rebuilding program.

Catch trends for the commercially important groundfish species in the Columbia area shows that the year to year variability in catch is considerable and a clear trend is not evident. Furthermore, full blown assessments are not available for many stocks. While the abundance trend for most species is unknown, Dover sole and yellowtail rockfish were reported to be in decline. (Such declines are not necessarily be interpreted as an indication that stocks will continue to decline because stock biomass is expected to decline until equilibrium is reached at the MSY level.

Black rockfish and lingcod dominate the coastal recreational marine fish catch. Black rockfish landings have increased from 160,509 to 293,182 between 1981 and 1986; lingcod landings increased from 9,546 to 22,364 over the same period.

Miscellaneous

Sturgeon: During the late 1800s, the demand for caviar and smoked sturgeon increased greatly and made fishing for sturgeon a highly profitable enterprise. There was neither proper management nor regulation of the fishery at that time and disastrous overfishing resulted in almost complete elimination of the breeding stocks. Today it is uncommon to catch a sturgeon larger than 500 pounds in the Columbia. The commercial catch of white sturgeon in recent years has ranged from 1/3 to 1/2 million pounds in contrast with three to six million pounds taken in the 1890s. Both gill nets and set lines contribute to the commercial catch, which generally occurs incidental to salmon catches during open salmon season. Despite decreasing salmon seasons, lower Columbia River sturgeon harvests have increased steadily in recent years. Upper river stocks, however, are believed to have become severely depressed due to construction of dams and deterioration of access to spawning areas.

Columbia River Smelt: For as long as commercial statistics are available, the Columbia River catch has exceeded 1,000,000 pounds annually, and has been nearly 6,000,000 pounds during peak years. The fish are taken with fine mesh gill nets in the main Columbia, principally below Vancouver, and with dip nets in the Grays, Cowlitz, Kalama, Lewis, and Sandy rivers, which are the main smelt producing tributaries. Other rivers which support runs include the Fraser and Nooksack rivers.

Shad: Shad are a large underutilized resource in the Columbia River. The commercial fishery averages 44,000 pounds landed per year between 1971 through 1986. (Ward 1986)

SECTION V

SUMMARY OF RISKS TO THE FISHERIES RESOURCES

INTRODUCTION

The fisheries resource, herein defined as species regulated by the Washington State Department of Fisheries (WDF), is renewable through both natural and artificial processess. Careful, responsible, management of these resources is important to perpetuation of a healthy resource. Health of this resource is measured, by Fisheries' managers, using population -- a healthy population is one strong enough to maintain a healthy brood stock while also allowing for a sufficient commercial and recreational catch.

Management can sometimes compensate for environmental damage that reduces fisheries-resource populations. For example, if populations drop to an unacceptable level, stricter catch limitations can be imposed thereby relieving catch pressure. Or, for certain species, fisheries managers can manipulate populations using artificial propagation. For this reason, population and catch data may not be accurate measures of the true health of, or extent of environmental impact on, a particular species.

Fisheries managers are fearful that the magnitude of past impacts to the resource associated with habitat degradation will reoccur in the future if existing growth projections materialize. Washington's fisheries resources, however, continue to be impacted by incremental damage associated with unregulated alteration of the environment and noncompliance with existing regulations.

Fisheries resources, integral to the economic health and heritage of Washington State, have been and continue to be adversely impacted by several of the "environmental threats" addressed by Washington Environment 2010 risk reports (Risk Reports).

The following summary of threats to the fisheries resource was compiled from information in the 23 Risk Reports for the introduction and conclusions sections. This discussion does not represent independent analysis or research by the authors.

It is important to realize that some issues appear to be emerging as threats, however, given the lack of data on risks, we cannot conclude with scientific certainty that loss is inevitable. We can however, infer from results of the risk analysis that there are numerous management challenges facing managers and the public.

IMPACT GUIDE

It is apparent from the Risk Reports that often there is not a direct link between a particular threat and its impact on the fisheries resource -- initially another resource may be impacted, which in turn has an adverse effect on the fisheries resource. The Risk Reports also reveal that, in many cases, the source of the threat (i.e. air pollution, water pollution, etc.) varies, but the end result, or subsequent predicted impact on the fisheries resource, is similar.

Information from the Risk Reports has been synthesized to provide a comprehensive overview of some of the interrelationships between water quality, water quantity, habitat and the fisheries resources and the ultimate potential impact on the fisheries resources, as explained below.

1. <u>Water Quality</u>

a. Land sloughing (also referred to as wasting or mass wasting) dirt eroding from land, and dredging and dredge materials disposal degrade water quality. Excess sediment can suffocate fish eggs; abrade fish gills; bury benthic and epibenthic dwelling organisms (potential fish food); block sunlight to aquatic plants thereby potentially reducing suitable fisheries habitat; obscure sources of food, habitat, and hiding places; increases water temperature at the surface, which can ultimately affect fish health; destroy channel integrity and character; and decreases the oxygen supply necessary for maintaining aquatic life. Cumulative impacts must also be considered.

b. Contaminating surface waters with increased nutrients can cause detrimental algal blooms. Excess algae can lower dissolved oxygen, which adversely affects the fisheries resource. Certain, sometimes less desirable, species may thrive at the expense of more important species.

c. Bacterial contamination of surface water can result in decertification of shellfish growing areas for commercial harvest.

d. Pesticides and/or herbicide contamination of surface water and/or sediments can reduce fish resistance to environmental stresses, impede smoltification (the ability to adjust from fresh water to salt water or vice versa) reproduction success, respiration, and growth; destroy habitat; cause cancer in fish and/or shellfish; or cause fish and/or shellfish mortalities. Level of impact is dependent on toxicity, persistence, fate - transport, partitioning, and bioaccumulation, with the potential for cumulative impacts on certain stocks.

e. Contaminating surface waters and/or sediments with toxics (both inorganic and organic) may cause fish/shellfish acute and chronic mortality; mutations; cancer; reproductive, developmental, and/or immunological abnormalities. Contaminants can reduce populations of benthic communities, which would include certain shellfish resources.

f. Contaminants in ground water can travel through the ground water aquifer and end up in surface waters, with the potential for the same end results as described above.

g. Contaminants that impact the quality of the top 50 micrometers of seawater (including Puget Sound and the Pacific Ocean) may also impact the fisheries resource. This area, referred to as the "microlayer", is ecologically important as a nursing ground for the egg and larvae stages of a variety of fish and shellfish. Virtually all shellfish resources of commercial and recreational importance have larvae and, often, eggs which float at or near the surface of the water during development. This is also true for a variety of marine fish species including the flatfish (such as English sole and halibut) and rockfish. These species are vulnerable to changes in the surface layer, which is the interface between the ambient air and the affected waterbody.

h. Contamination of fresh surface-water with excess salts increases ionic strength, which may in turn, cause aquatic species shifts.

2. Water Quantity/Variations in Stream Flows

a. During extreme low flow conditions, adult salmon may be unable to migrate as far upstream as they would normally, thus reducing streamlined area available for spawning: under worst case conditions, it may become impossible for salmon to migrate upstream (especially spring, summer and fall Chinook, which spawn late summer/early fall, before winter rains). Low flows also result in acute or chronic mortality, diminished aquatic production of food species; increased stream temperatures and attendant fisheries impacts; and increased crowding, competition for food, and predation. Abnormal water-flow patterns may fail to provide adequate migration cues, thereby impairing anadromous fish migration behavior.

b. Salmon reproduce by laying eggs in stream gravel, and once hatched, juvenile salmon stay in the stream until they migrate to the sea. Summer stream stagnation, resulting from low stream flow causes diminished growth of certain species' salmon eggs and/or young, and acute or chronic mortality. Some species production levels are related to the amount of available summer rearing area which in turn is dependent on summer stream flow. The lower the flow, the lower the production of these species.

c. As water supply diminishes, competition for water increases among irrigators, power generators, drinking water suppliers, and fisheries resources.

d. Excessive winter streamflow can cause streambed scour as the stream velocity increases to accommodate larger flows. Streambed scour degrades salmon habitat and kills and alevins. Abnormal water-flow patterns may fail to provide adequate migration cues, thereby impairing anadromous fish migration behavior.

3. Food/Habitat Removal or Disruption

Maintaining high quality habitat is essential to maintaining healthy fisheries resources. Habitat needs of the fisheries resources are complex and varied. Salmon, for example, use freshwater streams for spawning and rearing. They use wetlands and shoreline shallows during migration and rearing for food and refuge. They mature in ocean waters, then return to freshwater streams to spawn.

a. Removing streambank vegetation can increase the temperature of stream water, which in turn decreases fish/shellfish food production and may reduce fish production. Streambank manipulation can also remove areas used by fish for rearing and to escape from predators.

b. Certain activities that eliminate, diminish, or contaminate the food chain can ultimately result in death or diminished health of the fisheries resources. For example, a diminished supply of phytoplankton and micro organisms in the water will ultimately impact those plagic fisheries resources dependant on them for food.

c. Structures or debris in streams may block or restrict both downstream migration of salmon smolts and upstream migration of spawners. Blocked passage has resulted in irreversible losses of certain stocks. On the other hand, certain debris in streams, called large organic debris, is critical for stream stability and character. It creates habitat for fish.

d. Poorly designed and/or timed stream channel alterations can degrade spawning and rearing habitat, cause fish egg, fry, and fingerling mortality, and insect mortality.

e. Shifting gravel conditions during high river flows cause excessive fish egg and alevin mortalities.

f. Vegetation or gravel removal or alteration can modify hydrologic patterns (i.e. shift direction and amount of runoff), thereby affecting the quantity and quality of water, resulting in fisheries impacts as described in the water quality and water quantity sections, above.

THREAT-SPECIFIC RISKS

The following is a discussion of impacts to the fisheries resources as defined in each of the Risk Reports. The synthesized material, presented in the "impact guide" above, can be used as a guide to understanding impacts that can be expected from certain "chain-reactions" and/or sources of ecological degradation. To reduce repetitions, the material is presented in a form that can be used by the reader to better understand impacts associated with source-specific risks. The word "guide" and the number and letter from pertinent sections will be placed throughout the following discussion, in parenthesis, where appropriate.

Ambient Air Pollution

The lead author of the Air Risk Report, Dan Johnson, noted that there was a limited amount of information regarding impacts on Washington's aquatic environment from ambient air pollution. However, available information is summarized below. It is important to note that it is unlikely that air deposition could cause pollutant levels to rise high enough to see the effects described below. However, near point sources, air deposition could be a significant contributor.

Air pollution can significantly impact water ecosystems, especially the microlayer (guide, l.g.). As noted in the introduction, the microlayer is ecologically important as a nursing ground for the egg and larvae stages of a variety of fish and shellfish.

Polynuclear aromatic hydrocarbons (PAH's) from industrial sources were shown to reduce the growth rate of algae in the Puget Sound microlayer. One study found that fluoranthene, one of the PAH's deposited by industry near Commencement Bay, caused significant growth reduction in algae (guide, 3.b.). Algae are extremely adaptable and are replenished within 4 days.

A study conducted by the University of Oregon revealed that polynuclear aromatic hydrocarbons (PAHs) from unknown sources significantly reduced hatching of sole eggs in the Puget Sound microlayer (guide, i.g.)

The Ambient Air Pollution Risk Report also noted that high levels of heavy metals in aquatic environments can cause behavioral changes and death in toad tadpoles, and that heavy metals (e.g. nickel) can cause death to softshell calms (guide, 1. e.).

Indoor Air Pollution

No ecological risks identified

Releases from Radioactive Wastes/Radioactive Materials

The following discussion is limited to potential impacts at the Hanford facility, near the Tri-Cities.

The Hanford reach supports the only mainstem chinook salmon spawning habitat remaining on the Columbia River. This population is maintained by a combination of natural spawning in tributaries and artificial propagation. Fish were among animal species sampled during 1987 as biological indicators of environmental contamination. The Risk Report did not present data from these samples.

Contact with surface waters is assumed to be one of the two most significant pathways posing risk of fisheries-resource exposure to radionuclides. At Hanford, liquid-waste releases impact surface and ground water at low levels, raising the possibility of fisheries resource exposure to tritium, ruthenium, and plutonium. Because salmon migrate to sea for much of their life, they would not experience lifetime exposure.

Possible effects to local ecosystems due to chronic exposure to radiation include mutations, cancer, and reproductive, developmental, or immunological abnormalities. All could be manifest in declining populations, but, to date, no population declines have been attributed to Hanford. No measurable significant effects are currently noted for offsite populations.

Assuming that waste inventories do not significantly increase, and that existing wastes continue to be removed from the site, or disposed in a secure manner, then the ecological risk should decrease through the year 2010. However the lack of adequate attention to the existing waste volumes would degrade the local environment and potentially impact existing biotic systems, which are currently receiving considerable attention from state and federal agencies.

Global Warming and Stratospheric Ozone Depletion

Although there is disagreement among scientists about the reality of and subsequent effects associated with global warming and stratospheric ozone depletion, there is strong belief among many in the scientific community who are convinced that global warming and stratospheric ozone depletion are indeed a reality. This disagreement presents a dilemma: If we are to err in our assessment of the potential impacts related to global warming, are we safer to err on the side of precaution and plan so that unnecessary devastation does not occur; or should we take a chance, operating under the premise that global warming and subsequent impacts will not occur?

The author of the Global Warming and Stratospheric Ozone Depletion Risk Report expresses the opinion that:

> "Global warming and ozone depletion are characterized by a high degree of uncertainty, and a high degree of risk if we (society) are wrong in our assessment of the situation."

While, as the author notes, there is not published speculation on impacts associated with this phenomenon, the risk report speculates that global warming and ozone depletion may result in climate change, sea level rise, and ozone depletion. Impacts on the fisheries resource from these environmental alterations are discussed below.

A contributing author to the Global Warming Risk Report, Mary Lou Mills (WDF biologist), presented the following testimony before the legislature:

Prediction of the climatic, oceanographic and radiation consequences [that] will result from the global warming trend and depletion of the ozone layer is difficult. Translation of those effects into changes in fish or shellfish production is even more speculative. While we do not have accurate predictions about the fishery related consequences, we have many questions and concerns relating to these two phenomena.

Given the very speculative nature of my comments, they should not be taken as actual predictions of the consequences of ozone layer depletion or the global warming trend. In some cases, the possible results I describe may represent "worst case" consequences; in others they may be under estimates of impacts. These comments do embody some types of possible changes and concerns relating to the species managed by the Department of Fisheries (Mills, ML, September 22, 1988, Human Impacts of the Biosphere, legislative workshop, p.3).

CLIMATE CHANGE

Anticipated climate change could increase winter stream flows in all streams and decrease delayed runoff during the summer in snowpack fed streams.

Decreased summer stream flow reduces fisheries productivity of the stream (guide, 2.a). This condition would be aggravated by precipitation changes due to global warming. Late summer flows may be insufficient for adult pink, coho and chinook salmon to ascend the stream to spawn. In extreme cases, summer stream stagnation results in the death or diminished growth of salmon eggs or young in the gravel or rearing pools of the stream. There is considerable information available on the almost linear relationship between flows and coho survival.

Increased winter stream flow would result in excess streambed scour. Inevitably, stream bed and banks would be continually scoured as the stream enlarged itself to accommodate the larger flows. Bed scour is destructive of salmon spawning habitat, eggs, and alevins (guide, 2.d.)

Spartina Invasion

Many global-warming impact predictions, such as those described above, are based on effects observed in today's environment. The Global Warming Risk Report uses the spartina invasion of Willapa Bay as an example to illustrate "the kind of unexpected consequences global warming will have for Washington State".

> "If recent abnormally warm conditions continue, Spartina alterniflora [Smooth Cordgrass, native to Atlantic Coast], is predicted to expand from 680 acres to 31,000 acres, or 66% of the total intertidal mudflats of Willapa Bay, by 2025.

The author suggests that this invasion of spartina may be the first documented ecologic effect of global warming in Washington state. Implications of a Spartina invasion include loss of major oyster habitat.

Drought

Climate change is also expected to result in drought conditions, which would increase competition for freshwater between salmonid resources and human uses (guide, 2.c.). Recent drought conditions that some postulate may be linked to global warming, have undoubtedly caused a decline in juvenile coho and chinook salmon numbers due to decreased streamflows because of reduced instream area available for juvenile rearing.

Species Range Impacts

Washington State is located at the southern extremity of the range of several commercially and recreationally important species. For example, halibut, pacific cod and pink salmon are not found south of Washington State; we are close to the southern end of chum salmon and razor clam range; though ranges of coho and chinook extend south into northern California, runs of these species have been weak in California in recent years.

The ranges of these species may shift northward if Washington's climate is changed to resemble that of northern California's: existing fish populations may dwindle or disappear, and other species may appear. [Note: This may be of economic importance because, as noted in the resource characterization, chinook generally tend to migrate north, so that Sacramento River fish are taken off the Washington Coast.)

El Nino

Specific species alterations have occurred during past El Nino's: these events have not been proven to be directly associated with the observed alterations noted below.

Alterations occurring in conjunction with El Ninos include: appearance of subtropical species (including bonito) off the coast of Washington, dramatic increase in ghost shrimp populations, depressed Pacific cod reproduction, disease related razor clam populations decrease, and reduced marine survival of Columbia and coastal chinook and coho. [The author of the Resource Characterization notes that associations between effects noted above and El Nino are speculative].

SEA LEVEL RISE

Surf Smelt and Pacific Herring spawn throughout Puget Sound -- Surf smelt spawn in the upper intertidal at and just below mean higher high water; Pacific Herring eggs are deposited on marine vegetation in the intertidal and upper subtidal. Salmon, particularly pink and chum, use shoreline shallows as migratory and rearing areas to feed and escape larger predator fish.

With rising sea level, the loss of some intertidal and shallow subtidal habitat can be expected. The loss of upper intertidal spawning habitat will occur at select locations throughout the greater Puget Sound system. Because all spawning locations have not yet been identified, it is not known specifically where all losses would occur.

One of the potential impacts associated with sea level rise is surface-water encroachment, or inundation of, near-shore structures. Intensity of shallow-water habitat loss and associated impacts on salmon depend on the rate at which shoreline bulkheading and other similar activities occur. Where regulatory authority exists, shoreline protection measures are not allowed if they threaten fisheries resources.

However, when homes are threatened, shoreline protection measures may be considered. Many shoreline protection measures, entail filling the shallow water areas now being used for juvenile fish rearing. There may be no usable habitat left for intertidal spawners such as surf smelt. Affected species are highly sensitive to the effects; they have evolved to rear and spawn in these specific habitats.

Nearly all commercial oyster production in the state occurs in the intertidal areas. Inundation of historic oyster grounds could decrease the capacity of these areas for growing oysters and considerably reduce the state's oyster production. There are alternatives, oyster racks or rafts for example, that could mitigate as long as this type of aquaculture did not impact other natural resources. Additionally, alternative oyster production methods are more expensive than on-ground culture. This will create an economic impact on the industry.

OZONE DEPLETION

Studies in Antarctica indicate increased UV radiation may significantly alter the biologic diversity of similar species in the Pacific Northwest. Fisheries are dependent upon the phytoplankton and micro organisms present in local waters. Studies conducted to determine impacts associated UV radiation:

> " ... found that phytoplankton were two to four times more productive when UV [ultraviolet] light was excluded from their water. Increased UV radiation decreased the productivity of all types of phytoplankton, bringing about decreased photosynthesis, changes in protective pigment colorations, and significant shifts in species populations within the algal community (El-Sayed, 1988)"
>
> Further up the food web, studies in Puget Sound have shown that increased UV radiation decreases the activity, development rates, and survival rates of shrimp, shrimp-like crustaceans and crab larvae. Death rates in copepods are greatly increased while the fecundity in survivors is severely limited. Benthic organisms are often killed on exposure to excess UV radiation while egg development is retarded. (Risk Report, 1989)

Reduction of fisheries resources, particularly marine and shellfish populations, may result from ultraviolet-light penetration of the microlayer (guide, l.g.). Though we do not know how vulnerable these species are, it is likely that fish and shellfish eggs and larvae would suffer extreme damage as ultraviolet radiation penetrates the microlayer. If some species are more resistant than others they may become predominant.

Since phytoplankton are the basis for most ocean food chains, these changes could have profound effects on the food available and the types and quantities of fish production occurring in the ocean.

NONPOINT DISCHARGES TO WATER

The following discussion describes sources found to contribute to water quality degradation, discusses various pollutant pathways, and summarizes impacts associated with various nonpoint discharges.

Agriculture (including rangelands, pasturelands, and aguaculture)

Water quality threats of major concern posed by crop production include pesticides/herbicide contamination (guide, 1.d.), sedimentation (guide, 1.a.), turbidity, and increased nutrients (guide, 1.b).

Animal Production

Water quality threats, of major concern, posed by animal production include bacterial (guide, 1.c. and appendix 1) and herbicide contamination (guide, 1.d.); sedimentation (guide, 1.a.); turbidity; increased nutrients (guide, 1.b.), salts (guide, 1.h), ammonia, and habitat destruction (see guide, 3.a. and 3.d.).

Silviculture

Silviculture activities that have the potential to impact the fisheries resource include road construction, maintenance, and abandonment; site preparation; clear cut and partial cut practices; streamside-vegetation removal; and debris removal.

Water quality threats, of major concern, posed by silviculture practices include mass wasting (guide, 1.a.), physical disturbance including road building (guide, 3.a, 3.b., 3.c., 3.f., 1.a., and 1.b.), pesticide use (guide, i.d.), and increased nutrient release from logging and burning slash (guide, 1.b.). Silviculture impacts may be mitigated by an on-site consultation from Timber/Fish/Wildlife, one "tool" described in the Resource Characterization.

Construction

Water quality threats, of major concern, posed by construction include:

1. Habitat destruction resulting from removing vegetation during construction of buildings, highways, and land, including aquatic construction (guide, 3.a., 3.b., 3.d., and 3.f.);

2. Dredging and open water dumping of dredged material (guide, 1.a.). In addition to fisheries resource impacts described in the guide, 1.a., contaminated sediments can be resuspended, spreading contamination to relatively clean areas.

3. Runoff from roads and equipment used in construction can introduce metals, hydrocarbons, and other toxic substances to aquatic environments (guide, 1.e.).

On-site Wastewater Systems

The most significant fisheries resource impact associated with on-site wastewater-system failure is decertification of shellfish growing areas (guide 1.c.).

Mining

Water quality threats of major concern associated with mining include sedimentation (guide, 1.a.); and in some cases contamination of surface water with radionuclides, sulfur, and zinc (guide, 1.e.). In one case, zinc contamination from mine tailings resulted in elimination of 10 miles of fish spawning and rearing habitat.

Point-Source Water Pollution

Major pollutants associated with the pulp and paper mill industry include microbial pathogens, suspended solids, biochemical oxygen demand, nutrients and priority toxic organics, primarily dioxins/furnas and chlorination products. major impacts associated with these pollutants include sediment organic enrichment/anorxia, reductions in benthic community populations and suitable habitat, algal blooms, and shellfish closures. Priority toxic organics can accumulate in sediments and bioaccumulate in fish/shellfish. This can cause benthic community problems, fish/shellfish consumption restrictions.

Iron Steel and Metals Production

Major contaminants associated with the above mentioned facilities are metals, cyanide, and priority organics (polynuclear aromatic hydrocarbons). The major ecological concerns associated with discharge of these contaminants include: sediment contamination, benthic community depressions, tissue bioaccumulations, and potential tissue consumption restrictions for fish and shellfish.

Aluminum Manufacturing

Major pollutants associated with aluminum mills include toxic organics (polynuclear aromatic hydrocarbons and PCBS). The primary ecological concerns associated with both toxic organics and inorganics in marine and freshwater environments include sediment contamination, benthic community depressions, tissue bioaccumulation, and potential fish-consumption restrictions. [Water withdrawals associated with aluminum manufacturing contribute to water quantity impacts, see hydrological modification section].

Metal Finishers

Major contaminants associated with the metal finishing industry are metals, cyanide, priority organics (polynuclear aromatic hydrocarbons, phenols, and solvents) and pH. The major ecological concerns associated with discharge of these contaminants include: sediment contamination, benthic community depressions, tissue bioaccumulation, potential tissue consumption restrictions, and water quality violations.

Oil refineries

Major pollutants of concern in treated oil-refinery wastewater include chemical oxygen demand (COD), ammonia, oil and grease, polyaromatic hydrocarbons (PAHS), phenols, sulfide and metals (chromium, hexavalent chromium, copper, etc). Stormwater runoff from the plant site and storage area can also carry pollutants to receiving waters. Oil spills from loading facilities are another potential threat.

Environmental impacts may include the contamination of water, sediment, and aquatic and benthic organisms, and bioaccumulation of toxics. Type and duration of ecological impacts from accidental oil spills from loading facilities would be highly variable depending on the oil type and quantity spilled.

Inorganic and Organic Chemical Manufacturing Plants

Wastewater from chemical plants will vary widely depending on the type of product made and the process used to make the chemical. Effluent can consist of both cooling water and process wastewater. Cooling water discharges will usually be the largest part of the total discharge.

Ecological effects caused by chemical plant effluents will vary with the wastewater characteristics. Major concerns may include biological oxygen demand, pH, chemical oxygen demand, oil and grease, chemicals (organic/inorganic), metals and thermal discharges. Chemicals added to cooling water to retard the growth of slime may also effect receiving waters.

Pollutants may also enter the environment from surface water runoff from the plant site. Chemical spills or leaks from process units or storage areas may also be an environmental threat to surface or ground waters.

Ecological impacts will vary with the wastewater characteristics and may be localized in the immediate vicinity of each outfall. Thermal discharges may have relatively mild receiving water effects while chemically contaminated wastewater may have more intense effects (such as acute or chronic toxicity on receiving water biota, including fish and aquatic organisms fish feed upon or the bioaccumulation of toxics).

Electric Utilities

Wastewater discharged from power generation consists mostly of cooling water. Concerns from these effluents may include metals, thermal discharges, oil and grease and organics (e.g. compounds added to the cooling water to retard the growth of slime)

Ecological impacts may be localized in the near vicinity of each outfall. Thermal discharges may cause temperature increases in the receiving water. Organics and metals may have acute and chronic effects on receiving water biota, including fish and aquatic organisms fish feed upon.

Municipal Facilities (wastewater treatment plants)

Concerns associated with wastewater treatment plant effluents include biological oxygen demand, nutrients (ammonia and phosphorus), microbial pathogens, metals, organics, chlorine, and chlorinated organics produced during wastewater disinfection. A high percentage of wastewater treatment plants will cause chlorine toxicity when the receiving water dilution is below 100:1.

Other impacts may include: dissolved oxygen depletion, algal blooms caused by nutrients, bacterial contamination of shellfish, chlorine, organic and metal acute or chronic toxicity on aquatic and benthic organisms, and contamination and bioaccumulation of toxics (organics and metals). The Department of social and Health Services decertify shellfish beds within a certain distance of outfalls and marinas.

Sediments contaminated with metals and toxic organics are routinely found around storm outfalls. Fishery habitat is degraded by poor water quality and waterways sustain substantial hydrographic modification.

HYDROLOGIC MODIFICATION

Dam Construction and Operation

Activities and structures related to hydroelectric power generation include diversion dams, reservoirs, penstock, powerhouse, access roads, and transmission corridors. Environmental impacts are associated with construction, operation, and maintenance of these facilities. Any structure built within a stream channel has the potential to impede movement of aquatic organisms causing acute or chronic mortalities, especially in migrating fish.

Resource managers have developed strategies to minimize adverse impacts from instream development. Plans for new facilities must be reviewed to determine potential impacts; this review requires adequate staff, authority, and ultimately, funds. For the most part, this discussion describes impacts associated with facilities constructed prior to project review and implementation of subsequent protective measures.

Improperly designed diversion structures can cause direct mortality of fish if intake velocities cause fish to become trapped at the water-intake screen. If there is no screen, fish can pass through turbines; those that do often die. In some cases, screens are not adequately maintained, which increases problems.

Pipeline, canal, or penstock leakage can destabilize slopes and lead to mass wastage of slopes resulting in erosion that can drastically affect stream productivity.

Historically, dams have severely impacted the fisheries resource; the most dramatic impact being reduction of anadromous and resident fish spawning and rearing areas. Blockage of anadromous fish passage, and habitat and water quality alterations resulting from dam construction can also severely impact the fisheries resource. In some cases, spawning and rearing habitat upstream of dams has been permanently lost. As dams are proposed for relicensing, upstream habitat will be evaluated.

Impacts associated with historic dam construction include increased erosion and sedimentation caused by clearing streambank vegetation, blasting bedrock, and instream construction.

Operating hydropower dams to meet peak-power demand can cause fluctuations in stream levels, thus reducing fish rearing area and causing stranding of eggs. During dam operation, insufficient instream flows reduce fish habitat; make barriers impassible; and change flow velocity, impairing migration, damaging fish habitat, and/or stranding fish.

Dam operation often requires changes in reservoir level; the drawdown zone is biologically unproductive and subject to erosion (guide, 1.a.). Water quality may also be affected by the decay of flooded organic matter and release of soil and chemicals into the water (guide, 1.b., 1.d., 1.e).

Physical and chemical conditions of the original stream have been significantly altered when stream miles were replaced by reservoirs. These changes, including decreased flow velocity, and increased water depth, resulted in loss of spawning habitat for anadromous fish. Reservoirs also altered water temperature and water chemistry, and dissolved oxygen depletion in deeper, slower moving waters. These alterations, in turn, affected water quality downstream of the reservoir. Downstream impacts have included thermal and chemical stratification causing significant effects downstream.

Spawning gravel can be trapped behind dams, eliminating recruitment below the dam, resulting of loss of spawning area.

Fast-moving water discharging from the powerhouse tailrace can attract anadromous fish that are migrating upstream to spawn: this distraction can delay upstream migration. If this were to happen, abnormal water-flow patterns could fail to provide adequate migration cues, thereby impairing anadromous fish migration behavior: delays could reduce spawning success due to stored-energy-reserve depletion and increased predation.

Dam construction on the Columbia River has resulted in a decrease of accessible anadromous fish habitat from 13,000 stream miles (pre-1850) to the current level of 8,900 stream miles. This is a 31 percent decrease in Columbia River spawning habitat. During this same period, salmon populations have decreased by 75 to 80 percent; from an estimated (pre-European settlement) salmon population of 10 to 16 million fish to the existing average of 2.5 million salmon per year. The salmon population decrease described above cannot be attributed to dams alone; many other factors have contributed to population reductions.

Surface Water Withdrawal

Consumptive removal of surface and, in some cases, ground water, reduces streamflow. The greatest volume of water is withdrawn for municipal water suppliers, irrigators, and hydropower generators. The cumulative withdrawals of small domestic withdrawals are also significant.

Because summer and fall low flows limit fish production, flow reduction can immediately impact fish populations and productivity, particularly in small and medium sized, highly productive streams, where there is less water from which to draw. When instream flow is limiting on the low flow side, fish and fish habitat are impacted through reductions in flow, cover, stream velocity, and aquatic production of food species; increased temperatures, crowding, competition for food; and predation. Due to these factors, low flows will result in diminished fish abundance (guide, 2.a.).

Irrigation storage and diversion projects have severely reduced fish runs on several Columbia River tributaries, including the Okanogan and Yakima rivers. In Puget Sound drainages, dams supplying both water and power impact natural drainages. Irrigation in river basins, such as the Dungeness and Nooksack, have reduced stream flows historically used by fish. Some fisheries losses in the Yakima Basin will be restored as a result of well-planned, but costly efforts.

Diversion of streamflow can also adversely impact wetlands and other riparian habitats, causing changes in hydrology, salinity, and chemistry (guide, 1.b., 1.h., and 2.a.)

Construction and Flood Control in Streams, Lakes, Riparian Areas and Floodplains

Stream channel alterations such as dikes and levees cause channels to straighten, destroying the natural pool/rifle ratio, which is essential to salmonid feeding, spawning, and rearing. Stream-channel alterations can cause degradation of spawning and rearing habitat, fish egg and insect larvae mortality, fish crowding, and juvenile salmonid.

Flood control projects restrict channel size, which eliminates the stream's potential for reestablishing the pool/rifle ratio.

Dredging and filling reduce the shallow water areas and increase deep-water areas thereby affecting the pool/rifle ratio. These activities can also eliminate streamside vegetation causing thermal change; and cause increased predation, fish-gill abrasion, and sedimentation of spawning gravels (guide, 1.a). Removing (mining, dredging) or adding streambed materials causes continuous and excessive bedload movement, substrate shifting, and turbidity. If not constructed according to WDF hydraulic approval standards, gravel excavation can leave large pits and pockets. If this happens, when rivers recede, juvenile salmonids can become standard and then die. [Note: WDF does not generally allow dredging of streams except for U. S. Army Corps of Engineers projects, and then only in deep water, e.g. 20 feet MLLW]

Bridging and culverts can alter the number and diversity of aquatic species, cause streambed scour from increased velocity, resuspend contaminated sediments, reduce fish spawning area, and interfere with fish passage.

Forest Practices

Logging can block fish passage, reduce habitat complexity in streams, degrade water quality, cause stream sedimentation, create stream debris barriers, alter water temperature, destabilize streambanks, reduce aquatic food organisms, alter stream hydrology, and cause streambank wastage into streams and debris avalanches. Impacts may be mitigated by an on-site consultation, as allowed by the Timber-Fish-Wildlife Agreement.

Irrigation

Irrigation development has been the primary cause of reduced fish runs in lower Columbia River tributaries, due mainly to lower flows and unscreened diversions. Fish productivity losses due to reduced streamflow, in basins such as the Yakima, have been extremely high. Almost all of the Yakima basin is prime habitat for most species of fish; however, there is not enough water left for the fish at critical times of the year -- the fisheries resource declined almost in direct proportion to introduction of irrigated agriculture. [Note: WDF has been working to correct these problems. Programs include: the Yakima Screen Shop, which monitors, identifies, and services screens; and constructs and installs screens where needed; and the Yakima Basin Early Implementation intended to provide improved fish habitat and create more water for agriculture]

Dryland Agriculture Practices

Cultivation causes dramatic changes in soil and vegetation: soil infiltration rates may be reduced, and soil erosion and runoff may increase. These changes cause downstream impacts including increased flows, turbidity, sedimentation, channel erosion; and speeds channel migration.

Livestock Grazing

Livestock grazing can cause stream temperature fluctuations, increases in stream turbidity, sedimentation of aquatic habitat, bacterial contamination, and reduced fish production (1.a., 1.b., 1.c., 3.a). Best management practices (BMPS) can significantly reduce these impacts.

Urban Construction

Detention ponds and home construction can result in loss of riparian vegetation, loss of cover for fish, and increased sedimentation.

Urban Development

Urban development creates impervious surfaces which can cause increased stream flows, increased waste loads to surface water, reduced baseflows due to impaired infiltration, and disrupted fish spawning and rearing.

Groundwater Withdrawal

Ecological effects are similar to those resulting from surface water withdrawals, especially in cases of hydraulic continuity.

ACTIVE HAZARDOUS WASTE SITES (TREATMENT, STORAGE, AND DISPOSAL FACILITIES OR TSDF'S)

The Risk Report states: "no known [ecological] damage from Washington TSDFs has gone beyond contamination of soil and groundwater."

INACTIVE HAZARDOUS WASTE SITES

Marine and estuarine ecosystem risks include changes in species composition and depressed species abundance; sediment toxicity; bioaccumulation of contaminants in fish and shellfish tissues; fish disease (liver tumors) and mortality as shown in reciprocal transplant experiments and bioassay tests; reproductive effects; and localized exceedences of some ambient water quality criteria.

Freshwater ecosystems exceedence of ambient water quality criteria showing a potential for toxicity effects and avoidance behavior; changes in species composition and depressed species abundance; potential impacts on spawning and reproduction; bioaccumulation of contaminants in fish tissues; accumulation of contaminant concentrations in freshwater sediments with potential toxicity and foodchain effects; and fish disease and excess mortality.

Most impacts will be in relatively confined areas; only a few sites can be expected to result in spatially extensive impacts. Multiple-source urban embayments sites probably provide the extreme case for extent of impacts.

Without remedial actions, ecosystem effects may be longlasting, especially for contaminants that are not very biodegradable (e.g. heavy metals, some PAH compounds)

NONHAZARDOUS WASTE SITES

Major Damage pathways of nonhazardous waste sites are:

a. Contaminated runoff to surface water impacting aquatic flora and fauna;

b. Contaminated leachate, surfacing or otherwise discharging to surface water and causing impacts as above - potential impact on species important to humans (such as salmonid fish) for freshwater ecosystems.

ACCIDENTAL SPILLS AND RELEASES

Primary effects would appear to be death and contamination of fish, shellfish, marine mammals and other aquatic organisms.

The Risk Report estimates that there will be:

a. One large scale oil spill to marine or estuarine water once every 1 to 3 years (one in each of last 5 years);

b. Average of from 3 to 6 with substantial potential for major environmental damage;

c. 15 to 30 with significant impacts; and

d. 750 with some adverse impacts.

LITTER

Ghost nets, crab pots, fishing nets lost or cut loose to drift by commercial fishers may drift for months or years, fish become entangled and die. The Risk Report does not contain Washington-specific information.

WETLANDS LOSS/DEGRADATION

Loss of wetlands equates to loss of habitat for anadromous and game fish during early phases of their life cycle. Wetlands losses in Washington have been substantial -- more than 800,000 acres, or half of available wetlands in Washington State have been lost due to development (3.a., 3.b., 3.f.)

The Risk Report did not provide specific data regarding fisheries' losses related to wetland losses.

FORESTLAND LOSS/DEGRADATION

Conversion of forestland to nonforest uses, such as urbanization, increases the potential for pollution of surface water. This statement reflects the difference between forestland and urbanland, not urbanland versus harvesting timber.

Road construction increases surface erosion and mass wasting.

Timber harvest increases surface erosion and mass wasting, and increases soil compaction. The erosion rate 0.5 and 1.5 tons/acre after first year following clearcut harvesting.

CONCLUSION

As is noted in the "Historical and Current Status Section" of the resource characterization, survival of crustaceans species, such as the Dungeness crab, is primarily determined by the environmental conditions encountered during the larval and early post-larval stages. Consequently large fluctuations in abundance occur. Pacific cod recruitment is greatly affected by environmental conditions, especially water temperature, and the declining catches rates of Pacific cod probably result from low recruitment during warm water years.

The resource characterization also points out, in summary that Whiting, Pacific cod, flatfish, and surfperch declined during the 1980's, at least partially as a result of reduced abundance; regulation changes also contributed to the declines. The cause of the decline in catch and catch rate is uncertain although several possibilities have been suggested: overfishing, shoreline development, changes in fish behavior, loss of experienced fishers and increased marine mammal predation.

It is also important to note that, while relatively stable overall in central and southern Puget Sound and Admiralty Inlet herring-spawner abundance in Hood Canal appears to be very depressed. In northern Puget Sound the largest herring stock in the state has been experiencing extremely low abundance in recent years. Herring can be subject to fairly large fluctuations in abundance, mainly due to the environmental conditions encountered during their first three months of life.

Upper Columbia River sturgeon stocks are believed to have become severely depressed due to dam construction and deterioration of access to spawning areas.

Both overfishing and development have impacted fisheries resources, but one must understand that, while stocks can survive overfishing, fisheries depletion due to habitat loss is irreversible: without habitat the fisheries cannot be restored. Reversability of impacts on water quality, water quantity, and habitat modification, and subsequent fisheries resource implications range from 1 year to several hundred years.

Regulatory agencies can use permit restrictions or denials to alleviate some environmental problems, including habitat degradation, water quality degradation, and water quantity variations. However, as noted in several Risk Reports, environmental degradation continues despite regulation. Exceedences of water quality standards imposed through permits, unpermitted activity, and the incremental, currently unregulated, destruction of small upland wetlands and upland habitat continue to threaten fisheries resources.

This is not to say that regulatory controls have been ineffective. Quite to the contrary, hydraulic project approvals, mitigation policies, water quality laws, habitat restoration, hatchery production, catch allocation, proper project design and other creative management strategies have proven successful. Best management practices (BMP's) have been developed to reduce degradation from timber harvest and agricultural practices, although these BMP's have yet to be implemented statewide.

Despite these measures, however, population pressure, urbanization, water-use conflicts, and other threats continue to degrade resources crucial to survival of Washington's fisheries resources. To complicate matters, nonenvironmental effects from sources such as fishing pressure, noncompliance with harvest regulations, disease, and competition for the resource among user groups make more difficult the challenge of managing our fisheries resource.

Reducing catch pressure and/or increasing artificial propagation do not necessarily eliminate the source of a particular species population decline, especially if the source is environmental degradation. Neither of these solutions can adequately compensate or replace losses incurred due to environmental degradation. Catch reduction means that some people will not get the same portion of the resource to which they have become accustomed. Hatchery operation is expensive, and putting all eggs into one basket, so to speak, is expensive and can be risky. Hatchery populations are vulnerable to disease, atypical weather fluctuations, and human error.

SECTION VI: PROGRAMMATIC CONTROL STRATEGIES

Washington State Department of Fisheries duties are mandated through RCW 75.08.012 Duties of the Department, specifically:

> "The Department shall preserve, protect, perpetuate, and manage the food fish and shellfish in state waters and offshore waters.
>
> The Department shall conserve the food fish and shellfish in a manner that does not impair the resource. In a manner consistent with this goal, the Department shall seek to maintain the economic well-being and stability of the fishing industry in the state. The Department shall promote orderly fisheries and shall enhance and improve recreational and commercial fishing in this state."

The Washington State Department of Fisheries manages the fisheries resource with the goal to make available to the people of Washington the maximum economic, recreational, and aesthetic use and benefit of the food fish and shellfish resources of the state while preserving the basic reproductive stock. Within this general goal, the Department aims to ensure the continuing supply and best utilization of salmon, marine fish, and shellfish to recreational fishers and to those whose primary occupations are commercial fishing, fish processing, and fish product distribution.

An enhancement program continues to be an important factor in the Department's overall production program. Providing sufficient harvest for increasing numbers of fishers, particularly given the implementation of federal treaties, places an increasing demand on agency resources.

Management Structure: Program Activites

To best accomplish these mandates, the Department is organized into eight major functions: Marine Fish; Shellfish; Salmon; Planning, Research and Harvest Management; Administrative Support Services; Field Services; Information and Education; and Interjurisdictional Fisheries. Responsibilities and activities attributed to each of these programs are explained below.

Planning, Research and Salmon Harvest Management (PRHM)

PRHM works to ensure that the commercial and recreational salmon, sturgeon and other anadromous species fisheries are regulated in a manner that resource conservation needs are addressed. Fisheries management includes meeting catch allocation requirements between Indian and non-Indian fishers and the different non-Indian user groups. Applied research and technical support functions are carried out to address specific resource and fisheries information needs pertaining to production, habitat, and harvest management. A major program emphasis is the statewide development of long-term watershed plans for all important river systems that seek to optimize harvest opportunities for salmon consistent with long-term resource capabilities. The objective of this program is to ensure perpetual existence of the fisheries resource while obtaining maximum harvest of the resource in accordance with regional plans developed in cooperation with treaty tribes and fishing groups.

Marine Fish Program

The Marine Fish Program is responsible for conservation, monitoring, management, and applied research on numerous groundfish (lingcod, rockfishes, Pacific cod, flatfishes, dogfish, etc.), baitfish (herring, surf smelt, anchovy, etc.), and albacore. The objectives of the program are to rationally manage marine fish resources; increase recreational and commercial fishing opportunities; maintain sustained harvest yields; and participate in protection of marine fish habitats.

Shellfish Program

In addition to the traditional wildstock shellfish fisheries, the Shellfish Program also has major responsibilities for the private aquaculture industry and for the enhancement of various clam and oyster fisheries. The objectives are to maximize sustained yeild consistent with increasing demands by protecting existing habitat, enhancing stocks and habitat, improving culture techniques, and employing sound management principles; to protect shellfish stocks and operate state oyster reserves.

Information and Education (I & E)

I & E is responsible for communicating with recreational and commercial user groups, the media, and public citizens interested in the fisheries resource.

Units within the program address specific projects. The volunteer Fisheries Cooperative Unit helps the Department and volunteers to work together on enhancement of the fisheries resources. Aquatic Education increases educational activities for the general public. The Fisheries' Conservation Corp helps to train young adults in natural resources fields.

The objective of the program is to improve public understanding and support for the Department's mission and programs.

Field Services (Patrol)

Fisheries patrol officers, boat operators, and aircraft pilots are responsible for the enforcement of all fisheries laws and regulations pertaining to commercial and sport fishing, habitat protection, and protection of state facilities. The objectives of this program are to protect fishery resources from illegal activities such as poaching, overfishing, and violations of the Hydraulics Code and Forest Practices Code; inform the public of proper fishing methods; and cooperate with other state and federal agencies in general enforcement duties.

Salmon Program (Habitat Management and Salmon Culture Division)

The Salmon Program is responsible for enhancing the salmon population of the state of Washington. The program's goal is to perpetuate and enhance the runs of salmon by operating a hatchery system to produce artificially reared fish and enhancing natural spawning runs by protecting and improving salmon habitat. The objectives are to protect and restore natural salmon habitat; cooperate with Indian tribes to sustain harvest yields which are consistent with escapement goals and federal allocation guidelines; increase the contribution to Washington fishers from state-managed hatchery facilities; and maximize fishing opportunities for commercial and recreational fishers.

Habitat Management Division (includes enhancement and mitigation):

RCW 75.20.040 Fish guards required on diversion devices. All water diversion structures must be properly screened to prevent passage of fish into diversion device.

RCW 75.20.050 Review of permit applications to divert water-water flow policy State of Washington policy is to provide water flow to support fish populations at all times in the streams and rivers of the state. The director of Ecology has the permit authority while WDF and WDW advise Ecology.

RCW 75.20.060 Fishways required in dams, obstructions - Penalties, remedies for failure. All dams or fish obstructions caused by man must be equipped with a fishway for both free upstream and downstream fish migration. The WDF-WDW approved fishway must be maintained in an effective condition and supplied with water to freely pass fish at all times.

RCW 75.20.061 Director may modify inadequate fishways and fish guards. If a fishway or fish guard is inadequate and in existence on September 1, 1963, the director may correct the problem without cost to the owner of the structure. After the Department has corrected the problem, the fishways and fish guards shall be operated and maintained at the expense of the owner.

RCW 75.20.090 If a fishway is impractical, fish hatchery or culture facility may be provided in lieu. If the director of Fisheries determines a fishway at a dam is impractical, the person may provide mitigation at the option of the director to building and operating a fish rearing facility to compensate (replace) lost natural production of fish caused by the dam or other hydraulic work.

RCW 75.20.100, .103, and .106 Hydraulic projects or other work - plans and specifications approval - Failure to follow or carry out approval conditions - Penalty - Emergencies. The present law requires that any person who desires to construct any project or other work that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state must secure the written approval of the Department as to the adequacy of the means proposed for the protection of fish life.

RCW 75.12.070 Molesting food fish or shellfish unlawful - Permit required for use of explosives. This statute originally drafted to prevent unlawful capture of fish or shellfish, is utilized also to eliminate, or mitigate losses of fish and shellfish when in-water explosions must be used during construction projects.

RCW 43.21C State Environmental Policy Act (SEPA). SEPA was enacted to assure that the environment is given appropriate consideration in state and local permit decisions. This is accomplished by requiring documents that provide information on potential impacts from certain projects. WDF develops, reviews and responds to various SEPA documents and recommends or requires project design components that will eliminate, or reduce, or mitigate recommendations to protect, reduce, and mitigate impacts on fish, shellfish, vegetation, surface waters, recreation, and commercial fishing.

RCW 76.09 The Forest Practices Act, administered by the Department of Natural Resources, requires that a Forest Practices Approval (FPA) be obtained before beginning a forest practice on nonfederal forest land. Most activities related to growing and harvesting timber are subject to this law.

Fisheries primary obligation is to field review and issue HPAs as required. Field biologists assist forest landowners, tribes, environmental organizations, DNR, and other state agencies in designing and reviewing forest practices, especially practices affecting riparian management zones. Habitat management staff also serve at various levels on implementation, research and policy committees (both regional and statewide) that pertain to implementation of the Timber, Fish and Wildlife Agreement.

RCW 90.58 The Shoreline Management Act. This legislation (local government with Ecology review status) regulates various forms of land use and development in and within 200 feet of marine waters, streams with a mean annual flow of 20 cubic feet per second or more, and lakes which are 20 acres or more in surface area. Associated wetlands are also included.

WDF has advisory authority only. For projects that require a shoreline permit under the Act, WDF makes recommendations to local government for fish and wildlife mitigation and protection. This often comes in conjunction with or simultaneously with SEPA review. In addition, WDF is on the Ecology advisory task force that reviews and comments on Shoreline Master Programs. WDF, on occasion, intervenes in Shoreline Hearings Board matters and as witnesses in the proceedings. WDF also works with local government advising them of various habitat issues such as bait fish spawning areas, aquaculture, and the habitat needs of fish and shellfish in all waters of the state.

U.S. Army Corps of Engineers Section 10 and 404 permits are established by the federal Rivers and Harbors Act (1899) and the Water Pollution Control Act amended as the Clean Water Act (1972). These laws are designed to control water pollution and protect the nation's waters from uncontrolled modification. Section 10 permits are required for work in navigable waters which generally include all marine areas, streams which have been used in interstate commerce, and wetlands.

Fisheries uses Corps and Coast Guard public notices as applications for Hydraulic Project Approval (RCW 75.20.100). We respond directly on nonfederal projects to the applicant and advise Ecology (state of Washington Coordinator by Governor's office) of our action on the Hydraulic Project Approval. On federal projects we respond through Ecology as the state of Washington coordinator and designated manager of the federal water quality certification.

The Fish and Wildlife Coordination Act (16 U.S.C. 661-667; enacted 1958) applies when a proposal involves surface water and a federal permit is needed, or when federal funds are used for planning and construction. It requires that fish and wildlife receive consideration equal to other project features. Federal and state fish and wildlife agencies must be consulted by project sponsors to develop plans to prevent the loss or damage of fish and wildlife resources. This act gives WDF a strong voice through the U.S. Fish and Wildlife Service on many federal projects. Our comments are coordinated with WDW on fish habitat issues.

The Federal Power Act (16 U.S.C. 797-817; enacted 1970) allows state fish and wildlife agencies to intervene in licensing procedures for all non-federal hydroelectric projects in order to protect fish and wildlife resources. WDF consults with project sponsors, examines proposals and studies and inspects the site to help determine potential impacts on fish. Following this, conditions are identified for resource protection and a mitigation/compensation plan is developed. The program is administered by the Federal Energy Regulatory Commission (FERC).

The Federal Power Act was modified by the Electric Consumers Protection Act in 1986. The amendment gave a heavier burden of responsibility to the states in general and fish and wildlife agencies in particular.

Major changes included:

1. Required hydroproject siting will best adapted to a state comprehensive plans - including fish and wildlife plans.

2. FERC must now accept fish and wildlife agency recommended terms and conditions for project development, unless FERC finds them to be inconsistent with the purposes or intent of the Federal Power Act (a difficult standard to meet).

3. State and federal fish and wildlife agencies recommend appropriate studies/evaluations, which the applicant must do, unless he can convince FERC that they are not relevant.

We have a much stronger role as an agency and state in deciding hydrolicensing matters.

The National Environmental Policy Act (NEPA), P.L. 91-190, is similar to SEPA as is our involvement. As discussed in an earlier section WDF reviews the environmental documents and makes recommendations to protect and mitigate impacts on fish and habitat.

Timber/Fish/Wildlife, or "TFW," negotiations in 1986 brought an unlikely group of individuals together as they sought ways to achieve win/win answers to a broad range of resource issues that had them suing one another in years past.

For years timber interests, treaty Indian tribes, the State Departments of Fisheries, Wildlife (then Game), and Natural Resources, and environmental groups were involved in a kind of battle royal, fighting over conflicting interests, generally as they related to the impact of timber production and harvests on fish and wildlife. Each group had a bias and often it was impossible to convince them the other(s) had anything of merit to offer. Sometimes personalities got in the way of understanding.

The 1974 State Forest Practices Act regulates forest practices on state and private forest lands. Regulations adopted as a result of the Act were revised by the Forest Practices Board in 1975, 1977, and 1982. Further revisions relating to the riparian (streamside) forest zone were proposed for the spring of 1986. Each set of changes to the Act set off a new round of conflicts between the parties.

With new conflict beginning to surface, many of those who had been combatants began to look for a new way to solve their differences. Some wondered if they could not develop a system for managing forest practices that did a better job of protecting resources yet allowed timber companies to work profitably.

"Maybe we can do things the Forest Practices Board cannot," they wondered.

They sought a facilitator, agreed to put personality and historical differences aside and decided to explore the chance they could agree to agree.

The ground rules were that there would be no votes and each interest would have ample time to present its point of view. During the course of the discussions . . . they ultimately ran on for four months, long time enemies found time to really listen to one another and found they actually agree on many points.

The group faced a deadline. The proposed riparian changes to the Forest Practices Rules were going to be considered. If they were to develop another way to do business, it would have to happen before the Rules were amended.

The timber industry wanted predictability, small woodlot owners wanted to protect their land from stringent regulations that forced them to convert it for other uses, Indian tribes wanted to protect treaty fishing and hunting rights and archaeological and cultural and religious sites and the environment. State agencies wanted an effective and enforceable system of land management. Environmental groups represented a variety of views . . . water quality interests, fishers, wildlife advocates. Finally, in early December, 1986, they reached an Agreement in Principle they could pass on to the Forest Practices Board for review.

The Forest Practices Board blessed the Agreement. In February, the landmark exercise led the Department of Natural Resources to develop a new set of regulations reflecting the agreement.

Implementation began in January, 1988. All parties staffed up to meet the obligations of TFW. The first annual review found no great discomfort with TFW. The second annual review is slated for October, 1989.

Habitat Management Regulations and Policy: History of Regulations

The State Hydraulic Code was passed in 1949 and was interpreted by some as applying only to freshwater rivers, streams and their associated beds. During the 1960s, the U.S. Army Corps of Engineers began enforcing the Rivers and Harbors Act of 1899 by requiring federal construction type permits in all navigable waters of the state (including marine waters and freshwater lakes). The Governor of the state entered into an agreement with the Corps of Engineers that state input to Corps Permit Applications (Public Notices) would be coordinated through the Department of Ecology. This gave WDF an opportunity to better provide fish and shellfish habitat protection in the marine and estuarine waters of the state.

WDF biologists and engineers drafted and began using specific criteria in the review of marine projects in 1971. The original criteria protected only juvenile salmonids critical shallow water areas and shellfish areas from bulkheading and filling. The original criteria were expanded to protect surf smelt spawning habitat and Pacific herring spawning habitat. Most federal, state, and many local governments began using the criteria in their own permit systems (e.g. USFWS, NMFS, EPA, DOE, Shoreline Master Programs etc.). In 1978, the Washington Supreme Court strongly advised WDF and WDW to formally adopt WACs in marine and fresh waters. This was done about 1980 and are modified about every two years.

Habitat Management Policy - Washington Department of Fisheries is in the final stages of formalizing its long-standing policy of habitat management. The policy, simply stated, contains an objective of achievement of a net gain of the productive capacity of the habitat of the food fish and shellfish resources of the state. This will be accomplished by pursuit of three goals: 1) maintain the productive capacity of all existing food fish and shellfish habitat (protection), 2) restore the productive capacity of habitats that have been damaged or degraded by natural causes or as a result of human activities (rehabilitation), and 3) improve the productive capacity of existing habitat and create new habitat (enhancement).

In pursuit of goal number 1, the Department has a general practice of requiring, to the extent of its authority and influence, that the proponent of an activity potentially damaging to the habitat: 1) take all reasonable steps to avoid habitat damage, 2) take all reasonable steps to minimize any unavoidable habitat damage, and 3) replace, using proven methods, the full productive capacity of any unavoidably damaged habitat. Activities that cannot meet these conditions are opposed.

In pursuit of goal number 2, the Department uses legal means of requiring responsible parties to rehabilitate damaged habitat. Where no legal means exists, where no responsible party can be identified, or where the damage was from natural causes, the Department repairs the damage on a time-available, prioritized basis.

In pursuit of goal number 3, the Department conducts a varied habitat enhancement program. Salmon stream enhancement, artificial reef construction to increase population of marine fish species, and beach gravelling to increase the production of hardshell clams are examples of enhancement projects.

Mitigation policy

Mitigation policies provide a strict set of criteria that must be imposed if certain specific types of projects are undertaken. The following are examples of two such mitigation policies.

WASHINGTON DEPARTMENT OF FISHERIES GEODUCK MITIGATION POLICY:

Geoduck density above 0.4 m/2 (including pre-harvest levels)

Long-term habitat loss shall not occur without replacement of the lost production and habitat, utilizing a proven method for replacement of the lost production and an appropriate method for replacement of the lost habitat, provided that the method utilized for replacing the lost habitat is evaluated to determine its adequacy. Further, it is the policy of the Department to not allow any negative impact on geoducks which are deemed by the Director to be critical or unique for broodstock purposes.

Temporary loss of habitat may occur; however, any loss of production will require replacement.

Geoduck density below 0.4 m/2 (including pre-harvest levels

Long-term habitat loss may occur; however, any loss of production may require replacement, utilizing a proven method for replacement of the lost production.

Appropriate Method

An in-kind method of replacing lost geoduck habitat that is deemed acceptable by the Director of the Washington Department of Fisheries.

2. POL-89-04 ARTIFICIAL REEF DESIGN AND CONSTRUCTION

Artificial reefs are permanent alterations of the bottom habitat designed to enhance finfish and shellfish production and contribute to the management of these resources. This policy is to regulate the construction of artificial reefs to ensure that the marine resource enhancement benefits of the reef will outweigh potential impacts on the bottom habitat and other marine resources.

A. Criteria for artificial reef construction must meet one or more fishery or habitat needs

Fishery or habitat needs may include: (1) enhancement of fishery opportunity or catch at a specific location, (2) enhancement of spawning, recruitment or survival of fishery resources, and (3) effective mitigation for impacted rocky habitat.

B. Artificial reefs must minimize negative impacts on existing fisheries, and fish, shellfish and other natural resources.

C. Mitigation may be required for unavoidable impacts to fish, shellfish or other natural resources caused by the artificial reef.

D. Pre-construction biological baseline surveys of the proposed area are required at least one each seasonal quarter (January-March, April-June, July-September, October-December) for one year.

The Department will determine specific survey methodology once a proposed location is selected.

The biological data from these surveys must be made available prior to permit review.

E. Post-construction surveys of biological development on the artificial reef are required at least one each seasonal quarter starting one year after reef construction and proceeding for two years.

The Department will determine specific survey methodology once a proposed location is selected.

F. Artificial reefs must consist of only high density materials that are inert in sea water.

No more than 5 percent of the materials may be less than one foot in diameter.

G. Structures must consist of piles of loose material, or separate modules.

Research has shown artificial reefs significantly impact shellfish life on the natural substrate overcovered by the reef materials.

Total overcovering of the natural substrate shall not exceed 50 percent of the total permitted area.

Any one pile shall not overcover more than 25 percent of the total permitted area.

The distance between each pile shall not be less than 50 feet.

H. Proposals are to be reviewed by all resource programs prior to formal legal process.

Final proposal must represent agencywide consensus.

I. Artificial reef construction is subject to State Environmental Protection Act (SEPA) review and must meet all other applicable state, federal, and local regulations.

Salmon Habitat Enhancement

In the past few decades, the production of salmon from natural spawning in many streams in Washington has declined significantly. Deterioration of spawning habitat has been caused by naturally-occurring erosion as well as by expanded forest practices, agricultural activities, highway construction, dam construction, and urban and residential development. These processes in many cases, have resulted in water quality degradation, loss of stream bank cover, stream channelization, increased variability of flow, migration blocks, harassment of spawning fish, loss of rearing area, and deterioration of stream bed spawning gravels.

Historically, increased chinook and coho salmon production at hatcheries was the most common method employed for compensation of lost or damaged habitat. This has resulted in both significant successes and failure as not all hatcheries have been successful and the increased chinook and coho production in some areas has been at the expense of native salmon populations, particularly chum and pink salmon. In addition to direct losses through predation by the larger hatchery reared juveniles, native stocks can be adversely affected by factors related to disease, genetic integrity, and over harvest due to commingling with hatchery fish. Hatcheries are expensive to construct and operate and the increased production of juvenile salmon at some facilities may also be negated by increased natural mortality factors (disease, ability to find food, etc.) as compared with wild fish which are genetically more diverse.

All suitable habitat for native salmon should be utilized to the maximum potential and restored or enhanced where feasible, as this is the practical and ecologically safe way to preserve genetic diversity of various salmon stocks. Removal of small fish passage obstructions, restoration of damaged spawning and rearing habitat, and the construction of small, semi-natural, spawning channels are typical projects that cause little interference with the natural life history of salmon and, therefore, involve less research information and less risk than rearing in hatcheries. These projects represent a solid investment in the restoration/ enhancement of native salmon runs.

The presence of excessive amounts of fine sediments in the gravel is a common problem limiting salmon production in many streams. Successful incubation of salmon eggs and larvae requires clean, well-aerated gravel and survival is greatly reduced when fine sediments fill up the voids and prevent adequate water circulation through the nests constructed by the adult salmon in the stream bed. This sedimentation can result from a variety of man's activities that expose raw earth to erosion as well as from naturally occurring sources. Excessive sediments also fill in pool areas that serve as primary rearing habitat for juvenile salmon upon their emergence from the gravel and limit the production of benethic organisms which provide food for the juvenile fish.

Once sources of sediment have been reduced or eliminated in a watershed, natural processes begin to clean fines from the gravel. Gravel will be agitated during high stream flows, and finer materials will be re-suspended and transported downstream until lower current velocities again allow settling. Thus, natural cleaning of gravels can take several years, during which time there may be substantial reductions in spawning success or available area for spawners. In some cases, it is impossible to eliminate sources of silt and in others, natural flows are insufficient to clean gravels in a reasonable amount of time. In such areas, techniques developed by this program to clean or replace gravel are effective ways of increasing the productivity of the area.

Spawning success is also reduced where stream bed gravels are unstable and subject to large-scale erosion or deposition during high stream flows. High gravel deposition rates occur where the stream gradient lessens sharply, for example, when a hillside stream enters the floodplain of a large river. Gravel loss occurs where stream velocities during freshets are great enough to cause downstream movement of bed materials. Without natural or man-made controls, gravels suitable for spawning would be transported downstream during periods of high water, leaving only coarser bed materials.

Three primary techniques are presently used to accomplish rehabilitation of poor-quality spawning areas. They are: 1) gravel cleaning; 2) gravel replacement; and 3) side channel development.

Gravel cleaning is accomplished with a machine which "vacuums" sediment material from within the stream bed and deposits it outside of the wetted perimeter of the stream. Gravel replacement involves the use of heavy equipment to excavate contaminated, poor quality gravels from a stream channel. The spoils are disposed of away from the project site and clean, graded spawning gravel is placed into the excavated channel. Often, log weirs are used to stabilize the new gravel in the channel and control and stream bed gradient to create optimum spawning conditions.

Side channel (mini-spawning channel) developments employ several of the preceding techniques to rehabilitate river side channels for spawning. The head of the channel may be diked off and culverted to protect the area from flooding and to provide a controlled flow for spawning purposes. Depending on the gravel quality and gradient in the side channel, gravel replacement and the installation of weirs may be needed.

Additional spawning and rearing areas are made available by construction of passage facilities at falls and at impassible culverts that were installed years ago. (A multi-million dollar hydroelectric project can create an obvious adverse impact on natural fish populations but numerous, poorly installed road culverts can also take a large toll, although less obvious.) Stream bed controls are utilized at most obstructions and some concrete fishways have been built. Other rearing areas are established by the construction of small ponds which provide excellent protected over-wintering habitat for juvenile coho salmon and by reclaiming stream sections which were previously ditched, channelized, overgrown with vegetation, etc. Where appropriate, eyed eggs or fry are planted into rehabilitated streams to aid reestablishment of the runs.

<u>Salmon Culture Division</u>

Salmon hatcheries have been in existence for nearly 100 years. However, only in recent years has advanced fish cultural practices, disease control, and newly developed fish foods made hatcheries a highly effective tool in management of salmon stocks.

A common misconception is that there is no need to protect the natural habitat of salmon because hatcheries can supply all our needs. Although hatchery produced salmon make important contributions to our fisheries, for a variety of reasons it would be dangerous to rely exclusively on them. In addition, hatcheries are expensive to build and operate.

In some cases we do not even have the required technology. For example, the largest commercial fishery in the state is for sockeye salmon produced naturally in Canada's Fraser River. No hatchery program for sockeye has yet been successful. Similarly, few chum salmon and even fewer pink salmon are produced in hatcheries. Most hatcheries raise chinook or coho salmon. All the hatcheries in Puget Sound combined produce only about the same number of fish as do our streams. It would be even more expensive and impractical to replace our other food fish and shellfish resources with hatchery production.

Other fish culture facilities share hatcheries operated by the Department are short-term rearing net pens, spawning channels, salmon egg incubator channels, streamside egg boxes, and rearing ponds.

Shellfish aquaculture facilities include a geoduck hatchery on Hood Canal, and promising beach graveling projects to enhance hardshell clam natural production.

Shellfish Enhancement Projects - Coastal

WDF shellfish enhancement efforts in Washington's coastal region have targeted razor clams. We operated a pilot hatchery at Nahcotta from 1980-87. While we made considerable progress in spawning adult clams, and rearing through larval and juvenile stages, we did not attain a production level operation. In 1987 we were forced to terminate this project because of a funding shortage.

We have also operated a project which uses a combination hydraulic/airlift device, towed behind a boat, to harvest juvenile razor clams offshore, for transplant to intertidal beaches. We developed technology and procedures from 1980-84. In 1985 we transferred over 90 million juvenile clams from the Copalis Rocks area to Twin Harbors Beach and Long Beach. In 1986-87 we were unable to locate clams in significant numbers. In 1988 we transplanted over 30 million clams. While we still need to develop techniques for evaluating survival, hence contribution to the fishery, we believe that the operation will be a valuable long-term tool for enhancing intertidal razor clam stocks.

Artificial Reefs/Marine Habitat

Departmental research on artificial reefs has been ongoing since 1977. A total of five scientific documents were presented at the Fourth International Conference on Artificial Habitats for Fisheries in Miami, Florida in November, and have been accepted for publication in the Bulletin of Marine Science.

During 1988, work has been directed toward developing habitat criteria to provide increased protection for habitats critical to the survival of the five baitfish and 52 groundfish species under the management jurisdiction of the Department. Information on the habitat requirements of the majority of marine fish species is insufficient to ensure their complete protection and preservation. (WDF 1988 Annual Report)

SECTION VII: SUCCESSES

1986, a typical year, of examples of successes in prevention of habitat loss and resource enhancement

Small Hydro - Small hydro project proposals continue to proliferate throughout the northwest, with Washington receiving a full share. Over the past few years over 500 different sites have been proposed for small hydro development. Approximately 200 of these sites are still actively being considered and require the attention of the Habitat Management Division. Review and monitoring of these sites seek to make certain the salmon resource is protected from harm or that mitigative measures are included in each proposal. Through the past year, many of these small hydro project applications were processed through the Federal Energy Regulatory Commission (FERC) which meant WDF, tribal and federal entities worked together and consulted with the project applicant. Typically these projects require that habitat staff make certain plans which contain provisions for meeting instream flow requirements, consider long and short-term construction impacts, and that operating policies do not negatively affect the natural, productive capability of the waters.

Major Existing Projects - Washington's many large hydroelectric dams have significantly impacted the region's salmon resource and continue to do so in varying degrees. Dams on the lower Columbia River (below Chief Joseph and Hells Canyon dams) are among the most serious in terms of their effect on salmon. Over the past several years, efforts at these 13 large hydroelectric facilities have begun to turn this trend around. Springtime water flows have been controlled to help move juvenile migrants downstream in a timely manner. Submerged traveling screens (STS) have been installed at many of the projects to safely pass juvenile salmon and steelhead around the dam. Where there is no STS, spill conditions are developed to allow young fish passage. Three species of salmonids have responded well to the improved migration conditions - sockeye salmon, fall chinook salmon, and steelhead trout. Returns of these stocks have dramatically increased over the past few years.

Migration Negotiations - The state's fishery agencies and affected Indian tribes reached an agreement on FERC relicensing the Rock Island hydroelectric project on the mid-Columbia River. The agreement calls for the project operators to produce 2.5 million yearling sized salmon each year to offset losses caused by the facilities' turbines and reservoir. This is the first such utility agreement reached on the mid-Columbia River.

Additional negotiations are underway with the cities of Tacoma and Seattle regarding losses of fish habitat associated with their water diversion dams on the Green and Cedar rivers. Access to large areas of excellent habitat was denied when municipal water diversion dams were constructed in the two watersheds. Again, fisheries agencies have been joined by Indian tribes in these talks with the municipalities. Fish interests seek mitigation for past, present, and future fish losses.

Yakima/Wenatchee Basin Fish Passage - Major rehabilitation projects aiding both adult and juvenile fish passage in the Yakima and Wenatchee River basins were completed in 1987. The efforts were funded through the Northwest Power Planning Council's Fish and Wildlife Program. Fishway and fish screening projects have been completed at Sunnyside, Wapato, Horn Rapids, Roza and Prosser dams on the Yakima River and Tumwater and Dryden dams on the Wenatchee River. These passage facilities will allow adequate upstream-downstream movement of fish and are a major step in restoring salmon runs in these basins.

Yakima Screen Shop - The Screen Shop has two functions, to monitor, identify, and service the more than 100 area fish screens and bypass systems and to construct and install screening and bypass facilities where they are needed to move juvenile salmonids safely downstream past irrigation diversion structures and other water withdrawal projects. In 1986 the cost of inspecting and maintaining these screens was over $225,000. Without screening, a large portion of the salmon and steelhead spawned in the Yakima basin would be lost each year.

Yakima Basin Early Implementation - Federal legislation developed in 1986 and approved this year, funds a second phase of the Yakima River Basin Water Enhancement Program that will help provide improved fish habitat in the basin and create more water for agriculture. The program calls for new water storage facilities in the upper basin, consolidation of existing irrigation systems, and adoption of a water conservation plan. WDF's Habitat Division will work with other fisheries interests, agricultural and irrigation representatives, and others to design a program providing water for fish and other needs.

Environmental Review, Permits - In 1988 the combined permit and environmental review sections provided major habitat protection through writing 2,790 Hydraulic Project approvals, 406 Forest Practice permits and 602 Coprs of Engineers Public Notice responses. This totals almost 3,800 in 1988.

Marine Permits - Working closely with WDF's Shellfish and Marine Fish programs, the Marine Permit section of the Habitat Division strives to provide habitat protection for all Washington marine waters. In 1986 the team wrote almost 1,000 Hydraulic Project Approvals providing protection for the state's resources, yet allowing corporations and individuals to make wise use of marine waters and shorelands.

A broad range of issues required the attention of the Marine Permit staff. For example, plans to locate the U.S. Navy Carrier Battle Group at Everett led to concern that dredging activity in the area and the dredge spoils could harm Dungeness crab stocks. Review and modification of the dredging proposal was coordinated through the Marine Permit Section.

- A proposed Elliott Bay marina project needed review and modification to protect kelp beds and habitat used by juvenile salmon. A proposed ship harbor marina at Anacortes could have posed a threat to crab populations and eelgrass beds if unchanged.

- A U.S. Navy dredging plan for Hood Canal was modified to protect habitat important to young salmon and important eelgrass producing areas.

- Sewer outfalls planned for Elliott Bay required mitigation for associated losses of geoduck populations.

- A widening and deepening project for the Grays Harbor channel was reviewed and redesigned to lessen its impact on water quality, salmon habitat, and dungeness crab.

The Marine Permit staff also reviewed and fine tuned several U.S. Army Corps of Engineers projects on the lower Columbia River, eliminating negative impacts they may have had on sturgeon and juvenile salmon.

In addition to permit and project review, the Marine Permit staff was increasingly involved in work related to the state's increased emphasis on water quality. Staff represented WDF on several task forces including Puget Sound Water Quality Authority subcommittees, Puget Sound Dredge Disposal Analysis subcommittees, and the Oil Spill Advisory Committee.

In 1986 the Marine Permit section and the Shellfish Program worked on guidelines for pen siting and a companion geoduck mitigation policy to guide review and approval of future salmon net pen projects.

Finally, working with the Marine Fish, Salmon, and Shellfish programs, the Marine Permit Section was able to coordinate studies of the Arco Anchorage oil spill in Port Angeles Harbor and recover resource damage and full damage assessment costs from those responsible for the spill.

Water Allocation - Through 1986 the Habitat Management Division worked, primarily with the Department of Ecology, on improvements to the state's Instream Resources Protection Program (IRPP), a mechanism for preserving and protecting instream flows for fish and other needs.

Increasing water demands have placed pressure on many watersheds with new water users seeking lower minimum flow levels. WDF is working to guarantee protection of existing fisheries resources while aiding out-of-stream water users.

Satsop Spring Channels - Similar to the side-channels mentioned above, the spring channel investigations on the Satsop River focused on six ground water-fed areas. Four were modified to improve poor spawning and rearing habitat.

Downstream chum salmon migrants from these areas were trapped to measure egg to fry survival rates and to determine to what extent other salmonids use these channels.

Findings indicate at least a four-fold increase in egg to fry survival over average survival rates in stream settings without side-channels. The side-channel areas provide clean, stable waterflows and less temperature fluctuation than main river areas. They offer a very positive benefit to cost ratio and require little maintenance.

The Coal Creek Project - Typical of the habitat restoration work conducted statewide by WDF is the Coal Creek log weir fishway built in conjunction with slope stabilization project on this tributary to Lake Washington.

The problem here was twofold. A fish barrier had developed as a result of degradation at a culvert and bank erosion had endangered a major sewer line.

Fish passage was reestablished by building the stream level back up to the culvert with a series of streambed log controls. The eroding bank was sloped back and layered with willow cuttings so the bankline would be permeated with willow roots. The result is a bank capable of withstanding several water and flow levels without washing away. The willows also provide shade and cover for juvenile fish. The project is less costly than the traditional rocked (rip rap) bankline.

Toutle River Fingerling Planting - The destructive eruption of Mt. Saint Helens in May of 1980 nearly wiped out salmonids in the Toutle River and drastically changed habitat throughout the drainage. WDF's Habitat Management Division began releasing coho fingerlings in the system in 1983. The effort continued on a small scale until this year when short-term (two-month) coho rearing was initiated at the Toutle Hatchery (closed after being severely damaged by the 1980 eruption).

Since 1982, WDF's Habitat Management Division has opened 35 miles of Toutle River spawning and rearing habitat by removing log jams, modifying bedrock and developing off channel areas.

The Toutle coho stocks were prized by sportsmen throughout the lower Columbia River.

This year WDF and the Army Corps of Engineers entered into a cost reimbursable contract to mitigate for salmon habitat lost as a result of construction of the new sediment retention structure on the North Fork Toutle. This $300,000 package will allow WDF to continue enhancement projects on the Toutle.

Salmon habitat enhancement projects benefitted an average of 212 miles of stream annually during the period 1984-1988. A listing of stream miles still inaccessible to salmon because of obstructions e.g. impassable road culverts, is currently being compiled for future salmon production areas.

Timber Fish and Wildlife (TFW) - WDF continues to be active in the administration of TFW through membership in interdisciplinary teams and committees developing resource management plans. WDF has 16 Freshwater Regional Habitat Managers and three Freshwater Area Supervisors that share the TFW field responsibilities for the state. Other staff members are involved with the TFW Cooperative Monitoring, Evaluation, and Research Committee and the cooperative development of a Geographical Information System for use by the TFW participants.

The TFW Agreement allows fishery biologists on-site review and evaluation of forest practices. The Department now can assist in the planning process before the trees are cut so that there is sufficient protection of the fish and their habitat.

SECTION VIII - POPULATION GROWTH IMPACT

The potential for impacts on fisheries resources in the future certainly exists and relates to a number of predicted events. One of the most striking predictions for Washington State in relation to fisheries resources is the predicted increase in the human population. There are several aspects of this prediction that may have profound influence on fisheries resources.

An obvious influence which is likely to occur is an increased demand for fishing opportunity. A major increase in recreational pressures may be offset, in part, by increasing the available resource at least for some resources. In other cases, harvest management schemes will have to be altered to reduce catch. Without these changes, fish resources would decline. In any case, catch per person will decline with an increase in human population and an increase in recreational demand. It is important to consider the ultimate effect of this type of threat to the resource in comparison to impacts due to development. Overharvest may reduce resource populations but, with adequate numbers of seed stock, subsequent reduction in the harvest will allow recovery of the stock. Loss of habitat is permanent and the effect on production is felt in perpetuity.

The predicted population increase will result in an increase in the urbanization in the western area of the state. Urbanization brings with it a whole host of potential and in some cases probable events. These include loss of riparian habitat due to land conversion from agriculture and forestry to urban and suburban. With the increase in hard surfaces in urbanized areas, changes in stormwater quality, quantity and timing are also likely. As mentioned in the detailed analysis, the resultant changes in fish habitat include an increase in pollutants in streams and water bodies, increased scour in streambeds during high flows and a decrease in low flows. These changes all result from development that occurs on the lands not covered by water.

In addition to the changes in fish habitat resulting from the development above the ordinary high water, urbanization will bring an increase in pressure to make changes within the ordinary high water line. A major increase in human population will bring with it a major increase in water consumption and concomitant demand for water withdrawals. This would entail a further reduction of stream flows. The most likely areas for development are the flood plains. Movement into these areas will bring pressure to construct flood protection measures including dikes, levees, hardened banks (riprap, bulkheads, etc.) and flood control structures. All of these affect fish habitat directly or reduce riparian habitat available. In addition, there will be increased pressure to fill and develop wetland areas that become surrounded by urban areas. The subsequent changes to fish habitat would include direct loss of habitat if the wetland is used by fish, and potential changes in runoff water quality and flow regime.

The increasing human population will also entail a probable increase in decertification of shellfish beds. If the newly urbanized areas were sewered, the new outfall(s) will result in decertification due to the threat of contamination. In unsewered areas, intensive development will lead to increase in fecal coliforms in nonpoint runoff.

The recent trends in forestry do not bode well for fisheries resources. The trend is toward increasing size of clear cuts and ever shorter rotation cycles. These changes exacerbate the impacts mentioned previously under the forestry section of this report. A positive note relative to forest practices is that the Timber Fish and Wildlife Agreement has resulted in an adaptive management strategy which, it is hoped, will enable us to avoid some of the potential impacts. However, another alarming trend is toward an increase in the number of conversions from forestry uses to development uses. The impacts of these conversions are similar to those summarized above for urbanization.

The effects of global warming are also of concern. While there is some doubt about the size of the anticipated change and greater doubt about the projected time frame, the potential for profound influence on fish populations of recreational and commercial importance is high should the predictions prove true. Species most likely to be affected include temperature sensitive ones such as Pacific cod and some salmon species.

SECTION IX - FUTURE STATUS PROJECTION

Salmon: Coastal, Puget Sound and Columbia River (Sekulich and Edie 1989) Assuming habitat stability, catches (lbs. of fish caught, not number of pounds of fish per fisher) for the 1987-2010 period are expected to average approximately the same as the previous 12 years. Annual fluctuations related to short-term environmental and spawning escapement variations are obviously anticipated.

Shellfish Coastal (Northup 1989)

Razor Clams: Lack of understanding about the current disease life history, the method of infection and the exact relationship between infection intensity and subsequent levels of mortality make difficult to impossible the projection of resource viability through 2010. Since the onset of the disease in 1983, there have been no patterns established that can use to predict future clam populations with any reliability.

Based on the last five years and the fact that currently the razor clam population is still 100 percent infected, in the judgment of professionals, the current trend of declining populations and unstable fishery opportunities continuing for an unknown period of time.

Fisheries professionals cannot project any more than about six months into the future. The disease is too unpredictable and major changes in infection intensity can occur within a one or two month period.

In the judgment of professionals responsible for monitoring the razor clam population, until there is some dramatic change in the disease or the clams ability to resist the disease, we are probably stuck with it and need to manage accordingly.

Dungeness Crab: Abundance will continue to fluctuate. We expect fishery production to decline during 1990 and 1992 due to below-average strength of the 1986 and 1987 year classes and to increase in 1992 due to a much stronger 1988 year class. This assumes no major perturbations, either natural or man-caused, will occur in the coastal estuarine or nearshore environment.

Pink Shrimp: Abundance of pink shrimp is expected to continue fluctuating much as it has, and landings will follow suit. The trend toward greater numbers of vessels in the fishery bears observation, and may hold catch per hour of towing below levels previously attained.

Oyster: The most serious challenge facing the oyster industry of Pacific and Grays Harbor counties is that of water quality, degradation by either domestic or industrial pollution cannot be tolerated by an industry that will live or die by water quality.

Washington Department of Fisheries, Ecology, DSHS, Pacific and Grays Harbor counties and Willapa Bay/Grays Harbor Oyster Growers Association, as all of Washington State, must be eternally vigilant to protect our present good to excellent shellfish waters. A projection of water quality in the future remains to be an ever present concern, it can remain excellent or we can lose it. The future depends upon our true commitment to preserve our most valuable resource water.

Coastal Ghost Shrimp: As more emphasis is placed on recreational fisheries, the demand for ghost shrimp as bait will continue to increase. The magnitude of this increase, as well as its impact on the ghost shrimp population, are unknown. Projections as to future changes cannot be made without adequate baseline information. It is hoped that the lease/permit system and harvest logbooks will provide the needed information to keep and maintain a healthy and viable fishery well into the future.

Hardshell Clams

Shellfish Puget Sound (Burge and Baumgarner, 1989)

Puget Sound Dungeness Crab: Based on catch trends since 1951 and present management, Fisheries expects crab production to continue at existing levels in future years so long as habitats remain stable.

Sea Urchins: Limited entry legislation, passed this spring, should return the fleet to 1987-87 season levels. This would limit yearly harvest to an amount estimated to be sustainable annually - four million pounds.

Sea Cucumbers: WDF is monitoring key indicators (catch per unit effort, average size of harvested animals, and dive survey data) to detect signs of overfishing at the new levels. Limited entry or limited seasons may be required to hold harvest to acceptable levels.

Geoduck: The management plan for geoduck limits geoduck harvest to five million geoduck per year. Within five years we expect to double this figure due to successful "seeding" of harvested geoduck beds with hatchery-reared juveniles.

Spot Shrimp: So long as present management strategies are continued and habitats remain stable, condition of this resource should remain at existing levels in future years.

Hardshell Clams: Hardshell clam populations will remain stable or increase slightly although the populations may not be usable due to domestic and industrial waste pollution. The industry is expected to continue to enhance private tidelands for manila clam production and the state will enhance public tidelands for recreational and tribal use.

Marine Fish Puget Sound (Schmitt 1989)

Puget Sound Groundfish - General: Conditions in the future will vary by species/species group and each is discussed in the following sections. However, in general, groundfish are becoming increasingly popular to both recreational and commercial harvesters. Species that are currently under-utilized may experience increased exploitation however other species that are currently fully utilized may become under-utilized. For example, the closure of much of Puget Sound to bottom trawling results in under-utilization of many species, especially flatfish.

Puget Sound Lingcod: Lingcod populations have shown increases and decreases in the recent past which may have been a result of overfishing or natural variation in recruitment. Studies have shown that good year classes occur every few years and generally support the fisheries. As in the case of the population decline in Central and South Puget Sound, reduced abundance can occur.

Natural reductions in lingcod populations can be expected in the future because of variations in survival. However, conservative management restrictions on sport and recreational catches should be able to control the rate of decline and provide for a sufficient population of lingcod that will be able to replenish the population when survival improves. Conversely, populations may increase with successive periods of good survival, and some of the current restrictions may be relaxed.

Puget Sound Pacific Cod: The catch levels in the last 46 years have shown alternating periods of elevated and depressed catches occurring frequently. The expectation is that this is a natural pattern brought about by environmental conditions affecting survival of young fish. We can expect that there will continue to be periods of high catches and low catches ranging between 1.5 and 3 million pounds. The cod stocks in the areas which are now depressed should recover perhaps aided by the curtailment of fisheries in these areas. As the populations fluctuate, areas may be opened and closed in order to protect the stocks when they are at low levels.

Changes in management priorities and strategies may affect catches in the future. Reductions in commercial fishing areas will lead to decreases in commercial catches but not necessarily concomitant increases in recreational catch. Catch levels may decrease and may not be an effect of population change but of a change in fishing effort.

Broad scale climatic changes may influence the performance of the fishery compared to the recent years. Since cod are on the southern end of their natural range, global and oceanic warming may provide a poor environment for cod survival in our area, causing reduced commercial and sport catches and more erratic population fluctuations.

Walleye Pollock: Since pollock are on the southern end of their range, changes in the environment may affect the number of young fish available to replenish the adult stock. Environmental conditions would be expected to change again to promote recruitment to the adult population and pollock catches should become enhanced. Periodic increases and decreases would therefore be expected in the future.

Management strategies may help to stabilize the fluctuations by restricting fishing to protect the stock when it is at low levels.

Pacific Whiting: At present, whiting populations are low and recruitment is variable. Strict management of the resource will keep fishery exploitation rates low until the stock has rebuilt. Increased natural mortality by marine mammal predation may hinder rebuilding and the commercial fishery may not be allowed to return to its former level. A succession of good year classes may be necessary to bolster the depressed populations. Eventually, a series of strong year classes can be expected, but as with other codfishes, long-term variability in year class strength and populations can be expected.

Spiny Dogfish: Based upon the performance of recent fisheries and conservative management by Canada, the dogfish population is projected to increase greatly over the next 10 to 15 years. Simulation models projected into the future show that the population will decrease after this period of increased abundance and will reach a stable level with low or medium fishing effort. Yields will increase with the short-term increase in abundance but will be lower and stable after this period of increased abundance ends and populations become diminished but stable.

Market conditions may change prompting increased or decreased interest in the commercial exploitation of dogfish. Diminished market conditions and a failure of the fishing effort to achieve the predicted harvests could keep dogfish populations high. Conversely, dogfish effort may increase and without regulation, could decimate populations and cause poor yield in years to come.

Surfperch: How the recent declining trend in catch or catch per unit effort relates to population abundance is not clear. Presumably, the recent management restrictions will cause the decline to stabilize and possibly rebuild. Catch levels should not be allowed to exceed the historical high catches achieved in the early 1970s. Recreational and commercial effort should continue, with increased sport catches with sport effort. Commercial markets are expected to continue and may increase with the ever increasing demand for fresh bottomfish.

Flatfish: Flatfish catches are expected to decrease in the near future as a result of more restrictive regulations rather than abundance declines. The bottom trawl fishery in the major harvester of flatfish, will be permanently closed after July 26, 1989 in all areas south of Admiralty Inlet. Flatfish in the less restricted areas in northern Puget Sound may experience greater fishing pressure and may decline as a result. Flatfish populations in those areas with reduced fishing pressure should increase and probably will be under-utilized.

Halibut: Managed by international treaty. Projection not available.

Rockfish: Rockfish catch levels are expected to decrease in the near term not as a result of decreased populations but as a result of decreased commercial landings of rockfish. Management actions to reduce commercial fisheries will decrease the commercial rockfish landings, especially in Puget Sound south of Admiralty Inlet. As time progresses, the recreational catch may increase perhaps as a result of increased availability from the cessation of commercial fishing, but also as a result of more angler trips.

The effect of the short-term decrease in commercial harvest will be generally unknown since few indices and data exist to assess rockfish abundance. Average size may increase or decrease but insufficient monitoring exists to detect any changes.

Surf Smelt: Preservation of existing spawning habitat is critical, as a minimum, to maintain present population.

Herring: Projections of future herring populations do not exist, however fluctuations in abundance will continue to occur. In the judgment of professionals, even with conservative fisheries management, herring abundance may slowly decline overall due to environmental degradation of important habitat.

Marine Fish Coastal (Millikan 1989)

Because of a coordinated coastwide management regime, it is likely that the harvest of coastal groundfish stocks will continue to be maintained at levels ear or below the Acceptable Biological Catch. These levels of catch are set and reviewed annually to ensure the long-term health of the fishery. Thus, the coastal groundfish resource may be expected to exhibit a certain amount of natural variability, but should in general remain fairly stable over the long-term. In the case of Pacific ocean perch, however, it is unlikely that stocks will return to historic levels due to the level of bycatch of this species which occurs as part of the targeted fisheries.

The scenario painted above is based primarily on the assumption of continued management controls on fisheries and the absence of any large scale environmental degradation of a chronic nature. It is important to realize that an assumption implicit in most fisheries management regimes is that recruitment will remain relatively constant over the long-term. If environmental degradation by man impacts recruitment (e.g. destruction of spawning habitat, increased mortality of juveniles due to pollution of estuarine habitats) this assumption no longer holds, and projections should be modified accordingly.

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THE STATE OF THE ENVIRONMENT REPORT

VOLUME II
Part 6

Fish and Wildlife Resource Characterization Report

ENVIRONMENT 2010

State of Washington
October, 1989

WASHINGTON ENVIRONMENT 2010
FISH AND WILDLIFE RESOURCE CHARACTERIZATION

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WASHINGTON ENVIRONMENT 2010

FISH AND WILDLIFE RESOURCE CHARACTERIZATION

SUMMARY

There are approximately 500 species of fish and wildlife for which the Washington Department of Wildlife (WDW) has management responsibility. To provide a "characterization" of these resources, they are presented in the report as eight separate groups (Resident Fish, Warmwater Fish, Anadromous Fish, Big Game, Migratory Game, Furbearers, Upland Game and Nongame). These groups were selected because they reflect agency program organization.

Resident fish (trout, char and landlocked salmon) are present in nearly all streams and about 650 of the state's 5,000 lowland lakes and 1,200 of the alpine lakes. Warmwater fish (sunfish, catfish, perch, pike, and bass families) are present in about 90 percent of the lowland lakes. Anadromous fish (sea-run Dolly Varden, cutthroat and steelhead trout) occur in the majority of the streams and rivers. Big game (deer, elk, bear, cougar, bighorn sheep, moose and mountain goat) occur statewide wherever remaining habitat permits. Furbearers (raccoon, beaver, muskrat and skunk, among others) are also broadly distributed with higher concentrations associated with riparian areas and wetlands. Migratory game (ducks, geese, swans, coot, snipe, band-tailed pigeons and mourning doves) includes about 40 species which are distributed statewide by habitat requirements of individual species. Upland game (grouse, pheasants, quail, partridges, turkeys, rabbits, and others) are also variously distributed throughout the state. Nongame (approximately 400 species) are distributed throughout the state according to habitat needs and availability. Some are widely distributed while others occur only in isolated areas.

Statewide estimates of the current numbers of most fish and wildlife groups, though there are exceptions, are generally not available. Numbers are available in many cases, however, based on specific geographic area or species. The following are some examples. Currently, there are about 525,000 steelhead (combined summer and winter runs). There are about 200,000 black-tailed deer, 67,000 white-tailed deer, and 135,000 mule deer. Elk herds total about 57,000; bear 19,000; and cougar 1,500. Wintering waterfowl total about one million and production levels are about 600,000 annually.

In very recent years, numbers of species in most groups have remained fairly stable, but there are examples both of losses and gains. Over a longer time span, however, numbers in most groups show definite declines. Some examples follow. Prior to hydro development, the Columbia River alone supported about 550,000 steelhead. Since 1960, deer populations have declined by 50,000 for black-tailed, 15,000 for mule deer, but white-tailed numbers have increased by 17,000. Elk have increased moderately since 1960, bear have declined by about 10,000 and cougar numbers have increased by 900. Peak waterfowl harvests have dropped from 800,000 to 300,000 in 1987 though numbers may be increasing.

The major risk to the state's fish and wildlife can be summed up as habitat loss or alteration. If for example losses occur to agriculture lands, there will be losses to upland birds such as pheasant. Losses in riparian and wetland areas will reduce numbers of waterfowl, nongame, furbearers and fish. Many nongame species are grouped by special habitats (shrub/steppe, old growth, meadow/prairies and juniper forest among others). Loss or alteration of these habitats is critical to the wide variety of species that depends on them. Fish and wildlife resources are also threatened by accidental releases such as oil spills or point discharges and nonpoint pollution. Habitat loss, however, is considered to be the most significant threat of all this.

Washington Environment 2010 Risk Analysis efforts provided additional insight on the issue of threats to our wildlife resource. "Key threats," as defined by the Washington Environment 2010 Technical Advisory Committee included nonchemical impacts on recreation land, nonchemical impacts on range land, disruptions to the hydrologic cycle caused by human activities, pesticides, wetlands loss and/or degradation, accidental releases, radioactive releases, global warming and stratospheric ozone depletion and litter.

The additional information contained in these risk analysis reports is summarized in this report. It is certain that the overall habitat base will continue to decrease. It is uncertain what the rate of loss will be. In light of this, it is expected that the vast majority of species will decline in numbers. Existing numbers even of priority management species will be extremely difficult to maintain. We estimate that approximately 11 nongame species will be extirpated from the state by the year 2010.

WASHINGTON ENVIRONMENT 2010
FISH AND WILDLIFE RESOURCE CHARACTERIZATION

I. FISH AND WILDLIFE - For the purposes of this report fish and wildlife resources are largely discussed as groups. These groups consist of Resident Fish, Warm water Fish, Anadromous Fish, Big Game, Migratory Game, Furbearers, Upland Game, and Nongame. These eight groups reflect present agency organization and fish and wildlife management programs. Because of the direct relationships of fish and wildlife to healthy ecosystems, we considered using a habitat approach to this resource characterization. The overall lack of or sparsity of current and past information on a statewide basis, however, rendered such an approach infeasible even though habitat is so vitally critical to fish and wildlife management.

A. Resource Subcategories

Resident Trout - This includes populations of char, landlocked salmon and trout that do not migrate to the sea. Washington's resident trout fisheries are divided into three major programs.

Lowland Trout Lakes - All natural lakes and man-made lakes, ponds or reservoirs below 2,500 feet in elevation managed exclusively for resident salmonids or where the primary emphasis is for salmonids even if other game fish are present; plus lakes, ponds or reservoirs above 2,500 feet that have direct road access and are managed as "low-land lakes".

Resident Trout Streams and Beaver Ponds - All flowing waters (perennial or intermittent), natural impoundments of flowing waters, and small impoundments with beaver dams at the outlet that are managed primarily for resident salmonid resources. Other game fish species may be present. These waters are generally not accessible to anadromous game fish.

Alpine Lakes - All natural lakes and man-made lakes, ponds or reservoirs above 2,500 feet in elevation that are accessible only by foot, horseback, or ATV. The generally low productivity and short growing seasons in these waters precludes management of most game fish species other than resident salmonids.

Warmwater Fish - As used in the context of this report, includes any species of fish within five families; sunfish, catfish, perch, pike, and bass, (Centrarchidae, Ictaluridae, Percidae, Esocidae, or Serranidae). At present, all the warm water species in Washington are exotic to this area, mostly having been brought in during the late 1800's by the U.S. Fish Commission. Those species are listed in following sections with the probable year and place of introduction, the general ranges and habitat types.

Anadromous Fish - This includes; steelhead trout or anadromous "rainbow trout" (Oncorhynchus mykiss), both summer and winter runs; sea-run cutthroat trout (O. clarkii); and sea-run Dolly Varden (Salvelinus malma). The main characteristic of this group is that they all as adult fish return from the sea to spawn in fresh water. The timing and frequency of this life cycle varies from species to species and population to population.

Big Game - There are ten species or subspecies classified as big game. This includes black-tailed deer (Odocoileus hemionus columbianus), mule deer (O. hemionus hemious), white-tailed deer (Odocoileus virginianus ochrourus), Roosevelt elk (Cervus elaphus roosevelti), Rocky Mountain elk (Cervus elaphus nelsoni), black bear (Ursus americanus), cougar (Felis concolor), mountain goat (Oreamnous americanus), bighorn sheep (Ovis canadensis), and moose (Alces alces). The pronghorn antelope (Antilocapra americana) is classified as a game animal, but there has never been a hunting season for them. The grizzly bear and caribou are classified as protected wildlife. Since no hunting is contemplated in the foreseeable future on these protected species, they are treated as part of the Nongame Wildlife Program.

Migratory Game Birds - This category consists of approximately 40 species of birds including ducks, geese, swans, coot, snipe, band-tailed pigeon, and mourning dove. Many of these birds migrate up to thousands of miles during spring and fall. They are protected by federal as well as state laws and regulations.

Furbearers - Furbearing animals are animals generally recognized as having a fur coat that is of commercial value. The list of furbearers found in Washington includes: opossum, beaver, muskrat, nutria, coyote, wolf, red fox, raccoon, marten, fisher, short-tailed weasel, mink, wolverine, badger, striped skunk, western spotted skunk, river otter, Canada lynx, and bobcat.

For management purposes furbearing animals in Washington are classified in the Washington Wildlife Code as game animals and as furbearers. These include: beaver, muskrat, mink, river otter, marten, Canada lynx, bobcat, badger, raccoon, long-tailed weasel, short-tailed weasel and red fox.

Other furbearers such as wolf, fisher, and wolverine are not classified as furbearers in the Wildlife Code, but are classified as Endangered or Protected Species. Because the populations of these protected species are small and are very limited geographically, no harvest is allowed.

Opossum, nutria, coyote, striped skunk and western spotted skunks are not classified as game animals or furbearers in the Washington Wildlife Code. Therefore they are referred to as unclassified furbearers.

Upland Game - Twenty-one species are included in the upland game program: blue grouse, ruffed grouse, spruce grouse, white-tailed ptarmigan, sage grouse, sharped-tailed grouse, ring-necked pheasant, valley quail, mountain quail, scaled quail, bobwhite quail, chukar partridge, Hungarian partridge, wild turkey, mourning dove, band-tailed pigeon, common snipe, cottontail rabbit, snowshoe hare, black-tailed jackrabbit, and white-tailed jackrabbit. Except for grouse, rabbit and hare, most of these species are not native to Washington.

Nongame - These resources are described in two sets of "subcategories": programmatic and problematic. Discussion of the programmatic subcategories is necessary to establish definitions and an understanding of the general problems nongame wildlife face.

There are 497 recognized species of birds, mammals, fishes, reptiles, and amphibians in Washington. Of these, 406 are classified as nongame species (Appendix A). The Nongame Program has responsibility for managing invertebrate species as well, but there are too many to enumerate. There are numerous separate subspecies that are managed as if they were full species.

The Nongame Program has been divided into four main subprograms based largely on species status. These subprograms are: Endangered, Threatened, and Sensitive Species; Monitor Species; All Other Nongame; and Urban Wildlife.

Endangered, Threatened, and Sensitive Species - There are about 50 species of wildlife that must be listed or are being considered for listing as endangered, threatened or sensitive in Washington. It is unfortunate that populations of these animals have declined to the point where the Department is concerned they may not survive here without intensive management. Most populations currently exist in small, isolated, or widely scattered locations; all have experienced declines from historic levels due largely to loss of habitat or other human disturbance.

Species are classified into five categories according to: historical abundance or evidence of decline; size and distribution of populations; species habitat versatility or specificity and the vulnerability of this habitat to alteration; species tolerance to disturbance.

These five categories are as follows:

1. State Endangered - on the brink of elimination from all or a significant portion of its range in Washington;

2. State Threatened - could become endangered in Washington without active management or the removal of threats;

3. State Sensitive - could become threatened due to limited population size and distribution, sensitivity to disturbance during critical stages in its life cycle, or dependence on very specific habitat type.

4. State Monitor - of special interest due to its requirement for limited habitats, its function as an indicator of environmental quality, or unresolved taxonomic or population status problems.

5. Other Nongame - nongame species not otherwise classified above.

Only endangered, threatened, and sensitive species are included in this subprogram; monitor and other nongame species are included in separate subprograms.

Developing endangered species lists provides a means of informing the public and state and federal land management agencies as to which species warrant special attention when weighing land and water management alternatives. Drawing attention to species prior to their achieving endangered status permits all agencies to undertake management activities with much greater flexibility than would be available once a species has actually become endangered. If, through cooperatively designed management, we can avoid endangering species, we can hopefully eliminate the inflexible and controversial management practices often required to protect a fully endangered species.

Threatened and sensitive categories allow the Department to recognize and list those species approaching endangered status. This listing underscores the need for special management by land and water management agencies in the best position to help preserve these species.

Monitor Species - There are 116 species proposed as monitor species, 49 of which are invertebrates. These species have been identified as requiring special management emphasis due to their unresolved taxonomic or population status problems, their function as indicators of environmental quality, or their requirements for limited habitats. In recognition of their special needs, marine mammals and seabirds not classified as endangered, threatened, or sensitive have their own species group management plan in addition to the general monitor species plan.

Other Nongame Species - There are 406 vertebrate species which are nongame program's responsibility to manage. Of these 406, 225 are classified or proposed as monitor, sensitive, threatened, or endangered. The remaining 291 species include all vertebrate wildlife not classified as game or furbearing species, inland fish, and non wildlife species not classified as food fish by the Department of Fisheries. A total list of nongame vertebrate species is included in the appendix. Three important components of this group are marine mammals, sea birds, and urban wildlife.

Invertebrate wildlife species are also the nongame program's responsibility but are too numerous to list in the context of this document.

B. Distribution and Abundance

Resident Trout

Lowland Trout Lakes - There are approximately 5,000 lowland lakes in Washington with equal numbers on the East and West side of the state. Trout are present (either planted or wild) in approximately 650 waters.

Resident Trout Streams and Beaver Ponds - There are approximately 50,000 miles of streams in Washington. Virtually all of them have wild resident trout in them. Only a very small number of the state's streams are planted with hatchery fish.

Alpine Lakes - There are approximately 3,000 alpine lakes in Washington. They are primarily found in the Cascade and Olympic mountains. About 1,200 have trout populations.

Warmwater Fish

In Washington, of the nearly 5,000 lowland lakes and reservoirs, with about 564,467 surface acres of water (WDW, undated), it has been estimated in the past by WDW that 90% of all this acreage is occupied by warmwater fish. This equals about 508,000 acres of water.

Anadromous Fish

Winter run steelhead are found in most of the perennial streams of Puget Sound, the coastal area, Hood Canal, the Strait of Juan de Fuca, and the Columbia River upstream to the Wind River in Skamania County. Light (1987) estimated the total population of winter steelhead in Washington to be 263,200 fish, of which approximately 70% were of hatchery origin (184,200 fish) and 30% wild/natural origin (79,000 fish).

Summer-run steelhead are found primarily in the Columbia River system, with some relatively limited populations in larger coastal waters, the Strait and Puget Sound streams. All steelhead from the Columbia system above the Wind River are considered to be summer runs.

Light (1987) estimated the total Washington summer run populations at 258,800, of which 80% (207,700 fish) are hatchery origin and 20% (51,100 fish) are of wild/natural origin. (Note that these figures include all fish passing Bonneville Dam.)

Sea-run cutthroat are found in almost all stream systems in Puget Sound, Hood Canal, the Strait of Juan de Fuca, the Washington coast and the Columbia River system below Bonneville Dam. Historically, sea-run cutthroat occurred above Bonneville Dam possibly as far upstream as the Klickitat River.

There are no estimates of total abundance of sea-run cutthroat available. Sea-run cutthroat are believed to be less abundant than steelhead, however, and hatchery enhancement of this species is on a much smaller scale than for steelhead.

Sea-run Dolly Varden are found in larger stream systems in Puget Sound, Hood Canal, the Strait of Juan De Fuca, the Washington coast, and the Columbia Rivėr below Bonneville Dam. They are also associated with some smaller streams such as the Copalis River on the coast.

No estimates of total abundance of anadromous Dolly Varden are available. They are generally believed to be less abundant than either steelhead or sea-run cutthroat. There is no hatchery enhancement of this species.

Big Game

Black-tailed deer range throughout western Washington. Individuals home range can be as small as a mile or less in diameter. These deer use a variety of habitats; forested areas for shelter, open areas and cultivated lands for feeding, and edge areas for escape and movement. They use a wide variety of habitat types.

Mule deer are migratory and are found throughout eastern Washington from the grass/shrub and pine forest communities of Okanogan County to the irrigated farm areas of the Columbia Basin. The largest populations of mule deer are found in north central Washington where there is less competition with other big game species. In northern Washington, white-tailed deer compete with mule deer, while Rocky Mountain elk share range in south central and southwestern parts of the state.

White-tailed deer are Washington's least abundant deer and are found primarily in northeastern Washington, although their range extends west into Okanogan County and south to the Blue Mountains. White-tailed deer habitat is characterized by dense forest, brushy creek bottoms, and agricultural lands with adjacent woody cover. There are presently about 67,000 white-tailed deer. A separate subspecies, the Columbian white-tailed deer (Odocoileus virginianus leucurus) is found in restricted areas along the lower Columbia River, where it is fully protected as an endangered species. The Columbian White-tailed Deer Refuge, located near Cathlamet, has been established by the U.S. Fish and Wildlife Service to protect this rare subspecies.

Roosevelt elk are found in western Washington primarily from the Olympic Peninsula through the southwestern corner of the state, although huntable populations are also found in Pierce and King Counties and to a lesser extent in Skagit and Whatcom Counties. The largest populations presently occur on the Olympic Peninsula and Mt. St. Helens' area. As with black-tailed deer, logging significantly affects elk populations. Historically, animal numbers tended to increase in areas opened up by clearcutting. The Roosevelt elk is an inhabitant of forest lands, however, and requires the presence of standing timber or heavy cover for its existence. During stormy and windy weather, elk seek the shelter of heavily timbered areas. Loss of winter range is a major limiting factor. These animals presently total about 29,000.

Rocky Mountain elk were first introduced in both eastern and western Washington in 1912 and, after several transplants, are currently found mainly in the foothills of the Cascades in Yakima and Kittitas Counties, and in the Blue Mountains of southeastern Washington, and in small numbers in Pend Oreille County in the northeast corner of the state. Some Rocky Mountain elk were introduced in the Enumclaw area in western Washington and have interbred with native Roosevelt elk. The elk in the Mt. Rainier areas are a mixture of Roosevelt and Rocky Mountain elk. Habitat requirements are similar to those of Roosevelt elk. There are presently about 28,000 Rocky Mountain elk.

Black bear are distributed throughout the forested areas of Washington with the highest populations found in the Olympics, west side of Mt. Rainier, and in the northeastern corner of the state. Bear populations are presently estimated to be about 21,000.

Cougar are found throughout most of the forested areas of the state. Highest numbers occur in the northeastern part of the state and the Olympic Peninsula. Cougar have a home range of 75 to 100 square miles. This range is generally the same as its prey species: deer, elk, mountain goat, and mountain sheep. It is estimated that there are about 1,500 cougar in the state.

Mountain goat inhabit the remote areas of the Cascades and Olympic Mountains. They are native to the Cascade range from Mt. Adams to British Columbia. They were introduced to the Olympics. Present populations total about 7,500. Nearly 2,000 of these animals occur in national parks. Mountain goat winter range consisting of steep slopes, low elevations, conifer stands, two feet of snow or less and an abundance of mosses and lichens is critical to their survival.

Bighorn sheep in Washington consist of two subspecies: California (Ovis canadensis californiana) and Rocky Mountain (Ovis canadensis canadensis). The former are found along the

Cascades, primarily eastern slopes and the Blue Mountains. The latter occur in the northeast and southeast parts of the state. Numbers are estimated to be about 540 and 210 respectively.

Moose occur only in small numbers and only in the far northeastern part of the state. The preferred habitat of moose is composed of marshes, ponds, lakes, and various wetlands where aquatic vegetation and riparian growth is abundant. Current moose numbers total about 180 animals.

Migratory Game - Waterfowl, coot, and snipe are distributed throughout the state, but major concentrations occur in the Columbia Basin, Puget Sound, Grays Harbor, Willapa Bay, and the Columbia River estuary. Band-tailed pigeons occur primarily in low elevation forested areas of western Washington, while mourning doves are concentrated in irrigated portions of Eastern Washington. Breeding populations of waterfowl have been increasing since 1970 (Table 1). Washington presently provides wintering habitat for approximately 1 million ducks, geese, and swans, and produces over 600,000 ducks and geese annually. Washington is the wintering area for approximately 50,000 snow geese from Wrangel Island, USSR; 20,000 brant from the Northwest Territories, Yukon, and Alaska; and almost 3,000 swans from Alaska. Approximately 35,000 Washington hunters harvested approximately 400,000 ducks and geese in 1987 (Table 2). Table 3 provides inventories by species.

Furbearers - Furbearing animals are found throughout the state. All species in this group have furs of commercial value. The majority of furbearers are either directly dependent or closely associated with the riparian areas of lakes, streams, ponds, and wetlands. There is very little specific information available for distribution and abundance of these species. The most abundant and widely distributed species are raccoon, muskrat, and beaver.

Upland Game - Upland game species are distributed throughout the state from the "desert" areas of eastern Washington, to the alpine meadows of the Cascades, to the rain forests of the Olympics. These animals occupy a wide variety of habitats. Rabbit and ruffed grouse are the most abundant and widely distributed species in western Washington. In Eastern Washington, chukar, rabbit, and ring-necked pheasant are the most common and widely distributed animals.

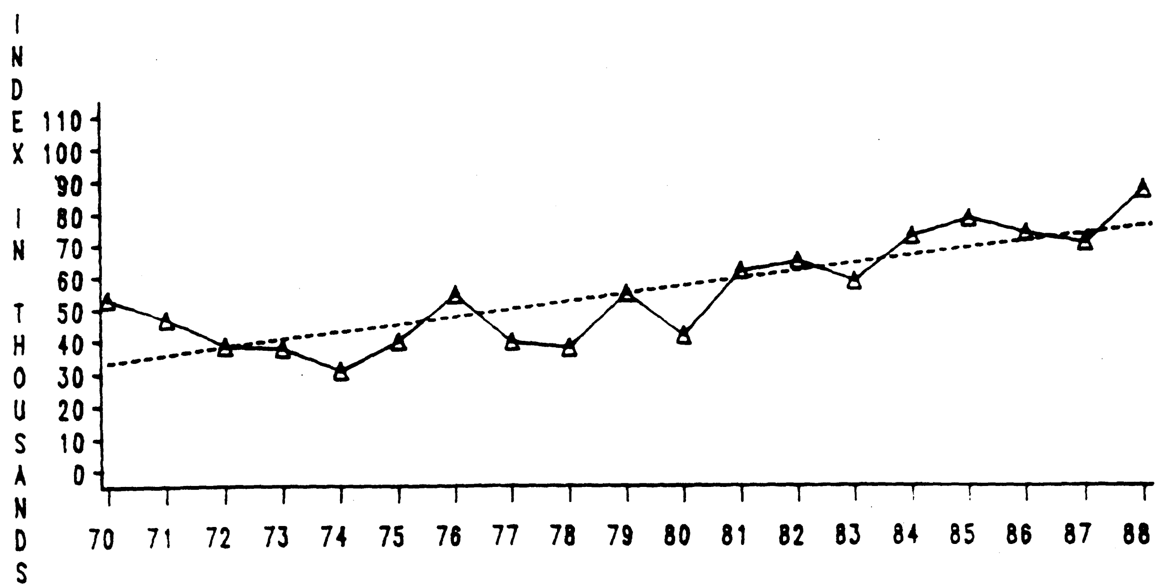
Nongame - Little is known about the distribution and abundance of most nongame species. Some have never been studied; many others have received only preliminary examination. Habitat is perhaps the best indicator for the status of these species.

Most of the species of special concern: endangered, threatened, sensitive, and monitor species (Appendix B), warrant this status because their populations have diminished to the point they are

TABLE 1

BREEDING POPULATION INDEX FOR MALLARDS

EASTERN WASHINGTON SURVEY AREAS



BREEDING POPULATION INDEX FOR OTHER DUCKS

EASTERN WASHINGTON SURVEY AREAS

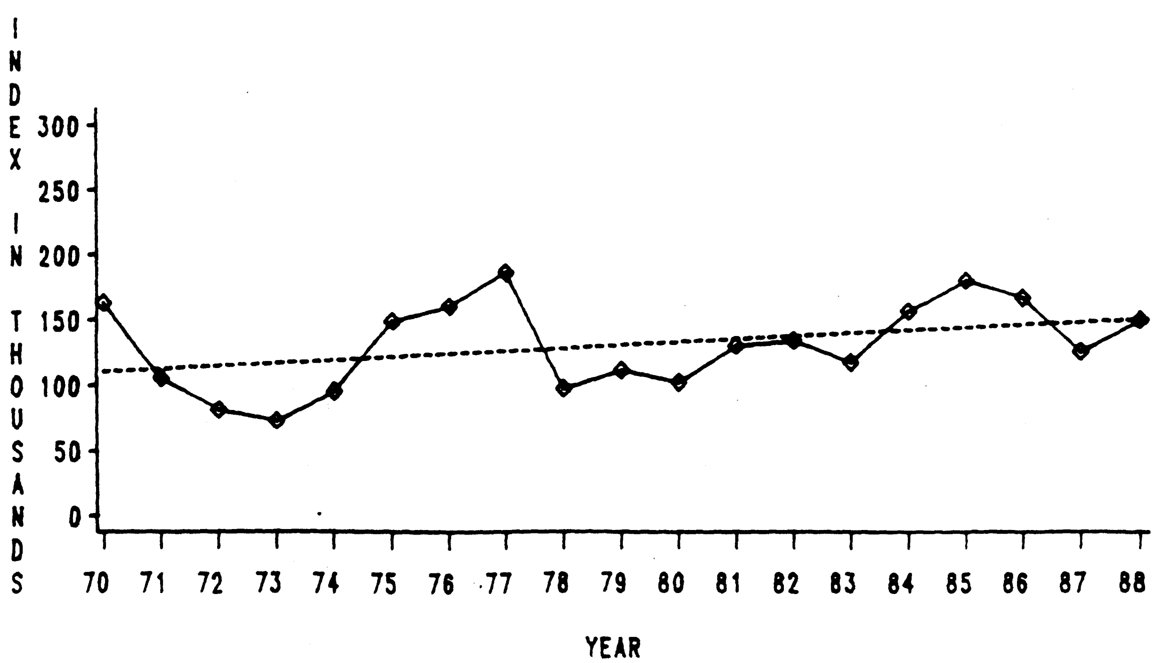
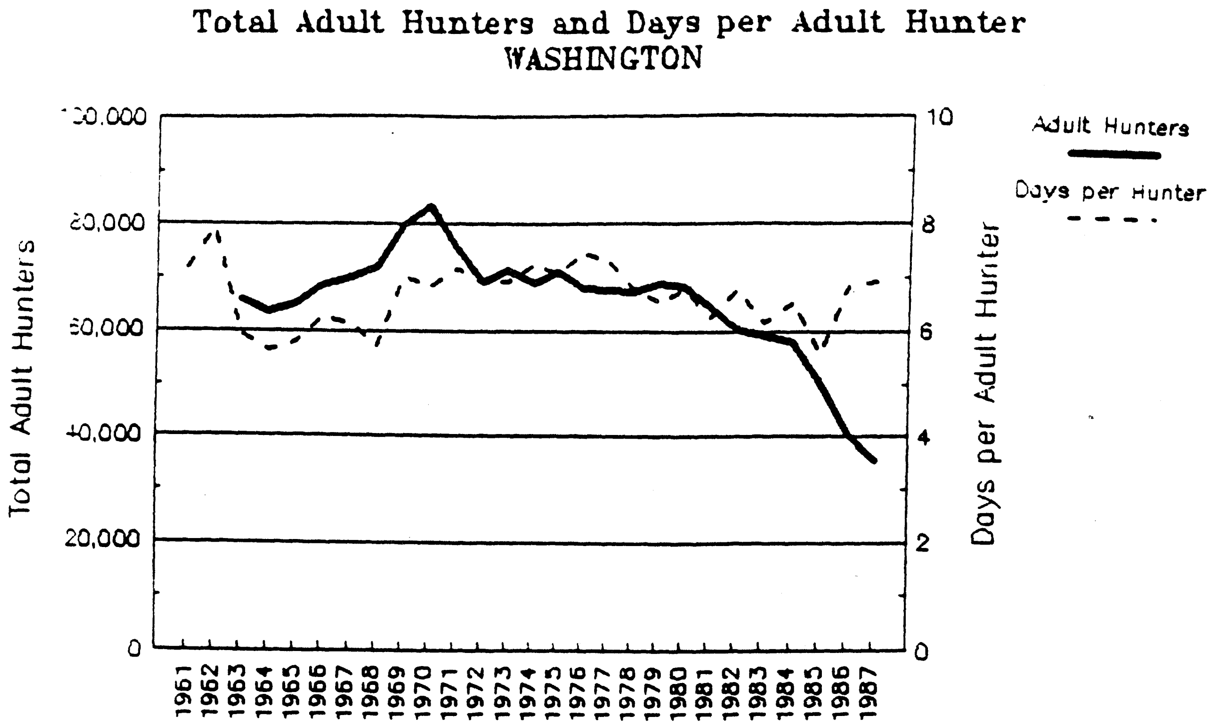
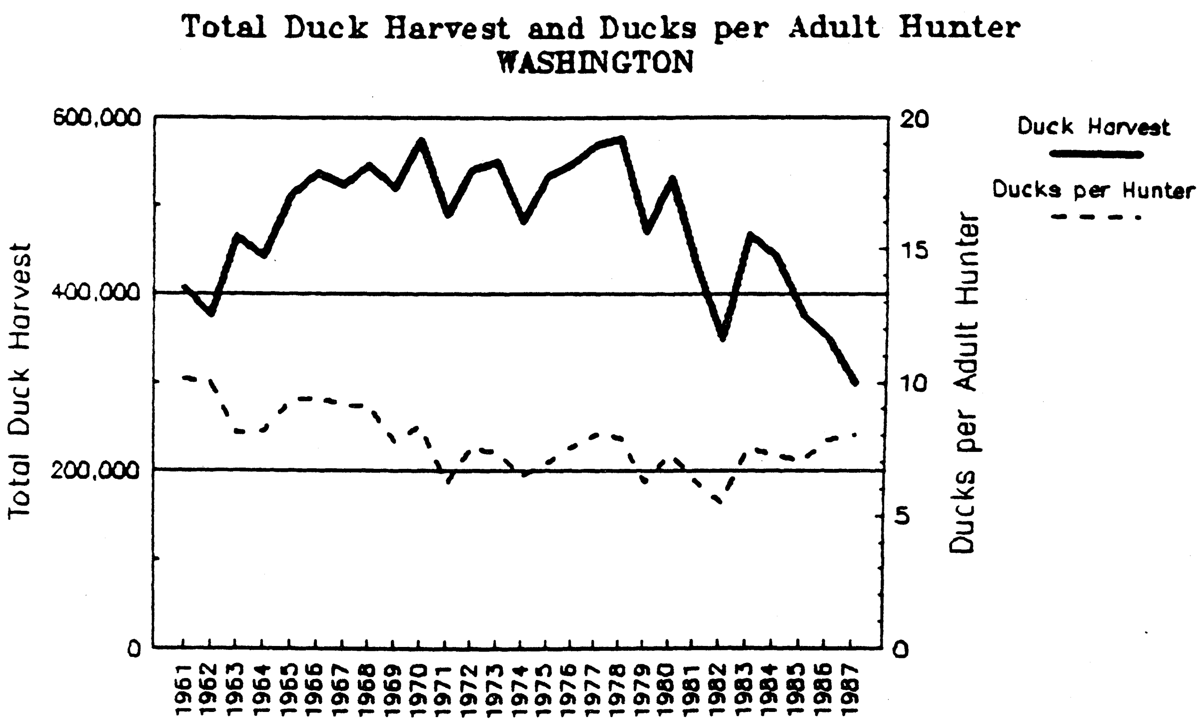


Figure 5 Eastern Washington breeding population indices (WDW surveys).

TABLE 2


Total Adult Hunters and Days per Adult Hunter
WASHINGTON
20,000
40,000
0
10
8
6
4
2
0
Total Adult Hunters
Days per Adult Hunter
Adult Hunters
Days per Hunter
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987


Total Duck Harvest and Ducks per Adult Hunter
WASHINGTON
600,000
400,000
200,000
0
20
15
10
5
0
Total Duck Harvest
Ducks per Adult Hunter
Duck Harvest
Ducks per Hunter
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987

STATE OF WASHINGTON
THE DEPARTMENT OF WILDLIFE
ANNUAL WINTER WATERFOWL INVENTORY

Species	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Mallard	439,425	603,356	476,063	541,550	417,033	708,498	501,489	525,671	611,420	485,948
Gadwall	2,791	1,394	5,816	2,724	2,875	5,339	3,041	2,530	5,032	5,674
Wigeon	97,301	102,386	59,323	70,191	83,915	91,448	91,855	60,319	153,526	96,074
Green-winged Teal	18,483	28,351	10,885	9,293	1,676	9,643	8,664	12,051	21,201	15,355
B.W. & Cinn. Teal	7	566	0	160	4	7	16	66	24	0
Shoveler	1,919	7,150	3,134	1,461	885	1,033	467	1,130	1,001	1,236
Pintail	70,653	84,077	19,903	32,051	43,371	51,162	38,895	21,925	74,797	78,612
Wood Duck	1	91	62	33	258	60	87	82	534	240
Redhead	693	7,724	8,542	7,463	6,262	5,336	6,897	1,682	2,458	1,354
Canvasback	6,869	7,282	6,000	8,423	5,290	9,614	7,107	3,483	3,472	4,041
Scaup	53,806	32,823	25,125	24,855	51,291	43,767	43,780	18,729	22,767	15,943
Ringneck	646	605	2,332	1,029	1,008	3,312	2,473	2,197	3,714	6,553
Goldeneye	19,569	19,723	11,703	15,022	15,932	18,804	30,880	9,839	14,036	13,430
Bufflehead	28,763	18,220	8,267	17,224	16,125	33,553	23,102	15,680	15,411	7,313
Ruddy Duck	3,481	3,663	5,709	2,044	5,275	5,638	10,631	3,345	7,727	2,558
Eider	100	6	0	0	0	0	0	1	0	2
Scoter	65,121	37,655	27,672	26,223	44,679	70,166	116,461	30,698	31,799	34,285
Old Squaw	284	321	105	100	85	598	564	207	370	121
Harlequin	89	2	12	30	20	137	268	116	228	170
Merganser	9,935	10,542	12,126	11,766	9,765	12,570	9,361	6,522	6,053	9,256
Unidentified Ducks	4,633	2,625	3,546	1,565	2,527	812	13,858	6,900	6,592	836
Snow Goose	28,930	30,000	29,500	29,831	24,700	21,250	24,312	33,674	41,563	36,084
White-fronted Goose	0	1	0	0	0	0	198	1	32	2
Canada Goose	19,300	59,731	43,569	89,020	43,845	31,407	39,052	35,317	43,355	50,920
Lesser Canada	49,472	1,361	7,734	420	1,516	44,386	24,692	26,471	22,254	31,603
Cackling Goose	0	2	2	0	2	0	2	0	250	26
Black Brant	7,665	10,107	6,451	3,113	7,097	11,793	12,026	14,371	19,831	18,538
Tundra Swan	2,037	4,197	2,906	333	965	2,619	3,647	1,948	3,661	2,101
Trumpeter Swan	424	370	115	66	324	65	388	206	304	962
Coot	29,141	24,541	31,914	15,697	26,292	18,257	25,249	35,142	39,434	33,549
TOTAL	961,868	1,098,827	808,516	911,801	828,109	1,202,325	1,039,462	870,324	1,152,858	952,817
10-YEAR AVERAGE	889,880	896,520	859,894	858,357	873,671	928,406	924,207	924,224	952,608	956,149

1982 - 19,000 Additional Snow Geese on Fraser Delta (Canada)
1983 - No Additional Snow Geese on Fraser Delta
1984 - 6,900 Additional Snow Geese on Fraser Delta
1985 - Fraser Delta Not Counted
1986 - 16,302 Additional Snow Geese on Fraser Delta
1987 - 6,390 Additional Snow Geese on Fraser Delta
1988 - 9,590 Additional Snow Geese on Fraser Delta
1989 - 1,438 Additional Snow Geese on Fraser Delta

CORRECTED 2/10/88

vulnerable to extirpation. There are two primary causes for this decline: the species is at the edge of its distribution and therefore its numbers are naturally low; or the species is dependent upon specific habitats that are limited in distribution and are, or have been, threatened with rapid decline because of man-caused habitat disturbance. These causes are not mutually exclusive.

Of the species of special concern, most are dependent upon specific habitats and warrant special management concern because of declining habitat availability. For the purposes of this report, regrouping these species into subcategories based on habitat dependence or other cause of vulnerability will be most useful.

In the following discussion, SE will stand for State Endangered and will refer to those species officially classified as endangered by Wildlife Commission action. ST will stand for State Threatened and will refer to those species designated as State Threatened by the Director. PE, PT, and PS refer to those species that possibly warrant classification as endangered, threatened, or sensitive species. The Wildlife Commission has yet to classify any species as threatened or sensitive as its authority to do so is unclear. The monitor classification is used internally by the Nongame Program to identify species in need of closer scrutiny to assess their population health and trend. These monitor species are excluded from the following discussion. An "F" included in the status code means the species is also listed by the federal U.S. Fish and Wildlife Service.

Nongame species of concern grouped by special habitats

Shrub Steppe ferruginous hawk (ST), pygmy rabbit (ST), burrowing owl (PS), golden eagle (PS), gyrfalcon (PS), loggerhead shrike (PS), sage sparrow (PS), sage thrasher (PS), Swainson's hawk (PS), western bluebird (PS), Merriam's shrew (PS), pallid bat (PS).

Old Growth spotted owl (SE), fisher (PS), grizzly bear (F & SE), long-eared myotis (PS), northern goshawk (PS), pileated woodpecker (PS), Larch Mt. salamander (PS), Dunn's salamander (PS).

Riparian bald eagle (F & ST), common loon (PT), long-eared myotis (PS), purple martin (PT), western pond turtle (ST), wolverine (PS), Columbia white-tailed deer (F & SE), peregrine falcon (F & SE).

Bogs and other small wetlands sandhill crane (SE), western pond turtle (SE), Beller's ground beetle (PS), Hatch's click beetle (PS), silver bordered fritillary (PS).

Snags black-backed woodpecker (PS), fisher (PS), long-eared myotis (PS), pileated woodpecker (PS), purple martin (PT), three-toed woodpecker (PS), western bluebird (PS), white headed woodpecker (PS).

Oak Woodlands western grey squirrel (PS), golden eagle (PS), loggerhead shrike (PS), pallid bat (PS), western bluebird (PS).

Meadow/prairies Oregon fritillary (F & SE), Mardon skipper (PS), bordered fritillary (PS), grizzly bear (SE & FT), loggerhead shrike (PS), long-eared myotis (S), pallid bat (PS), sandhill crane (SE), Townsend's big-eared bat (PT).

Sandspits bald eagle (F & ST), merlin (PS), peregrine falcon (F & SE), snowy plover (SE).

Juniper Forest sage sparrow (PS), ferruginous hawk (ST), Swainson's hawk (PS), loggerhead shrike (PS), sage thrasher (PS), western bluebird (PS), golden eagle (PS), burrowing owl (PS).

Dune Oregon silverspot butterfly (F & ST), snowy plover (SE).

Caves pailid bat (PS), Townsend's big eared bat (PT).

Marine marine mammals (California sea lion, northern sea lion, killer whale, harbor porpoise (PS), Dall's porpoise, Minke whale, California gray whale (FE), plus others), marine birds (pelagic cormorant, Brandt's cormorant, double-crested cormorants, rhinoceros auklets, marbled murrelets, common murre, tufted puffin plus others), and all unclassified marine invertebrates and fish.

Nongame species of concern of other or multiple habitats

1. Grizzly Bear (F & SE)

2. Caribou (F & SE)

3. Columbia White-tailed Deer (F & SE)

4. Bald Eagle (F & ST)

5. Peregrine Falcon (F & SE)

6. Brown Pelican (F & SE)

7. White Pelican (SE)

8. Wolf (F & SE)

9. Sea Otter (SE)

10. Sandhill Crane (SE)

C. Historical Background

Resident Trout - Resident trout from historical times have been scattered throughout the state.

Lowland Trout Lakes - There are seven species of trout found in lowland lakes: Brook, brown, cutthroat, bull, kokanee, lake and rainbow trout. The most common species is cutthroat and the most popular with anglers is rainbow. There is generally a lack of natural spawning area (streams) for five of the species. Populations are supported by a major hatchery program. Approximately ten percent of waters have wild populations of trout.

Resident Trout Streams and Beaver Ponds - There are five species of trout found in resident trout streams: brook, brown, cutthroat, bull and rainbow trout. Other species may enter from lakes to spawn. Cutthroat trout are the most common species and rainbow the most popular. Virtually all stream trout populations are wild fish spawned naturally in the stream. Spawning occurs in the spring for some species and the fall for others.

Alpine Lakes - There are six species of trout found in alpine lakes: brook, brown, cutthroat, golden, lake and rainbow trout. Cutthroat are the most common and rainbow the most popular for anglers. Little spawning habitat naturally exists in alpine lakes, therefore 90 percent of the trout populations are provided by hatchery fish.

Warmwater Fish - These fish are not native to Washington. Most were introduced in the late 1800s and early 1900s by the U.S. Fish Commission.

Sunfish (Centrarchidae)

Largemouth bass (1890, Lake Washington, Sprague Lake, and Loon Lake.) These fish are very widespread on both sides of Washington, in lake, reservoir, and slowly moving river habitat types. They prefer shallow, warm, weedy habitats with sand or mud bottoms.

Smallmouth bass (1924, Spencer Lake on Blakely Island.) Smallmouth bass are still found in Spencer Lake. They also have inhabited a number of Washington rivers for years, such as the Columbia River and its reservoirs, Snake River, Okanogan River, Grande Ronde River, and the Yakima River. They also occupy Lake Washington, Lake Sammamish, Island Lake (Mason County), Lake Stevens, Lake St. Clair, Lake Osoyoos, and all the major irrigation reservoirs associated with the Columbia River in eastern Washington. In recent years they have been stocked by the Department of Wildlife into additional waters such as Banks Lake, Lakes Goodwin and Shoecraft, Lake Whatcom, Palmer Lake and the Pend Oreille River. Smallmouth bass like rocky shoals, and deeper, cooler, more clear water than largemouth bass do.

Black crappie (1893, Willamette River, Oregon.) Crappies like large (over 100 acres) water bodies, and are generally associated with underwater vegetation. They are found commonly in both eastern and western Washington.

White crappie (1890, Lake Washington.) White crappies are much less common in Washington than black crappies, with the largest concentration in Lake Wallula (McNary Pool) of the Columbia River. They can tolerate much muddier water and are less associated with vegetation than black crappies.

Bluegill (1890, Sprague Lake, Loon Lake.) Bluegill are fairly widespread on both sides of the state, in all types of waters. They like shallow, warm, weedy areas.

Green sunfish (1890, Sprague and Loon Lakes.) Is not a common fish in Washington, with most of the waters containing these fish in east-central Washington. This fish likes shallow, weedy, warm areas.

Pumpkinseed sunfish (1893, Willamette River, Oregon.) This is one of the most widespread warmwater fish in Washington. It seems to adapt to almost any habitat type, but prefers shallow, warm areas with fairly dense vegetative cover. It never gets large in Washington, with the state record only weighing 12 ounces.

Rock bass (1889, original release location not indicated.) Rock bass are not widespread in Washington, with most of them apparently located in southwest Washington. They like rocky areas near vegetation or near underwater structures, but are not strongly associated with dense vegetation.

Warmouth (1892, Loon Lake.) This species has limited distribution in Washington, which is similar to rock bass (mainly southwest Washington). It can tolerate much muddier water than rock bass, and likes to be close to dense vegetation and over mud bottoms.

Catfish (Ictaluridae)

Brown bullhead (1882 or 1883, Silver Lake, Cowlitz County.) The brown bullhead is one of the most widely distributed species in the state and is very common in both eastern and western Washington. It can tolerate a wide range of environmental extremes, and can live almost anywhere. If given a choice, it likes shallow muddy warm areas near vegetation.

Black bullhead (first reported in the Columbia River in 1927, last reported in 1937, may not actually exist in Washington state now, if it ever did. There was a state record black bullhead reported in 1988, but it turns out the fish was actually a brown bullhead.)

Yellow bullhead (1905, Willamette River, Oregon.) The yellow bullhead is probably only found in eastern Washington, and is fairly common in some waters adjacent to or connected to the Columbia River. It reportedly likes clear water adjacent to vegetation, but it has been found mostly in muddy ponds or irrigation waters in warmwater fish surveys in Washington.

Blue catfish (Unknown. Even though the blue catfish is listed in our fish pamphlet with a state record, it is likely this fish was misidentified, and that we have no actual blue catfish in Washington.)

Channel catfish (1892, Clear Lake, Skagit County.) These fish are abundant only in the Columbia River and tributary streams downstream from the Tri-Cities area. They are fairly common in the Snake River and Walla Walla River. The Department of Wildlife has stocked channel catfish in a few areas of northwest Washington and the Columbia Basin. Although channel catfish prefer riverine habitat, they can also do well in lakes or even small ponds, preferring very warm temperatures, and can tolerate fairly muddy conditions. They are not strongly associated with vegetation.

Flathead catfish (Unknown.) Even though flathead catfish are not listed as a game fish in Washington, they do exist in the Snake River, with a fish of over 22 pounds confirmed in 1981.

Perch (Percidae)

Yellow perch (1890, Sprague Lake and Loon Lake.) Perch are one of the most widely distributed warmwater fishes we have in Washington. It is so widespread, it has been the most frequent target of lake rehabilitations in trout lakes. Perch occupy all types of habitat, but prefer warm lakes with fairly clear water, sandy bottoms, and fairly abundant vegetation.

Walleye (Unknown. First confirmed from Banks Lake in 1962, may have actually been in Lake Roosevelt from about 1955.) Walleye prefer fairly large and deep lakes or rivers, strongly associated with rock and gravel bottoms, points, dropoffs, etc. Walleye are now found throughout the Columbia River system in Washington, as well as all the irrigation reservoirs connected to the Columbia. The Department of Wildlife has recently introduced walleye into Sprague Lake and the Pend Oreille River.

Pike (Esocidae)

Northern pike (Unknown, first verified in 1980 from Long Lake on the Spokane River.) We know of only three verified recoveries of northern pike in Washington to date, the one from Long Lake, one from the Pend Oreille River near the Washington-Idaho line, and one from the Snake River near Lyon's Ferry. It is probable that there are no reproducing populations of pike in Washington. Northern pike prefer clear water, with clean sand or gravel bottoms, and abundant vegetation.

Tiger muskellunge (1988, Mayfield Lake.) Tiger muskies are a sterile hybrid and are not expected to maintain themselves without supplemental stocking. There are no plans to introduce tiger muskies anywhere else in Washington other than Mayfield Lake until at least 1992. These fish are associated with rocky bottoms near structures and points. (Note: grass pickerel are also found in Washington but have not been classified as game fish.)

Temperate bass (Serranidae/Percicthyidae)

Striped bass have been found in limited numbers in Washington fresh waters (Columbia River) since the 1930s but they have never been declared game fish. There are presently no plans by WDW to introduce this species into any waters of the state.

Anadromous Fish - Steelhead catch data for 1968-69, 1987-88 run years are presented below for Washington sport angiers and treaty Indian fisheries in the U.S. vs Washington and U.S. vs Oregon (Columbia River) case areas (note: 1968 through 1974 Columbia River commercial landings also include non-Indian commercial landings that were allowed under Oregon Law. This practice was outlawed in 1975).

Total run size estimates and spawning escapement estimates for hatchery and wild summer and winter run fish are available on a limited basis. Total run size of winter and summer steelhead entering the Columbia River are present in WDF/ODF & W (1988). WDW data resource inventories show total run size estimates and wild spawning escapement estimates for major river systems in the Boldt Case Area (Table 4).

A general depiction of wild steelhead escapement statewide is that many runs were in a depressed state by the mid-to-late 1970's. At that time, significant steps were taken to reduce harvest by all fisheries to bolster escapement. Since then, escapements have generally rebuilt to where minimum escapement goals are being met on most systems being surveyed.

It should be noted that general decreases in stream productivity and in accessible spawning and rearing habitat may mean that historical levels of natural production are not achievable today.

Chapman (1986), for instance, estimated that the average run of steelhead entering the Columbia River between 1880 and 1920 was 554,000 fish, all of which were natural production. Total wild population passing Bonneville in 1988 was about 96,000 fish. Additional data are contained in Tables 5 and 6.

Sea-run cutthroat historical abundance data is very sparse and limited to sport catch, fish trap and dam count data on a few river systems. It is probably safe to assume that historic sea-run cutthroat population levels were never large when compared to other anadromous fish. Royal (1972) indicated historical steelhead populations in Washington comprised only 2-3% of the total anadromous populations. It is doubtful that sea-run cutthroat populations were larger than steelhead and may have been less.

Larson (1982) indicated the size of sea-run cutthroat populations in Grays Harbor did not justify a special season. A report on Minter Creek in 1934 (anonymous) indicated sea-run cutthroat were very limited in quantity. Meigs (1941) found the catch of sea-run cutthroat on the North Fork Stillaguamish was less than that of summer steelhead during the summer fishery. Creel checks showed the sport catch for the Columbia River varied from 5,076 and 6,824 in 1969 and 1970 to 1,820 in 1978 and 2,139 in 1979 (WDW, 1980).

For sea-run Dolly Várden no estimates for sports harvest or total run sizes are available.

Table 4

Steelhead Spawning Escapement in Boldt Case Area Rivers (WDW, 1985 & 1988)

Wild steelhead escapement estimates in the major river systems were as follows:

	1985	1988
Quillayute System	10,699	12,185
Humptulips System	4,046	3,410
Chehalis System	10,434	6,535
Skagit System	8,963	13,194
Snohomish System	6,432	7,744
Lake Washington System	1,116	858
Green System	2,188	2,378
South Prairie Creek	764	----
South Fork Skokomish River	510	742
Tahuya River	212	102
Dewatto River	86	23

TABLE 5

ESTIMATED ANNUAL ABUNDANCE OF ADULT STEELHEAD IN COASTAL WASHINGTON AND PUGET SOUND STREAMS

A. Winter-run stocks (hatchery and wild origins).	
1. Puget Sound Streams.	
a. Green[1]	12,061
b. Lake Washington[1]	3,402
c. Nisqually[1]	5,600
d. Nooksack (1986-87 estimate only)[2]	6,018
e. Puyallup[2]	11,663
f. Samish[2]	1,475
g. Skagit[1]	15,459
h. Snohomish[3]	23,149
i. Stillaguamish[2]	8,865
2. Hood Canal[4]	4,021
3. Strait of Juan de Fuca (1986 estimates only)[4]	
a. Elwha	6,357
b. Other streams	5,210
4. Coastal stocks	
a. Chehalis (1986-87 estimate only)[5]	7,307
b. Hoh[1]	11,912
c. Humptulips[5]	8,022
d. Naselle[6]	1,978
e. Queets (1980-1986 average)[5]	15,312
f. Quillayute[1]	25,037
g. Quinault[5]	18,433
h. Willapa[6]	2,910
5. Total annual abundance, all winter-run stocks:	194,191
B. Summer-run stocks	
1. Hatchery origins	
a. Average (1981-1986) number of smolts released each year (626,038)[7] multiplied by a 3% smolt-to-adult survival rate.[8]	18,781
2. Wild origins[8]	
a. Average hatchery: wild ratio of adult fish = 90:10[8]	2,087

TABLE 5 - Continued

	3. Total annual abundance, all summer-run stocks	20,868
C.	Total number of adults (all stocks) returning each year before harvest (194,191 winter-run fish)	215,059

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[1] Based on average run size estimates, Washington State Dept. of Game (WDG) pnpublished data (1977-78 to 1985-86)

[2] Run size estimates based on catch data (1985-86 return years) combined with estimated escapement relative to escapement goals (Robert Gibbons, WDG, 1987 personal communication).

[3] Estimated wild run size and mean annual catch, 1980-81 to 1985-86 return years, expanded by 15% (assuming an 85% exploitation rate, R. Gibbons, WDG, 1987 pers. comm.).

[4] Point No Point Treaty Council and WDG, 1986.

[5] Quinault Fish Division and WDG, 1987.

[6] Based on a doubling of the mean annual (1979-80 to 1984-85 return years) sport catch (WDG 1980b, 1981a, 1982b, 1983b, 1984a, 1985a), assuming a 50% exploitation rate (R. Gibbons, WDG, 1987 pers. comm.).

[7] Washington State Department of Game. 1982a, 1983a, 1984b, 1985b, 1986b, 1987.

[8] Robert Gibbons, WDG, 1987 pers. comm.

TABLE 6

WASHINGTON STATE STEELHEAD HARVEST STATEWIDE 1974 - 1988

	Sport[1]			Tribal[2]				
Year	Summer-run	Winter-run	Total	Summer-run	B.C.A. Winter-run	Col. River Summer-run	Tribal Total	Overall Total Harvest
1974-75	30,565	87,806	118,372	N/A	69,060	13,200	82,260	200,631
1975-76	20,919	47,887	68,806	1,152	62,926	7,800	71,878	140,684
1976-77	34,963	51,532	86,495	1,102	43,935	11,800	56,837	143,332
1977-78	52,364	107,115	159,479	1,189	56,386	38,200	95,775	255,254
1978-79	43,277	79,443	122,720	1,266	48,845	19,800	69,911	192,631
1979-80	33,549	103,430	136,979	1,974	47,263	8,900	58,137	195,116
1980-81	45,575	71,607	117,182	3,858	66,559	9,800	80,217	197,399
1981-82	61,071	54,685	115,756	6,366	54,627	9,700	70,693	186,449
1982-83	48,419	47,672	96,091	5,326	49,831	9,600	64,757	160,848
1983-84	37,134	68,647	105,781	2,695	59,829	20,400	82,924	188,705
1984-85	59,604	115,767	175,371	3,045	102,562	78,700	184,307	359,678
1985-86	65,051	72,070	137,121	4,007	86,012	83,500	173,519	310,640
1986-87	82,769	89,044	171,813	3,841	96,011	72,300	172,152	343,965
1987-88	53,378	73,758	127,136	3,542	91,283	82,600[3]	177,425[3]	304,561[3]

1 Sport harvest estimates from bias corrected punchcard data.

2 Harvest data from B.C.A. (Boldt Case Area) catch reports; Columbia River Data from T.A.C. (Technical Advisory Committee) reports adjusted to cycle year and to reflect only catches made in the mainstem and Washington tributaries.

3 Preliminary, subject to revision.

Although settlement of the West reduced the fur industry, it did not reduce pressure on furbearers. Many settlers trapped for both fur and food. The addition of more settlers increased the pressure on the fur resource.

In Washington, the beaver population was so threatened that beaver protection laws were enacted in 1909. It was not until 1963 that beaver could again be trapped for their furs.

Upland Game - Historical data for this group are very limited. Harvest data for grouse dating back to 1963 show a low of about 250,000 birds in 1965 to a high of nearly 450,000 in 1969 and for pheasant a low of about 400,000 in 1971 to a high of 650,000 in 1963. Quail range from a high of about 320,000 in 1968 to 150,000 in 1969 (WDW, Hunting Season Environmental Impact Assessment, 1976).

There are seven species of grouse (family Tetraonidae) all of which are native. The sharp-tailed grouse was once abundant throughout the grasslands and scattered timber areas of Eastern Washington. It has been said that they were killed by the wagon loads in the first part of the century. Today they are restricted to scattered lands and have a total population of less than 10,000.

Quail and partridge (family Perdicidae) were introduced to Washington. California and possibly mountain quail were first introduced near Olympia in 1857. Hungarian partridge were introduced near Spokane in 1906 (Phillips, 1928). Chukar, native to India, were introduced in the 1920s. Pheasants from China were first introduced in 1883 by Judge O.N. Denny.

Nongame - Very little or nothing is known about the historical distribution and abundance of the majority of nongame species. Species fact sheets assessing the status of all special species have been prepared and are on file at the Department of Wildlife's Nongame Data System. Since there are over 180 special species for which fact sheet status assessments have been written, it is beyond the scope of this document to include this level of detail. At least 50 of these species have been determined to be vulnerable to possible deleterious population declines. Concern for the species' well-being stems from: historical abundance and evidence of decline; limited size and distribution of populations; low species' habitat versatility, high vulnerability of these habitats to alteration, and evidence of decline in habitat; and species' intolerance to disturbance.

Big Game- The following tables provide data reflecting the big game species, population estimates, the numbers of hunters, and the numbers of animals harvested.

Table 7

Species	Year	Population #	Hunters #	Animals Harvested
Black-tailed deer	1960	250,000	110,000	22,000
	1970	172,000	150,000	19,000
	1980	200,000	120,000	25,000
	1987	200,000	90,000	20,000
Mule Deer	1960	150,000	60,000	12,000
	1970	103,000	75,000	15,000
	1980	130,000	80,000	12,000
	1987	135,000	60,000	12,000
White-tailed deer	1960	50,000	30,000	6,000
	1970	65,000	35,000	7,500
	1980	50,000	40,000	6,000
	1987	67,000	30,000	6,000
Elk	1960	50,000	52,000	8,000
	1970	51,000	99,000	11,000
	1980	58,000	105,000	11,000
	1987	57,000	82,000	8,000
Black bear	1960	30,000	20,000	9,000
	1970	22,000	21,000	3,000
	1980	18,000	27,000	2,600
	1987	19,000	10,000	1,000
Cougar	1960	600	200	40
	1970	1,500	400	300
	1980	1,500	300	60
	1987	1,500	200	60

Mountain Goat	1960	10,000	700	270
	1970	10,000	900	340
	1980	7,500	800	269
	1987	7,500	300	140
Bighorn Sheep	1960	35	0	0
	1970	220	10	10
	1980	600	32	8
	1987	700	13	8
Moose	1960	20	0	0
	1970	60	0	0
	1980	100	3	3
	1987	180	6	5

Migratory Game - Surveys of wintering waterfowl, harvest, and reproduction were initiated in the 1940s. Approximately 600,000 waterfowl wintered in the state at that time, and about 800,000 were harvested. Roughly 70,000 hunters participated in waterfowl hunting at that time. Since 1960 there has been a peak of hunters and harvest of about 80,000 and 600,000 respectively in 1970 to a low of 38,000 and 300,000 in 1987. This information is provided in Table 8 and Table 2.

Furbearers - In Washington, the fur trade contributed to early settlement of the area. Major fur companies such as the Pacific Fur Company, Hudson Bay Company and North West Fur Company purchased furs, supported trappers and encouraged development of fur trading posts and forts. Early fur trading posts in Washington included: Fort Okanogan (1811); Spokane House (1811); Fort Spokane (1813); Fort Nez Perce (1818 - later changed to Fort Walla Walla); Fort Vancouver (1824); Fort Colville (1825); and Fort Nisqually (1833).

In the 1800s fur resources were overexploited. The British had overharvested the resource in anticipation of losing control over a large portion of North America. In addition, a change in fashion (silk hats replaced beaver hats); the California gold rush (which attracted trappers from other parts of the West); and settlement of the West all contributed to a decline in the fur industry in the late 1800s.

TABLE 8

TEN YEAR COMPARISON OF LICENSE SALES
JANUARY 1 THROUGH DECEMBER 31

	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES
State Resident Hunt & Fish	132,586	134,547	141,060	126,349	114,828	115,907	110,434	102,575	99,661	98,621
State Resident Fish	428,353	424,273	448,164	422,352	424,880	402,937	401,060	416,599	437,015	433,009
State Resident 3-Day Fish	-	-	-	-	-	-	-	8,416	11,853	13,207
State Resident Hunt	223,780	220,444	203,306	196,290	190,092	172,968	159,920	165,456	161,866	164,061
State 3-Day Nonresident Fish	32,270	29,252	35,669	31,611	27,996	29,143	26,127	24,432	26,102	26,895
State Nonresident Fish	7,696	7,029	8,175	9,992	9,487	10,419	9,907	8,837	8,279	8,390
State Nonresident Hunt	3,252	2,962	3,056	3,106	2,069	2,935	2,373	2,234	2,276	2,463
State Res. Trapping	2,249	1,824	1,737	1,998	872	1,177	939	1,035	1,168	905
Juvenile Trapping	-	133	83	149	53	90	115	76	74	54
Adult Res. Trapping	13	13	17	17	6	14	26	21	13	2
Conservation License Decal	-	-	-	556	1,784	2,153	1,778	1,014	721	708
Total Game Licenses	830,199	820,477	841,267	792,420	771,069	737,743	712,679	730,694	749,028	748,315
Archery/Muzzle Permits	21,795	23,015	25,179	9,723	-	-	-	-	-	-
Archery Stamps	-	-	-	14,318	15,830	18,376	2,174	31	13	-
Muzzle Loading Firearms Stamp	-	-	-	2,636	1,992	3,846	542	13	2	-
Migratory Waterfowl Duck Stamp	-	-	-	-	-	-	-	36,602	44,686	46,095
Hound Stamp	-	-	-	1,230	1,409	1,847	1,570	1,758	1,864	1,986
Upland Bird Permits	115,659	121,118	119,095	9,150	-	-	-	-	-	-
Upland Game Bird Stamp	-	-	-	86,098	83,902	76,619	64,978	57,992	60,871	53,349
Upland Game Bird Punchcard	-	-	-	10,313	12,164	11,950	11,833	11,620	10,028	9,893
Steelhead Permit	110,840	112,659	111,367	101,805	101,425	110,845	138,731	105,856	114,089	115,004
Resident Deer (Total)	249,788	246,439	221,879	210,196	202,038	179,991	186,528	180,819	175,341	183,671
Modern	-	-	-	-	-	-	-	158,904	153,529	160,704
Muzzleload	-	-	-	-	-	-	-	2,667	4,286	4,491
Archery	-	-	-	-	-	-	-	13,480	17,526	18,476
Nonresident Deer (Total)	-	-	-	-	-	658	668	663	717	776
Modern	-	-	-	-	-	-	-	533	596	645
Mullzeload	-	-	-	-	-	-	-	11	23	26
Archery	-	-	-	-	-	-	-	72	98	105
Resident Elk (Totals)	115,104	104,107	99,451	99,618	87,825	82,038	84,551	82,552	79,516	81,414
1983 Resident Elk License	-	-	-	-	-	4,565	-	-	-	-
Westside Early Resident	65,333	52,254	-	-	-	23,603	27,194	25,451	20,064	21,386
Westside Late Resident	-	-	-	-	-	9,288	10,462	11,065	10,918	9,776
Westside Muzzle Resident	-	-	-	-	-	450	957	1,209	1,651	2,251
Westside Archery Resident	-	-	-	-	-	4,944	6,919	7,204	7,634	7,483
Colockum Early Resident	11,300	10,785	-	-	-	4,621	5,004	4,968	4,050	4,449
Colockum Late Resident	-	-	-	-	-	1,567	1,676	1,178	2,133	2,135
Colockum Muzzle Resident	-	-	-	-	-	397	491	630	1,162	1,506
Colokum Archery Resident	-	-	-	-	-	669	1,061	1,221	1,445	1,507
Yakima Early Resident	9,734	11,001	-	-	-	13,291	11,613	12,813	10,572	11,100
Yakima Late Resident	11,068	12,131	-	-	-	5,918	6,417	4,175	5,414	5,465
Yakime Muzzle Resident	-	-	-	-	-	213	436	679	1,070	1,090
Yakima Archery Resident	-	-	-	-	-	905	1,141	1,499	1,921	2,252
Blue Mt. Early Resident	17,669	17,936	-	-	-	6,105	6,575	7,153	6,080	5,982

	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES
Blue Mt. Late Resident	-	-	-	-	-	4,195	3,021	1,897	3,540	3,372
Blue Mt. Muzzle Resident	-	-	-	-	-	556	668	475	695	509
Blue Mt. Archery Resident	-	-	-	-	-	751	916	989	1,169	1,142
Nonresident Elk (Totals)	1,360	939	831	1,068	616	913	670	699	745	842
1983 Nonresident Elk	-	-	-	-	-	172	208	-	-	-
Westside Early Nonresident	686	347	-	-	-	234	61	253	213	261
Westside Late Nonresident	-	-	-	-	-	37	7	23	43	50
Westside Muzzle Nonresident	-	-	-	-	-	5	73	13	11	15
Westside Archery Nonresident	-	-	-	-	-	21	32	70	78	68
Colockum Early Nonresident	86	66	-	-	-	34	5	45	36	66
Colockum Late Nonresident	-	-	-	-	-	12	5	2	7	5
Colockum Muzzle Nonresident	-	-	-	-	-	7	8	5	1	8
Colockum Archery Nonresident	-	-	-	-	-	7	89	3	6	9
Yakima Early Nonresident	104	107	-	-	-	142	22	125	117	132
Yakima Late Nonresident	88	57	-	-	-	26	3	16	24	19
Yakima Muzzle Nonresident	-	-	-	-	-	11	12	2	6	11
Yakima Archery Nonresident	-	-	-	-	-	9	81	11	16	24
Blue Mt. Early Nonresident	396	362	-	-	-	112	44	139	127	112
Blue Mt. Late Nonresident	-	-	-	-	-	66	9	19	28	27
Blue Mt. Muzzle Nonresident	-	-	-	-	-	11	11	7	17	8
Blue Mt. Archery Nonresident	-	-	-	-	-	7	-	8	15	27
Resident Primary Bear	26,830	26,386	13,234	12,642	10,595	11,584	9,480	9,964	10,276	9,597
Nonresident Primary Bear	-	-	-	32	46	95	61	57	55	43
Resident Spring Bear	-	-	-	-	611	630	627	586	447	4
Nonresident Spring Bear	-	-	-	-	1	11	10	0	1	1
Resident Cougar	-	-	-	61	56	400	390	274	226	157
Nonresident Cougar	-	-	-	-	2	9	12	16	15	0
Resident Turkey	1,376	1,170	1,104	660	634	674	547	468	428	856
Nonresident Turkey	-	-	-	-	-	5	9	4	1	3
Single Deer/Elk Application	-	-	-	56,260	46,871	34,648	32,447	30,885	36,820	36,554
Partnership Elk Application	-	-	-	2,599	2,076	2,709	3,554	4,765	5,180	5,313
Goat Tag	842	776	752	594	471	448	289	306	352	301
Nonresident Goat	-	-	-	-	-	-	-	3	2	5
Sheep Tag	31	31	40	33	19	12	12	11	13	12
Nonresident Sheep	-	-	-	-	-	-	-	0	0	0
Mosse Tag	-	-	-	3	3	3	4	5	6	7
Nonresident Moose	-	-	-	-	-	-	-	0	0	0
Total Big Game Tags & Permits	643,625	636,640	592,932	619,039	568,586	538,311	539,687	525,949	541,692	545,873
Taxidermist	112	131	145	131	112	121	132	123	126	144
Resident Fishing Guide	111	144	161	156	151	201	226	238	245	269
Nonresident Fishing Guide	5	6	7	9	4	7	11	6	7	9
Game Farm - New	34	56	41	34	37	27	34	27	20	28
Game Farm - Renewal	146	150	169	144	97	170	176	94	104	118
Fur Dealer	86	75	87	41	36	28	31	29	33	32
Falconry Stamp	-	-	-	45	30	23	124	137	137	170
Fish Contest Permit	-	-	-	-	31	107	133	109	242	230
Field Trial permit	-	-	-	28	74	110	126	117	106	104
Scientific Collection Permit	-	-	-	21	122	133	114	116	131	108
Fish Planting Permit	-	-	-	26	59	10	66	37	57	62
Anadromous Fish Buyer License	-	-	-	-	37	71	77	79	98	108

	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES	NUMBER OF LICENSES
Duplicates	6,364	6,911	6,890	4,418	4,846	9,211	10,768	10,430	10,337	11,045
Total Miscellaneous Licenses	6,858	7,473	7,500	5,053	5,636	10,219	12,018	11,542		
Disabled Veteran Hunt & Fish	-	-	-	-	1,047	1,931	2,184	3,048	3,373	3,752
Complimentary Fish	14,659	14,917	16,257	-	16,863	16,273	23,422	31,616	38,663	44,735
Blind Fish	-	-	-	-	247	339	315	336	371	380
Wheelchair Fish	-	-	-	-	-	425	557	601	863	981
Developmental Disability Fish	-	-	-	-	-	-	-	562	924	1,016
SDHS Group Fishing Permit	-	-	-	-	-	-	-	68	77	86
Complimentary Steelhead Punchcard	26,766	26,871	25,553	-	-	-	-	-	-	-
Total Complimentary Licenses**	41,425	41,788	41,810	-	18,157	18,968	26,478	36,231	44,271	51,071
1982 Upland Bird Stamp	-	-	-	-	-	-	-	128	29	4
1983 Upland Bird Stamp	-	-	-	-	-	-	-	151	30	4
1984 Upland Bird Stamp	-	-	-	-	-	-	-	152	29	5
1986 Migratory Waterfowl Stamp	-	-	-	-	-	-	-	2,147	30,921	12,179
Total Collectors Stamp	-	-	-	-	-	-	-	2,578	31,009	12,192
Steelhead Credit Returns	-	-	-	-	-	-	-	5,842	25,511	26,208
TOTALS	1,522,107	1,506,378	1,483,509	1,416,512	1,363,448	1,305,241	1,290,863	1,312,836	1,403,159	1,396,086

* 7 Day License, 1979 through 1981, 3 Day License 1982 on.
** Free Punchcards Issued to Oldsters & Juveniles from 1979-81.

II. RISKS TO AND CURRENT STATUS OF, FISH AND WILDLIFE

A. Introduction

The risk discussion in this section is divided into two subsections. The first is a general discussion of threats to wildlife as determined by professional wildlife managers in Washington State government. It is organized into key indicator groups reflecting the current program structure and management alignment of the Washington Department of Wildlife, and is called the Resource Management Program Perspective. This format will provide insight into current programmatic activities, internal resource allocations and other agency actions of interest to the reader. It is, in fact an inventory of pressing problems and the organizational context within which solutions are being pursued. The key indicators are; resident fish, warmwater fish, anadromous fish, big game, migratory game, furbearers, upland game and non game.

The second section brings all the risks to wildlife identified in the 2010 risk analysis reports, together in one place. This information supplements the Resource Management Program Perspective and represents the best professional judgement of the risk report authors regarding the potential impact of the risks they analyzed on Washington wildlife. It is, therefore, organized by risk subject area and it's content limited to the findings of the risk reports. This should help the reader understand emerging opportunities and priorities for wildlife protection and enhancement in Washington State, over the 20-year planning horizon.

B.1 SUMMARY OF RISKS TO WILDLIFE; RESOURCE MANAGEMENT PROGRAM PERSPECIVE

A. Key Indicators - Resident fish, warmwater fish, anadromous fish, big game, migratory game, furbearers, upland game, nongame. These groups were selected based on agency program organization and management responsibility.

Resident Fish - As with all groups of fish and wildlife, resident fish populations are dependent on habitat. Development of lake and stream shorelines has caused decreased water quality, loss of riparian areas, streambed disturbance, and destruction of spawning and rearing habitats. As shorelines are developed and recreational pressures increase, access to anglers is also lost.

Competition for water with irrigation and other out-of-stream water developments becomes more intense each year. There is also competition with salmon for spawning and rearing habitat. Operational priorities of reservoir management agencies often conflict with management of game fish.

In some areas, beaver control programs conflict with management of beaver ponds for sport fishing. Bird predation and illegal planting of undesirable fish species are additional factors which affect resident fish populations. Water oriented recreational activities also may conflict with fishery management and angler use. The potential risk of over harvest also exists.

Warmwater Fish - Warmwater fish populations also are threatened by habitat loss and/or alterations. Shoreline development in particular is an important factor in the condition of this resource. This is because shoreline vegetation is vitally important for reproduction, food production, and to provide feeding, hiding, and nursery areas. Water level fluctuations may also affect shoreline vegetation and threaten these populations.

Overharvest can change the age structure of fish populations and result in a less attractive fishery. Invasion of warmwater fish habitats by some exotic fish species can also be very damaging by lowering production through competition and predation, carrying diseases, and changing habitat. There are also some areas around the state where pollution from septic systems for lakefront home building has caused fish kills.

Anadromous Fish - Anadromous fish in Washington state are threatened by changes and loss of habitat in both fresh and saltwater areas. Stream and shoreline degradation, loss of shallow areas in estuaries, water pollution, and decreased water flows have all contributed to the decline of these fish runs. In many areas, upstream and downstream migration of anadromous fish is blocked by dams and other instream structures. Overharvest of wild/natural stocks and genetic interactions with hatchery fish are also significant factors in determining the health of these populations. Predation from increasing numbers of marine mammals is also a factor.

Anadromous fish compete with salmon and resident game fish for spawning and rearing habitat. Competition for water between out-of-stream water developments and fisheries resources is also a significant threat.

Big Game - Big game habitat is threatened as land is converted, altered, or managed for incompatible uses. Sufficient winter range, in particular, limits a number of these populations. In addition, road and ORV access to big game areas may increase the incidence of poaching and hunting pressure, reduce production by exposing critical habitat to excessive human disturbance, interfere with migration of some species, and detract from quality recreational experience.

The effect of current timber management practices (shortened harvest rotation cycles) has mixed impacts. Clearcut areas provide an abundance of forage for black-tailed deer, but cover may be lacking. However if sufficient old growth forest is left standing, logging practices can be beneficial to deer.

In the long run, expanding human development may have more effect than forest practices on deer habitat and harvest opportunities. Residential, commercial, and industrial development continues to reduce the amount of food and cover available for deer and other wildlife, as well as the number of areas open to hunting.

As with black-tailed deer, logging significantly affects Rocky Mountain and Roosevelt elk. Although their numbers have tended to increase in areas opened up by clearcutting, these animals require heavily timbered areas for cover. Elk are not affected by urban development as much as deer because they generally do not occupy regions in the Puget Sound area most subjected to growth. However, residential expansion and intensive farming in rural areas occupied by elk are factors which may either eliminate habitat or increase potential for agricultural damage by elk.

For mule deer, land practices detrimental to big game habitat, such as intensive timber management, livestock grazing, riparian losses and conversion to agriculture, recreational and residential subdivisions, are reducing the ability of the range to support wildlife. In most areas of mule deer range, populations are limited by the amount of winter habitat.

Loss of suitable habitat, primarily through sprawling urbanization limits white-tailed deer populations. Expanding human populations and agricultural development continue to deplete white-tailed deer habitat, but at a slower rate than for many other species.

As with mule deer, winter habitat limits the size and range of Rocky Mountain elk populations due to competition from livestock grazing and conversion to agricultural or residential development. Damage problems resulting from competition with agriculture, especially orchards, restricts elk range.

Fluctuations in deer numbers also affect cougar. The primary factor controlling cougar numbers is the relative scarcity of wilderness area.

Mountain goat populations in Washington are threatened by clearcut logging, and deteriorating habitat conditions as a result of fire suppression. Without periodic natural fires, amount and quality of forage available for goats are diminished. Parasites and disease also pose significant risks to some goat populations.

Suitable bighorn sheep ranges are very limited in Washington because of competition with other big game species, and conflicts with domestic livestock and private land development. As with mountain goats, fire is an important factor in maintaining sheep habitat. Bighorns also have poor resistance to disease and parasites.

Although moose populations have grown steadily since the mid-1950s, natural range succession is now reducing available moose habitat in Pend Oreille County.

Migratory Game - In many areas, habitat is being converted, altered, or managed for uses which are not compatible with waterfowl. Particularly important are losses of feeding and resting areas. Dredging and filling in estuaries and wetlands, draining of wetlands, logging and associated activities, urban and industrial development, and vacation home building all affect populations of waterfowl. Other risks include pesticides, oil spills, changes in northern breeding areas, and other human disturbances.

Mourning dove populations in eastern Washington are threatened because of lost nesting habitat due to conversion of orchards to dwarf tree varieties and installation of overhead sprinkler systems. They are also affected by pesticide application and dam construction and operation, as well as "clean" farming which leaves little or no residual weeds and grains.

Furbearers - Furbearer populations are influenced by the same habitat changes that affect other wildlife species. Changes in both aquatic and terrestrial habitat affect these animals. Abundance and quality of shallow water areas and riparian habitat are the main factors governing numbers of fur animals. Certain local populations may also be at risk when conflicts arise between furbearers and people (i.e. farmers, ranchers, timber producers, irrigation interests, etc.).

Little is known about annual population trends, effects of trapping regulations on densities, productivity of populations, and levels of harvest for management of the species.

Upland Game - Since the early 1970s critical habitat for wildlife in upland areas has disappeared at an alarming rate. There has been a decline of amount, distribution, and quality of habitat, particularly in shrub-steppe and farmland areas. Restricted access to private and public land has also reduced opportunities for public hunting, and increased the occurrence of road hunting and illegal trespass.

Expanding agricultural development and sagebrush removal projects have had serious effects on habitat for sage and sharp-tailed grouse. This critically small habitat base is being continually eroded. Increasing nonconsumptive use (viewing on leks) also may be disruptive to breeding populations. It is estimated that about 80% of Washington's original shrub/steppe habitat has been converted to agricultural uses.

General urban expansion has depleted habitat for forest grouse species, and expansion of agriculture in eastern Washington has resulted in losses of breeding and wintering range. Expanding human populations and new farming practices have also eroded pheasant habitat.

Mortality from pesticides (rodenticides) reduces populations of rabbits and hares adjacent to orchards and wheatlands, and may be a problem in timberlands. Herbicides and pesticides may have adverse impacts on other upland game species as well.

Nongame - Habitat deterioration is as much a problem in maintaining nongame wildlife populations as it is with game species. Land use changes, especially in the urbanizing areas of western Washington, are reducing both numbers and diversity of nongame wildlife.

In general, the following risks pertain to all groups of nongame wildlife:

a. Little is known about the numbers, distribution, habitat requirements, natural history, and ecology of most nongame species. Some have never been studied; many others have received only preliminary examination. Without this knowledge, management of these species is impossible.

b. Much of the habitat needed to support these species has been destroyed, is still being lost, or is being managed for incompatible uses. Habitat loss is the major reason why many of these populations have declined to where they have become endangered, threatened, or sensitive. Presently available habitat is insufficient to sustain permanent populations for some species.

c. There is large demand but insufficient opportunity for public education and enjoyment of nongame wildlife.

Special habitats which are particularly important to nongame wildlife include shrub/steppe, old growth forest, riparian, bogs and small wetlands, snags, oak woodlands, meadow/prairies, sandspits, juniper forests, coastal dunes, caves, and marine habitats. Loss and/or alteration of these habitats pose significant risks to many nongame species of wildlife.

B.2. SUMMARY RISKS TO WILDLIFE; ADDITIONAL INSIGHT FROM 2010 RISK ANALYSIS

Impacts on wildlife from nonchemical impacts on forest land

Nonchemical impact on forest lands include physical modifications (e.g. roadbuilding) and other impacts that affect Washington's forests. These impacts often result from changes in the use of the forest that alter the mix of commodities produced; they influence the profitability of current and future economic activities and diminish or alter ecological values, constrain recreational opportunities and preclude future use options.

Specific examples include erosion of forest land topsoil, habitat loss for old-growth dependant species, and the aesthetic impact on recreational users of publicly owned forest lands.

Conversion of forest land to nonforest uses, for example, causes increased loading of wildlife into remaining forest land. When the carrying capacity of the remaining land is exceeded, the excess wildlife population dies.

Conversion of forest land also causes a reduction in the diversity of fauna supported in forest ecosystems.

As a generalization, it can be said that forest harvesting causes a reduction in the functional and structural diversity of forest ecosystems.

Conversion of old-growth to second growth, for example, causes a loss of ecosystem structure and diversity which manifests itself as a reduction in the number and diversity of species supported in forest land.

Conversion of old-growth causes fragmentation of wildlife habitat and the phenomenon of island biogeography. Island biogeography dictates that some post harvest forest stands will be left to small to support their populations of wildlife in the sense of meeting lifecycle requirements (i.e. can forage but can't reproduce). Lehmkul and Ruggiero (1989) suggests that fragmentation of old-growth may be approaching a critical level for the viability of wildlife associated with these late successional forests.

Impacts on wildlife from nonchemical impacts on recreation lands

Nonchemical impacts on recreation lands include physical modifications to those lands caused by such things as road building, concentrated use, misuse and urbanization. These impacts can result in reductions in overall recreational opportunities, as will as ecological damages such as loss or degradation of wildlife habitat and damage to vegetation.

The most serious threat to wildlife from nonchemical degradation of recreation land is habitat loss and disruption from concentrated use of recreation land.

Road building in urban/rural, roaded and semi primitive recreation lands causes loss and degradation of wildlife habitat. Road building is a key element in the conversion of semi primitive recreation land. Once roading occurs, wildlife is continuously disrupted from vehicle noise and increased access.

Resource extraction activities on roaded and semi primitive recreation lands causes loss and degradation of wildlife habitat. The loss may be only temporary, however, if the environment is allowed to recover.

Urbanization/development of urban/rural, roaded, semi primitive and primitive recreation land causes degradation of wildlife habitat.

Misuse of urban/rural, roaded, semi primitive and primitive recreation land causes degradation of wildlife habitat.

<u>Impacts on wildlife from disruptions of the hydrologic cycle caused by human activities</u>

Analysis of the ecological consequences of disruptions of the hydrologic cycle cased by human activities revealed eight principal threats to wildlife. The eight are; dam construction, surface water withdrawal, flood control, forest practices, irrigation distribution works and on-farm irrigation practices, livestock grazing, storm water detention ponds and homebuilding along streams and urban development. Each will be treated separately.

It is important to note that while these modifications often have adverse impacts associated with them, such as loss of wildlife habitat, they also have benefits, such as irrigation of cropland and increased recreational opportunities.

Dam construction causes decreased stream flow which, in turn, causes a loss of spawning and rearing habitat for resident and anadromous fish.

Additionally, fish mortality results from dissolved oxygen or oxygen saturation, both of which are associated with dam operation (e.g. air entrained behind penstocks).

Surface water withdrawal reduces stream flows and surface water acreage in lakes and reservoirs. This results in loss of fish habitat, reducing the fish species diversity in affected water-bodies. The problem is particularly acute in streams which suffer velocity alterations from surface water withdrawal.

Surface water withdrawal also causes loss of riparian vegetation, a prime habitat for terrestrial organisms. Loss of habitat triggers increased food competition which results in increased predation.

Finally, surface water withdrawals decrease discharge into wetlands, impacting the habitat value of these unique and productive eco-systems. It should be recognized, however, that the process of withdrawing surface water for irrigation can create wetlands.

Flood control in lakes, riparian areas and floodplains is a broad category of activity which includes stream channel alteration, dredging and filling and bridging and culverting.

Stream channel alterations decrease fish spawning and rearing habitat, induce fish egg and larvae mortality, fish crowding and fish fry and fingerling mortality.

Dredging and filling causes the elimination of stream side vegetation which is prime wildlife habitat. Loss of streamside vegetation causes increased food competition and predation in wildlife populations. Additionally, loss of streamside vegetation causes increased sediment loading in streams. Sediments can abrade fish gills and foul spawning gravels.

Bridging and culverting cause increases in steam velocity. Faster water scours spawning gravel, causing the loss of spawning areas.

Forest practices alter the hydrologic cycle significantly and wildlife does not escape the impact of those alterations. Logging alters surface and ground water patterns in the area logged. Infiltration capabilities change and flow regime in surface water courses is altered.

The result can be loss of habitat complexity in streams, death or removal of the habitat provided by riparian vegetation and fish blockage.

Irrigation distribution works and on farm irrigation practices both create and destroy wildlife habitat. This phenomenon occurs when leaking irrigation canals cause a reduction in dryland habitat and the creation of wetlands and streams in formerly arid or semi arid areas.

Livestock grazing, storm water detention ponds and homebuilding along streams and urban development all alter the hydrologic cycle to the general detriment of wildlife. The principal source of stress from these activities is the loss of riparian vegetation along the banks of waterbodies.

Additional stress occurs when development alters surface water drainage patterns causing increased peak flows and other changes which, in turn, cause disruptions in fish spawning.

Impacts on wildlife from pesticides

Analysis of risks to wildlife from pesticides use in Washington included a review of a draft report produced in 1988 by the U.S. EPA Seattle office and later work performed for the Washington Department of Wildlife by Mr. Wendell Oliver.

The focus of Washington Environment 2010 efforts was on the indirect exposure to animals (including wildlife and birds), through ingestion of residues in food having been treated with pesticides, or that have taken in pesticides from soil or air. Additionally, indirect exposure to animals from ingestion of residues in animals that have eaten food treated with pesticides or plants that have taken in pesticides from soil or air, was considered.

The major sources of pesticide exposure cited in the Washington Environment 2010 definition of the pesticide threat included agricultural and commercial use (including short range aerial drift), and bioaccumulation in food chains.

It is recognized that some of the case studies cited to illustrate the general discussion of pesticide effects involve pesticides that are no longer in use. The development, registration and use of pesticides is a rapidly changing and heavily regulated field; A situation which complicates any attempt to analyze the current impact of pesticides on wildlife.

Analysis is further complicated by the fact that there are currently over 350 active pesticide ingredients registered for use in Washington state. That number changes because the U.S. EPA maintains an ongoing re-registration program for the active ingredients in pesticides, pursuant to the Federal Insecticide, Fungicide and Rodenticide Act. The re-registration process requires manufacturers to list the pesticide ingredients they wish to defend and produce data to substantiate the safety of the product. If safety cannot be proven to the satisfaction of regulatory agencies, the product is delisted, or certain applications of the product are disapproved.

It is also interesting to note that not all of the approved active ingredients are commonly used in our state. Mr. Dick Maxwell of, Washington State University, now estimates that 50 of the 350 active pesticide ingredients approved for use in the state, account for 95% of the pesticides used in Washington agriculture.

In recent years, the standards for registration of pesticides that have the potential for acute and/or chronic impacts on nontarget species, have become increasingly restrictive. Certain applications of Diazinon, for example, have been disapproved based upon their potential for adverse impacts on birds.

Terrestrial and aquatic ecosystems are exposed to to pesticides through direct application and indirectly by drift.

Exposure to pesticides can result in acute effects to nontarget species through either direct mortality of the organism or significant impairment such that mortality occurs through another source (a predator, for example).

To illustrate, in the past, exposure to diazinon has been responsible for bird kills. In 1970, Patterson reported dead and dying Canada geese along the Columbia and Okanogan rivers that were suspected victims of Diazinon, Lindane, Parathion and Endrin used in the study area. A notable decline in bird populations indigenous to this area was reported in areas where heavy use of these pesticides was occurring.

Chronic effects over time, while not causing immediate mortality to the individual, can eventually result in reduced wildlife populations. Exposure to pesticides can result in a range of effects from fetal abnormalities and tumors to changes in behavior. The following are examples of chronic effects resulting from exposure to pesticides by nontarget species.

- Malathion is believed to have been responsible for weakening the defense of breeding grounds by sharp-tailed grouse, which leads to predation of the clutch.

- Birds dosed with methyl parathion display much lower activity levels than unaffected birds. Changes in activity levels may threaten the ability of wildlife to find food, escape predators or migrate successfully.

- Reduced parenting was reported in song birds exposed to organophosphate.

- Parathion exposure has been associated with lack of nest attentiveness in laughing gulls resulting in a fledgling success rate 30% below normal.

- Organophosphate and carbamates are associated with delayed neurotoxicity in mammals.

- Phenoxy herbicides are associated with fetal abnormalities in mammals.

While these examples of acute and chronic effects are not necessarily Washington specific or associated with major pesticides in use in Washington, the species affected and the pesticides used are all present in western states.

Pesticides also impact wildlife by virtue of their presence at the ecosystem level.

Acute and chronic effects of pesticides on individual organisms within an ecosystem can result in adverse effects on the ecosystem itself. Such effects can cause a reduction or alteration of species diversity. The food chain may be altered which, in turn can change the energy flow and nutrient cycling. Pesticides can reduce habitat quality by altering the physical resource. This impacts the stability and resiliency of the ecosystem.

Aquatic herbicides, for example, can be toxic to aquatic insects and fish. These nontarget aquatic organisms are highly important as a food source for duckling and other waterfowl, and other birds (including upland birds). Most of the pond and floating aquatic plants that are targeted for removal provide important food and cover for wildlife in wetland habitats and riparian zones.

Croplands, forest lands and rangeland ecosystems are all subjected to pesticides use for various management purposes (e.g. noxious weed control, silviculture, pest management). Overuse or misuse in other forms, poses the risk of degrading wildlife habitat by removing vegetation or destabilizing the food chain by destroying nontarget organisms such as soil microbes, predators and pollinators.

Impact on wildlife from wetlands loss and/or degradation

Loss and/or degradation of wetlands is defined as nonchemical conversion or alteration which results in a net reduction to total wetland and/or impairment of the physical functions and ecological values of the impacted wetland. Examples include filling and draining.

Wetland loss is extremely severe or fatal to both resident wildlife and migratory animals which rely on wetlands for part of their annual lifecycle (e.g. shorebirds and waterfowl).

As individual wetlands are reduced in size, diversity and complexity, their functions and values are also lost. For example, a degraded wetland may become to small to provide habitat for certain species or contribute in a measurable way to flood control.

Impact on wildlife from sudden accidental releases

This category of risk focuses on catastrophic events with acute impacts, often requiring some sort of emergency response. Toxic chemicals are accidentally released into the environment in a variety of ways during manufacture, transport or use. The categories of chemicals of particular interest include toxic organics, toxic inorganics, oil and other petroleum products.

Impacts to wildlife from these events occur primarily as a result of transport related spills. The consequences often include death and contamination of fish, shellfish, other aquatic organisms including marine mammals, and birds.

Impacts on wildlife from radioactive releases from wastes/materials handling/storage

The analysis of this risk was narrowly defined to include only those radioactive releases associated with the storage and handling of radioactive waste materials. Sources of waste materials include active and decommissioned nuclear power plants and nuclear weapons manufacturing facilities, hospitals and other medical facilities, mining and milling operations, abandoned hazardous waste sites and certain industrial activities.

The analysis concluded that the risk of wildlife being exposed to significant qualities of radioactive wastes in Washington state was negligible. Scientifically verifiable information on wildlife exposure was found for the Hanford Nuclear Reservation only.

Waterfowl, deer, fish, game birds and rabbits on the Hanford Reservation all have been documented to have low levels of radionuclide concentrations in their tissue.

Impacts on wildlife from global warming and stratospheric ozone depletion

Global warming is caused by the addition of greenhouse gases to the atmosphere. Ozone depletion is caused by the addition of chlorofluorocarbons to the atmosphere.

Global warming raises the possibility of a shift in the range of wildlife and fish species northward. In addition, it is possible that species may migrate to higher elevations as the climate warms.

Impacts on wildlife from litter

For purposes of Washington Environment 2010 litter is defined as waste materials including, but not limited to disposable packages or containers and not including mining, logging, sawmill, farming or manufacturing wastes. Of particular concern in the 2010 analysis was the issue of marine debris.

Marine mammals and birds are strangled by plastic six-pack rings after becoming entangled.

Marine birds eat plastic bits and feed them to their young. The plastic is ingested and results in death by starvation or infection.

Fishing nets lost or cut loose to drift by commercial fishermen, may drift for months or years. Marine mammals, fish and birds become entangled and die.

Seabirds have become entangled in many kinds of marine debris including fishing nets, monofiliment fishing line, kite string and plastic bags.

C. Current Conditions

Resident Fish - Resident fish populations in most areas of the state are in fair to excellent condition despite threats to their habitat. For lowland trout lakes this is largely due to hatchery programs; there is little spawning habitat. Stream trout populations are only fair as they are especially vulnerable to development and overfishing. Trout populations in alpine lakes are excellent, and are expected to be sustained as long as acid rain is kept in check.

Warmwater Fish - Generally, warmwater fish populations in Washington are in fairly good shape despite threats to their habitat. These fish species tend to be relatively tolerant of environmental extremes.

Anadromous Fish - Wild populations of steelhead have shown positive response to increased protection and institution of spawning escapement goals in certain areas of the state. However, knowledge is limited about levels of escapement required for a stable population of steelhead in the Columbia River.

Sea-run cutthroat and Dolly Varden populations are believed to be depressed in many areas of the state, although hard data are not available. Estimates of total population size and spawning escapement presently are not feasible on a large scale.

Populations and harvest opportunities for sea-run cutthroat in saltwater have declined in recent years due to habitat alteration, incidental harvest by commercial salmon fisheries, competition from salmon, possible overharvest by sport fishermen, and regulation restrictions enacted in 1980 and 1986.

Big Game - Populations of big game vary considerably according to land use and vegetation patterns. Population estimates are contained in Table 7.

Presently, black-tailed deer populations are found throughout western Washington. In low snowfall areas, deer populations tend to increase when mature Douglas fir forests are clearcut in small patches. In areas of heavy snowfall, mature and old-growth forest provide important deer wintering habitat.

Because of favorable habitat changes in forested areas, Roosevelt elk populations and harvest are much higher now than 30 years ago. Peak populations were reached about 1980. Since then population numbers have stabilized in most areas, except in extensive clearcut areas where elk populations have declined.

Mule deer populations have generally increased in both numbers and harvest from the low levels of the early seventies. White-tailed deer are also gradually increasing.

Populations and harvest of Rocky Mountain elk have increased substantially from the first reintroduction, but have stabilized in recent years. Habitat limitations, particularly winter range, will prevent any significant population increases. The rapid increase in numbers of elk hunters from the forties to seventies has leveled off to about 80,000 elk hunters per year.

Black bears in western Washington have adjusted to even-aged timber management which emphasizes clearcutting of Douglas fir. Eastern Washington bear habitat appears to be maintaining its ability to support bear populations. The statewide bear population is now estimated to number 21,000 and is once again increasing, particularly in western Washington.

Current statewide populations of cougars are stable. This balance is being maintained more by conservative seasons than by habitat protection.

Compared to mountain goat populations in 1961, goat numbers are down about 30% west of the Cascade Crest and 50% on the east side. Future population levels will be determined largely by efforts made by land management agencies to protect native habitat.

Bighorn sheep populations are limited in size and distribution in Washington. Most of Washington's sheep are released on lands owned or controlled by WDW. Bighorn sheep populations are increasing, especially in the Blue Mountains. Hunter interest exceeds supply, and while Washington's sheep are doing well, supply will never reach demand for these majestic animals.

Moose populations are small but increasing from the small, forested areas of eastern Pend Oreille county.

Migratory Game - In general, wintering populations of waterfowl have increased about 50% since the 1940s. This is due primarily to development of wintering habitat associated with the Columbia Basin Irrigation Project. Waterfowl harvest has been declining since the early 1980s, primarily due to a 55% decrease in the number of waterfowl hunters. The waterfowl production index has been increasing since the survey was initiated in 1970. Band-tailed pigeon and mourning dove populations have exhibited a downward trend for the past 20 years. Pigeon populations have declined in numbers throughout the Pacific Flyway during the last decade due to unknown causes. Snow goose and brant populations are increasing. Appreciative use of migratory birds is increasing.

Furbearers - Populations of most species have been stable for the last decade, and in most cases harvest has been below the biological potential. WDW's goal for this group is to increase populations of eastern Washington bobcat, Cascade red fox, and marten above current levels, and to maintain populations of western Washington bobcat and all other species at current levels. Due to wetland and riparian habitat losses, this may not be possible.

Upland Game - Upland game species are typically relatively short-lived with high reproductive potential. Overall, harvestable supply exceeds current and anticipated hunting demand in most cases. With the exception of forest grouse species, availability of upland game depends largely on access to private land and the quality and disturbance factors on existing habitat.

Some species (such as chukar, Hungarian partridge, and turkey) are increasing, while others (pheasant, sage and sharp-tailed grouse) continue to decline due to habitat loss. Populations of forest grouse species have been generally constant on existing habitat. Ptarmigan populations apparently are stable, and no significant changes in alpine habitat are anticipated. Populations of rabbits and hares also have remained fairly stable. Even with a steady, overall decline in riparian habitat in Eastern Washington, quail populations appears to have been climbing steadily.

Nongame - Habitat fragmentation caused by agricultural, timber, commercial, and residential development has created small islands of habitat which support isolated populations with limited means of genetic exchange. Isolated populations are much more prone to extinction than larger, expansive populations. The WDW Nongame Program has identified over 180 species that potentially are at risk. Fifty-one non-pelagic species are considered at risk for population declines in the immediate future. An additional eight invertebrate species have also been identified as imperiled. These 59 species are classified as endangered, threatened, or sensitive species, or as probable candidates for these classifications. Of these 59, 11 are thought to be highly vulnerable and likely to become extirpated from the state by the year 2010.

D. POSITIVE ASPECTS OF THE RESOURCE

Fish - Resident, Warmwater, Anadromous - WDW provides angling opportunities for hundreds of thousands of resident and non-resident anglers each year, and demand for sport angling continues to grow every year.

Because lowland lakes are generally more productive than high lakes and more accessible to the public, they traditionally have provided more freshwater angling opportunities than all other fisheries combined. This program provides over 4.6 million days of recreation each year to 380,000 anglers. The resident trout stream program provides over 1.5 million days of recreation each year for 178,000 anglers, and alpine lakes provide 800,000 days each year to 131,000 anglers.

Warmwater fish populations are large enough and adequate enough that an estimated 244,274 anglers spent 3,448,900 days fishing for warmwater species in Washington in 1986.

An estimated 102,000 sport steelhead anglers caught 127,000 fish during the period from July 1987 to June 1988.

Wildlife - Big game, Migratory Game, Furbearers, Upland Game
During 1988, a total of 3.4 million person/days of recreation were carried out during hunting seasons for big game, upland birds, and waterfowl. WDW Wildlife Areas include 770,000 acres which provide about four million person/days of recreation.

Expanding human populations in Washington continues to be vitally interested in wildlife, and big game animals are a prime attraction for outdoor enthusiasts.

While deer and elk provide the most hunting opportunities, other species also contribute to the overall recreational experience available in Washington. Mountain goats are of considerable value as trophy game animals and for appreciative enjoyment of hikers, backpackers, and photographers. Moose also have a mystique attracting special attention because of their trophy size and appearance, their small population, and relatively recent appearance in Washington. The appreciative value of moose is perhaps more significant than its value as game, although limited hunting by permit will continue.

In spite of wetland losses in many of the continent's major breeding areas during the 1980s, Washington's wintering waterfowl populations have remained stable. Increased acreage planted to corn in the Columbia Basin has resulted in a growing duck population in that area. Favorable production conditions have allowed our local duck and goose breeding populations to increase.

In 1988, mid-winter waterfowl counts were up 32% from the previous year, and 25% above the long-term average. The snow goose population in the Skagit Delta area climbed to almost 42,000 in 1988, the highest level recorded. The brant population rose to almost 20,000, the highest level since 1967. Because ducks, geese, and swans normally concentrate in large numbers, and often in localized areas protected from hunting, they are valued highly for appreciative use as well as harvest.

Nongame - A U.S. Fish and Wildlife survey of hunting, fishing, and other wildlife related recreation showed that in 1980 Washington provided 21 million days of appreciative wildlife use, involving both game and nongame species. Based on projections from this survey, appreciative wildlife use was expected to increase to over 22.5 million days annually by 1986.

Many nongame species are generalists and are able to use a wide variety of habitats, both pristine and disturbed, successfully. Many of these species continue to thrive in increasingly disturbed habitats.

III. CURRENT STATE PROGRAMS FOR CONTROL OF RESOURCE DEGRADATION

A. Control Mechanisms

Title 77 RCW established WDW, definitions of terms, powers and duties, prohibited acts and penalties, and required licenses. Chapters 77.04, 77.08, 77.12, 77.16, 77.21, and 77.32 RCW are further implemented by Chapter 232-12 WAC. In general terms these statutes and rules provide regulations which allow the WDW to "preserve, protect, and perpetuate" fish and wildlife. This ranges from the establishment of hunting and fishing seasons and bag limits to the requirement of fish passage facilities at dams and the classification of fish and wildlife.

State Environmental Policy Act (SEPA, RCW 43.21C), affects all state, county, city, and other jurisdiction laws, regulations, and policies. It was enacted to assure that the environment is given appropriate consideration in state and local permit decisions. This is accomplished by requiring information on potential impacts from a project. WDW reviews and responds to these documents and makes recommendations to protect, reduce, and mitigate impacts on fish, wildlife, vegetation, surface waters, and recreation.

The Hydraulic Code (RCW 75.20.100, .103, and .106) requires a Hydraulic Project Approval (HPA) from either WDW or the Department of Fisheries for work within the ordinary high water line of waters of the state. "State waters" includes marine waters, lakes, ponds, rivers, sloughs, backwaters, drainage ditches if originally a natural watercourse and intermittent streams even when they are dry. Just about any activity from building a bulkhead to putting in a dock to dredging for gold is covered. The purpose of this permit is to protect fish life and fish habitat. Each HPA sets conditions specifying the type, method, and timing of project work in order to protect fishery resources.

The Forest Practices Act (RCW 76.09), administered by the Department of Natural Resources, requires that a Forest Practices Approval (FPA) be obtained before beginning a forest practice on non-federal forest land. Most activities related to growing and harvesting timber are subject to this law. Our primary obligation is to determine if an HPA is also required. In addition, WDW reviews all forest practices applications potentially affecting wildlife and wildlife habitat. Field biologists assist forest landowners, tribes, environmental organizations, DNR, and other state agencies in the design and review of forest practices, especially practices affecting riparian management zones, threatened and endangered species, big game winter range, and species and habitats of special interest. Table 9 summarizes these activities.

TABLE 9

WASHINGTON DEPARTMENT OF WILDLIFE
HABITAT MANAGEMENT DIVISION

SUBJECT: Forest Practices Applications...WDW Regional Summary
PERIOD: 1988 TOTAL

	TASK----------------------	WDW REGIONS 1	2	3	4	5	6	TOTAL
1.	FPAs received from DNR	1141	149	357	1376	2484	2964	8471
2.	FPAs with wildlife concerns	605	100	235	627	985	1980	4532
	(Describe below your criteria for screening FPAs with wild-life concerns)							
3.	FPAs reviewed by "TFW Bios" in:							
	+ office	1131	140	358	1387	2338	1094	6444
	+ field	110	12	91	54	100	94	451
4.	FPAs reviewed by "other WDW personnel" (exclusive of HPAs):							
	+ office	95	0	0	0	127	350	572
	+ field:	12	4	5	61	5	125	212
5.	FPAs not reviewed but should be:	371	68	165	250	0	1072	1926

OTHER INFORMATION NEEDED								AVE.
1.	Average time (hours) to review one FPA in the:							
	+ office?	0.20	0.24	0.35	0.45	0.05	0.59	0.26
	+ field?	6.0	16.0	6.0	6.0	4.5	7.0	8.0
2.	Percent of total time spent travelling?	55	70	33	27	20	45	41
3.	No. ID Teams attended?	20	6	22	33	60	17	158
4.	Number of annual timber harvest reviews attended?	2	1	3	10	9	4	29

The Shoreline Management Act (RCW 90.58) at the local level regulates various forms of land use and development in and within 200 feet of marine waters, streams with a mean annual flow of 20 cubic feet per second or more, and lakes which are 20 acres or more in surface area. Associated wetlands are also included. WDW has advisory authority only. For projects that require a shoreline permit under the Act, WDW makes recommendations to local government for fish and wildlife mitigation and protection. This often comes in conjunction with or simultaneously with SEPA review.

WDW reviews and responds to water right applications (RCW 75.20.050). This is administered by Department of Ecology (DOE). If fish resources could be impacted, field investigation is usually performed. Depending on potential impacts, we may request DOE to set conditions to install fish screens, to limit the quantity of water withdrawn, or to modify or eliminate a diversion structure. Where critical fish habitat could be destroyed, we may ask that the water right not be issued. The Water Resources Act (RCW 90.54) and Minimum Water Flows and Levels (RCW 90.22) are closely tied to water rights. The former provides for base flows to be provided in streams and for lakes and ponds to be retained in substantially their natural condition. The latter empowers DOE to establish minimum flows and water levels to protect fish, wildlife, and water quality. WDW makes recommendation to DOE to help accomplish this.

Bald Eagle Protection Rules (RCW 77.12.655 and WAC 232-12-292) are designed to protect bald eagles, a state and federally listed endangered species. Rules have been adopted which define the extent and boundaries of eagle habitat buffer zones. WDW cooperates with landowners and permitting agencies to develop site management plans for habitat that would be impacted by various land use activities.

U.S. Army Corps of Engineers Section 10 and 404 permits are established by the federal Rivers and Harbors Act (1899) and the Water Pollution Control Act amended as the Clean Water Act (1972). These laws are designed to control water pollution and protect the nation's waters from uncontrolled modification. Section 10 permits are required for work in navigable waters which generally include all marine areas, streams which have been used in interstate commerce, wetlands or lakes more than one acre in surface area, and streams with a mean annual flow of five cubic feet per second or more. WDW reviews all Corps permits and provides the Corps with recommendations and conditions for work methods, timing, project design, and other measures to protect and mitigate impacts on fish and wildlife and their habitat.

The Fish and Wildlife Coordination Act (16 USC 661-667; enacted 1958) applies when a proposal involves surface water and a federal permit is needed, or when federal funds are used for planning and construction. It requires that fish and wildlife receive consideration equal to other project features. Federal and state fish and wildlife agencies must be consulted by project sponsors to develop plans to prevent the loss or damage of fish and wildlife resources. WDW coordinates with the Department of Fisheries and the U.S. Fish and Wildlife Service in efforts to minimize damage to fish and wildlife through project mitigation plans, design changes, habitat enhancement, and land purchase.

The Federal Power Act (16 USC 797-817; enacted 1970) allows state fish and wildlife agencies to intervene in licensing procedures for all non-federal hydroelectric projects in order to protect fish and wildlife resources. WDW consults with project sponsors, examines proposals and studies and inspects sites to help determine potential impacts on fish and wildlife. Following this, conditions are identified for resource protection and a mitigation/compensation plan is developed. The program is administered by the Federal Energy Regulatory Commission (FERC).

The National Environmental Policy Act (NEPA, PL 91-190), is similar to SEPA as is our involvement. As discussed in an earlier section WDW reviews environmental documents and makes recommendations to protect and mitigate impacts on fish, wildlife, and habitat.

The Federal Endangered Species Act (PL 93-205; enacted 1973) declares that threatened or endangered species of fish, wildlife, and plants are of "esthetic, ecological, educational, historical, recreational, and scientific value to the nation and to its people..." It is federal and WDW policy to conserve these species and their habitats. We coordinate with the U.S. Fish and Wildlife Service to accomplish this.

The Department is continually striving to enhance consumptive and nonconsumptive uses of waterfowl through habitat and regulatory programs. The Department supported legislation in 1985 which created a "duck stamp" required of all waterfowl hunters, with revenue dedicated for waterfowl habitat enhancement and acquisition. Hunting regulations are adjusted annually to meet population objectives and ensure sustainable populations.

B. Successes

There have been numerous successes in current state programs in reducing and helping prevent serious deterioration or loss of a variety of fish and wildlife resources. The following examples are used to illustrate some of these successes.

More than 2,000 SEPA/NEPA documents are reviewed by WDW yearly. Approximately 50 to 60% of these resulted in beneficial project changes and fish and wildlife mitigation or compensation. The following are some examples of these accomplishments.

Hanford Reach Dredging - The Seattle District U.S. Army Corps of Engineers was proposing to dredge the Hanford Reach of the Columbia River to facilitate barging and shipping traffic clear to Wenatchee. This portion is one of the last comparatively undisturbed natural stretches of the Columbia River and is renowned for its fish and wildlife and scenic resources. We estimated that approximately one half of the numbers of fish and wildlife would have been eliminated by dredging and spoil disposal. At the request of the Northwest Power Planning Council we coordinated and conducted a tour of the area which was attended by the majority of the Council members, their staff, state and federal agencies, Indian tribes, and newspaper and television reporters. Presently the Hanford Reach is being considered by the U.S. Congress for designation under the Wild and Scenic Rivers Act. We assisted with coordinating recommendations from the Governor supporting inclusion under the Act.

White Salmon and Klickitat Rivers - Similar to our involvement and efforts for the Hanford Reach, we reviewed and provided recommendations for Wild and Scenic River designations for portions of the White Salmon and Klickitat Rivers. Our recommendations called for increasing the amount of protected land from 240 acres to 320 acres per river mile. This has already been accepted for at least the Klickitat River. A variety of wildlife and fish such as steelhead trout and salmon will benefit from the protection a Wild and Scenic River designation will afford. Habitat such as mature Ponderosa pine and Oregon white oak will also receive added protection. This in turn will help to preserve wintering bald eagle populations. wild turkey, and western gray squirrel, a state species of concern because of its diminishing numbers.

A proposal for marina construction and restaurants, a motel and various businesses was planned for the southern portion of Padilla Bay near Anacortes in Skagit County. The project location provides critical eelgrass habitat for black brant and migrating juvenile sea-run cutthroat, steelhead trout and Dolly Varden. An adjacent sand island is used as a wintering area by 3,000 to 3,800 dunlin. Bald eagles and peregrine falcons feed in the area. One of only three graveling areas for black brant is adjacent to the site. We have recorded peak one day migration period counts of up to 80,000 western sandpipers. This equates to a total number of 200,000 to 300,000 sandpipers. Our review criticized the proposal for its failure to recognize these resource values and for its lack of mitigation. We also made recommendations for modifying the proposal to lessen impacts. Approximately 10.8 acres of salt marsh, 0.8 acres of eelgrass and 45.8 acres of intertidal mudflats were involved. Our initial concerns were pointed out the year before but were not incorporated into the EIS. As a result, we recommended denial of the Corps permit.

Hydraulic Project Approvals which were investigated, issued or denied by WDW totaled 2,300 (June 1987 to July 1988). One hundred percent of these resulted in some degree of mitigation. Some examples follow.

Wilson Creek Culvert - An HPA was submitted by the Kittitas County Fairgrounds to relocate and culvert approximately 2,100 feet of a trout bearing stream (Wilson Creek Tributary Yakima River). As this was a channel change, SEPA was required. The county exempted the project, making WDW lead agency. During the field investigation for the HPA, the proponents were notified that the project, as proposed, was unacceptable due to impacts on brown trout, but submitted the checklist with no changes (2,100 feet of culvert). Being lead agency, WDW determined the project to be of significance and notified the proponent that an EIS would be required. Rather than write an EIS the fairboard agreed to scale the project down to a 1,500' channel change, with 900' culverted, and fish habitat improvement in the open channel area. A mitigated DNS was issued reflecting this change.

Snake River Road Widening - The Asotin County Planning Department was planning on widening part of the Snake River Road. The road parallels the river along a narrow shelf with the river on one side and sheer rock walls on the other. In reviewing their plans and specifications for Hydraulic Project Approval we found that they would need to fill a total of 0.63 acres in the Snake River which provides important habitat for steelhead trout. Project alternatives were extremely limited. Through scrupulous review, however, we were able to modify the proposal by use of guard rails and a retaining wall thereby reducing the amount of necessary filling to 0.25 acres. The county also agreed to install four deflectors to replace lost fish habitat and to revegetate with native plants to replace lost riparian vegetation.

Walla Walla Water Supply - The City of Walla Walla replaced 14 miles of their domestic water supply lines to increase capacity from 22 cfs to 48 cfs. To mitigate fish habitat damages the City provided us with a $10,000 fund which will be used this fall to make structural habitat improvements in Mill Creek. However, upon follow up inspection, we discovered that one of the Hydraulic Project Approvals we had issued had resulted in an anadromous fish passage block on Blue Creek. The City also willingly installed a log fish weir to create a jump pool for fish to correct the passage problem.

In the period of June 1987 to July 1988, 306 Section 10 and 404 Corps permits were reviewed. Approximately 40% of these included mitigation conditions. Examples follow.

Ice Harbor Channel Widening - Permits for this proposal were actually reviewed during a previous reporting period. The Corps of Engineers has now completed the navigation channel widening project on the Snake River and fulfilled their mitigation agreement as well. This resulted in $24,000 to pay for hatchery operation costs to replace anadromous fish losses. Also, in September 1987, 5,000 12-inch minimum sized catfish were planted below Ice Harbor Dam to replace warmwater fish losses which occurred due to under water blasting and dredging.

Wastewater Outfall - The proponent was planning to extend the underwater outfall near Port Kelly at a pulp mill 9,000 feet into the Columbia River. They wanted to begin dredging, however, two weeks before the established anadromous fish window for this portion of the river. As mitigation for working outside of the fish window we tried to reach an agreement to repair a public boat launch located near the site at the Walla Walla Yacht Club. It is the only public boat launch in the area, but it had been closed due to disrepair and unsafe conditions.

Mill Creek Wetland Fill - This project involved an illegally placed fill at the confluence of Mill Creek and the Green River in King County. About 25 acres were filled to create land to build a savings bank on. The filling was reported to the Corps of Engineers and the applicant applied for an after the fact permit to retain the fill. Since the applicant did not propose any form of mitigation or compensation, we recommended that the fill be removed and the site be restored to its original condition. A similar situation occurred on Hylebos Creek in Pierce County. The City of Fife proposed to fill 0.28 acres of wetlands as part of a road widening project. No mitigation or compensation was proposed. It was therefore recommended that permits not be issued or be denied until agreement could be reached for adequate mitigation.

In 1988 WDW reviewed 8,471 Forest Practice Applications. Fish and wildlife concerns or recommendations for mitigation were expressed on 4,532 of these. Table 9 provides a more detailed breakdown of these efforts.

To control undesirable exotic fish species WDW relies on enforcement and its lake and stream rehabilitation program. The best example of the successes of rehabilitation occurred at Sprague Lake where rotenone was applied to about 2,000 acres of interconnected lake, stream, and marsh habitat in the fall of 1985 to eliminate carp. The lake was subsequently restocked with a population of warmwater fish skewed towards predatory species to prevent reinvasion by carp. The predatory species stocked included largemouth and smallmouth bass, walleye, channel catfish, rainbow trout and brown trout. The only species stocked which would not act as an effective predator at some point in its life cycle was the bluegill.

The use rate for angling at Sprague Lake increased to approximately 20 times what it was prior to the rehabilitation when the lake was dominated by carp. Water quality in the lake also improved substantially, and based on information from other areas, waterfowl and furbearer use at the lake will also increase substantially. Our strategy of carp control has been effective so far, because during three full seasons of monitoring the lake for reinvasions by carp, Dr. Al Scholz at Eastern Washington University has only recovered one carp, which was an adult fish. Apparently no detectable numbers of young carp have been able to survive in Sprague Lake so far. The program and evaluation of the Sprague Lake project will be presented in a report to be finished by Dr. Scholz by the end of March, 1989.

Another example of controlling habitat degradation can be seen at Mayfield Lake in Lewis County. The degradation in this area was caused by construction of two dams on the headwaters of the Cowlitz River. The lower dam (Mayfield Dam) formed Mayfield Lake. This dam featured a surface outlet, which caused the warm surface waters to flow out of the lake. Immediately above Mayfield Lake was Mossyrock Dam, which formed Riffe Lake. Riffe Lake had a very deep water outlet through Mossyrock Dam, which caused very cold water to flow out of Riffe Lake into Mayfield Lake. As a result, Mayfield became a very cold lake, and all the warmwater game fish in Mayfield Lake ceased to spawn after Mossyrock Dam was completed. As a result, there were not enough predators to control the squawfish population, which multiplied excessively. Once the squawfish population became dominant, they preyed heavily on other fish species in the population and salmonid survival dropped to nearly zero. The Department of Wildlife tried at least 10 different solutions to this problem through 1986, none of which worked. The latest attempt to control the squawfish population (while simultaneously creating a trophy fishery) was to introduce tiger muskies into the lake. This plan was implemented in the fall of 1988, so we do not know how successful it will be, but we have considerable confidence.

Another proposal to control habitat degradation was a potential answer to water level and temperature fluctuation in the Columbia River below Priest Rapids Dam. This dam is being operated as a peaking power facility, but this has caused increasingly severe fluctuations of downstream water level and temperature. As a result, smallmouth bass populations in the Hanford Reach are being adversely affected. A proposal was made by WDW to the Northwest Power Planning Council in 1987 to fund the development of nursery ponds for smallmouth bass immediately adjacent to the impacted area. However, salmonid management agencies associated with the Columbia River opposed this plan, and it was not accepted by the Council. This plan has sound biological merit, and can be implemented without danger to Columbia River salmonids.

The duck stamp program has significantly improved habitat in the state's major waterfowl areas, through manipulation of water levels, excavation, food and cover plantings, fencing, and habitat acquisitions. Several of these projects have been done in cooperation with local conservation organizations and Ducks Unlimited, Inc. through the MARSH program.

C. Opportunities

A total of 3.4 million person/days or recreational activity were carried out during hunting seasons for big game, upland birds and waterfowl.

Wildlife Areas totaling about 770,000 acres provided about 4 million person/days of recreation.

The winter feeding program supported 5,000 elk, 10,000 deer, and 20,000 upland birds while providing 150,000 people chances to observe wildlife last year.

A total of 1,257 trapping licenses were purchased during the 1987-88 season. Trappers harvested 8,921 beaver, 690 bobcat, 7,354 coyote, 21,843 muskrat, 682 river otter, and 2,504 raccoon.

Mid-winter waterfowl counts were up 32 percent from last year, 25 percent above the long-term average. Production indices for ducks were similar to 1987; goose production surveys indicated excellent production in 1988.

The snow goose population in the Skagit Delta area climbed to almost 42,000 in 1988, the highest level recorded.

The brant population rose to about 20,000, the highest level since 1967.

The resident trout program provided recreation to 530,000 licensed anglers in 1987.

Columbia River wild steelhead exceeded the aggregate escapement goal at Bonneville Dam for the first time since we have been monitoring this parameter.

Between July 1987 and June 1988, treaty fishermen took 164,000 steelhead in Washington. An estimated 102,000 sport steelhead anglers caught 127,000 fish during this same period (this does not include Columbia River mainstream sport catch by Oregon anglers).

Mid-wintering bald eagle counts have risen from a total of 1,377 in 1982 to 2,373 in 1988. Nesting pairs have increased from 178 to 307 for the same period, and nesting success has gradually increased by about 0.3% since 1982.

IV. IMPACT OF POPULATION GROWTH ON RESOURCE

As the population of Washington grows, fish and wildlife habitat becomes more and more burdened by the number of people on the land. Demand for wildlife-oriented recreation will continue to increase each year. Conversely, wildlife habitat can be expected to decline each year. Projections for the Pacific Northwest indicate that one-half acre of land is lost to wildlife production (calculated for big game) for every family added to the population.

Resident Fish - It is estimated that the number of anglers in Washington will increase slower than the projected rate of population growth. Unless habitat is vigorously protected, all streams are strictly managed to insure adequate reproduction of wild fish, hatchery production is increased 25-30%, and access to currently available water is increased by 25-30%, angler satisfaction will decrease dramatically and existing populations of wild fish will be further depressed.

Warmwater Fish - Trends indicate that an ever smaller portion of the public is participating in fishing. This may eventually affect the public's willingness to accept some of the more controversial aspects of fishery management, such as use of rotenone or other chemicals to kill fish, expenditures of money for fish management, habitat protection when interests of fish conflict with interests of a non-fishing public, assuring access for anglers, etc. This would likely result in a decline in the amount of fish management that WDW would be able to do. As this decline would have the most effect on resident trout fisheries, it likely would divert more angling pressure to warmwater fisheries.

Anadromous Fish - For steelhead, the relationship between population size and angler participation is complicated by the number of fish available and the cost of a steelhead permit. Steelhead permit sales have varied most according to the size of the run. It is doubtful that a 30% population increase would result in a similar increase in participation. WDW has projected the need to increase hatchery production by 10% for all anadromous species. Increased angler effort would be dealt with through regulation of wild harvest if necessary to meet escapement goals.

Increased human population probably will result in increased angler harvest of sea-run cutthroat and Dolly Varden, but not at proportionate rates. WDW estimates a 10% increase over the 1986 Angler Survey estimates. The trend toward more restrictive regulations to protect natural/wild populations will increase, with higher minimum size limits for some streams, and increased use of catch and release or wild cutthroat release when hatchery enhancement occurs.

Monitoring of wild stocks should increase over present efforts. With proper protection, wild stocks that are presently below escapement should recover. Catch and release fishing for wild fish may become increasingly popular, at least on selected rivers or reaches of rivers. Increased understanding of interactions between hatchery and wild fish may allow higher planting levels than are currently used.

Big Game - Increasing human populations generally result in decreasing wildlife populations. Wildlife inhabiting the Puget Sound area will be most severely impacted by population growth. As urban sprawl takes over prime wildlife habitat, fewer big game animals will be able to survive.

Black-tailed deer, for example, currently number about 200,000 in western Washington. By the year 2010, these numbers will not exceed 150,000. Mule deer currently number about 135,000, but winter ranges are being developed for recreational purposes and housing development. By 2010, mule deer populations will not exceed 100,000. White-tailed deer currently number about 67,000 and should remain stable in the foreseeable future.

Elk populations currently number about 57,000 and could be severely impacted in the future. Habitat and damage problems will result in a population reduction to less than 50,000 by 2010.

Cougar and bear populations should not be seriously impacted in the foreseeable future. Current populations of 21,000 bear and 1,500 cougar should be realized by 2010.

Mountain goat and sheep populations will also remain fairly stable. Current sheep populations of about 800 and goat populations of 7,500 should be maintained. Moose populations may increase to 200 and then stabilize.

Migratory Game - An increasing human population will have its greatest negative effect on quality of wetland habitat and agricultural acreage, thereby affecting migratory birds. Given current population projections, decreases in quality and quantity of breeding, migration, and wintering habitat will occur. These populations are also threatened by increases in pesticide use and disturbance. If controls are increased, impacts may be mitigated. Other factors (i.e. agricultural and forestry practices, status of northern breeding areas, and weather conditions) also influence the status of this resource.

Furbearers - Some species of furbearers, such as lynx and marten, face reduced numbers based on forest management practices to the year 2010. All species will face reduced numbers habitat degradation as the state's available habitat base is depleted, particularly wetlands and riparian areas. Management directed at protection and enhancement will be necessary to maintain current status for most species.

Upland Game - Appreciative demand for upland game species is expected to increase in the future. Unless habitat protection and enhancement is increased, pheasant, sage and sharp-tailed grouse populations will become extremely low or non-existent in historical areas.

Nongame - If Washington continues to grow as projected, its wildlife will likely become less diverse. While many nongame species are generalists and continue to thrive in increasingly disturbed habitat, species sensitive to disturbance or environmental toxins, already low in numbers, limited in distribution, or dependent upon diminishing habitats surely will decline by the year 2010.

The Nongame Program has identified over 180 species that are potentially at risk (endangered, threatened, sensitive, or monitor species). With the unprecedented growth, it is likely that some of these species will become extinct in Washington by 2010 despite efforts to protect them.

With increased loss of shrub/steppe habitat, there will be fewer ferruginous hawks, pygmy rabbits, burrowing owls, golden eagles, gyrfalcons, loggerhead shrikes, sage sparrows, sage thrashers, Swainson's hawks, Merriam's shrews, and pallid bats. Some of these species are already so limited in distribution that if development occurs in their remaining occupied habitat, the species will likely become extinct from Washington by 2010. Others may suffer from genetic problems or isolated catastrophe. Pygmy rabbits are the most likely nongame candidate for extirpation.

With logging of remaining low elevation old growth forest, it is likely that the spotted owl will become extinct on the Olympic Peninsula. This may not occur by 2010, but it is unlikely that this population can persist much longer unless old growth management policies change. Other old growth species such as fishers, VanDyke's and Dunn's salamanders, marbled murrelet, and northern goshawk will certainly diminish in numbers by 2010.

Nongame species particularly associated with riparian habitats include bald eagle, giant Columbia River spire snail, and giant Columbia River limpet. If anadromous fish runs continue to decline, bald eagle populations dependent on them will also diminish. The snail and limpets are known to exist in only a few free-flowing reaches of the Columbia River system. If these areas are lost to development, these species also will become extirpated from Washington.

Bogs and wetlands support western pond turtles and Beller's ground beetles. Both species could be gone by 2010 unless more active conservation programs are implemented.

Numerous woodpecker species are dependent on snags. Purple martins and western bluebirds are also dependent on snags for natural cavities. Black-backed, white-headed, and pileated woodpeckers would be expected to diminish if there is a notable loss of snags by 2010. Purple martins and bluebirds can be sustained through nest box programs.

Oak woodlands are the primary habitat of western gray squirrels. These areas have become so fragmented that many small populations have already died out. This species will likely be gone from most of Washington by 2010.

The Oregon silverspot butterfly is found only along coastal salt-spray meadows. It is nearly extirpated now and it is unlikely that this species will exist in Washington in 2010. Upland sandpipers are also associated with meadow/prairie habitats. There are only a few nesting pairs known to nest in Washington; this species will probably be gone by 2010.

Snowy plovers require sandspits and coastal dunes for nesting. Washington has a current estimated nesting population of 12 pairs which will likely be extinct from the state by 2010.

Townsend's big-eared bat is known from only a few caves in Washington. With adequate protection from spelunkers, this species should persist to 2010.

Sea otters are Washington's most vulnerable marine mammal. Outer coastal rocks also support thousands of nesting seabirds. The status of these species in 2010 depends on the incidence of oil spills.

V. 2010 STATUS OF FISH AND WILDLIFE RESOURCES

The fish and wildlife resources of Washington are extremely diverse and vary to extreme degrees in both abundance and distribution. This is largely a reflection of habitat quality and availability. Numbers and kinds of wildlife in a shorter time frame can also vary at any given time due to natural migratory patterns, weather and climate fluctuations, natural events such as flooding and volcanic eruption, hunting and fishing success, management direction, poaching, disease, and man-caused events such as land use change and oil spills. For migratory species, numbers can be affected by events and situations which occur out of state.

The majority of factors affecting fish and wildlife numbers and kinds are cyclic in nature, management options, enforcement limitations, or problems such as harmful use of pesticides which may be corrected or controlled if identified in time. Habitat, however, is an entirely different matter. In the overall sense, the distribution and abundance of Washington's fish and wildlife is directly related to the quality and availability of habitat. Without it, successful resource management in the long-term is impossible.

Based on available information, and professional judgement and experience, we are asked to predict alternative "plausible" futures for fish and wildlife in the year 2010. Because of such a limited time frame to gather information and prepare this report, obvious data gaps, numerous uncertainties, and potential events beyond our control, we feel that the best we can say safely regarding the status of fish and wildlife is that it will either get better, get worse, or remain about the same. Since there are no compelling reasons or evidence to suggest that it will improve or even remain the same, we feel that overall fish and wildlife resources will deteriorate.

Appendix A
Vertebrate Species Managed by the Nongame Program
(Excluding primarily pelagic or accidental visitors)

Pacific lamprey	-	Entosphenus tridentatus
River lamprey	-	Lampetra ayresi
Western brook lamprey	-	Lampetra richardsoni
Pygmy whitefish	-	Prosopium coulteri
Olympic mudminnow	-	Novumbra hubbsi
Chiselmouth	-	Acrocheilus alutaceus
Lake chub	-	Couesius plumbeus
Tui chub	-	Gila bicolor
Peamouth	-	Mylocheilus caurinus
Northern squawfish	-	Ptychocheilus oregonensis
Longnose dace	-	Rhinichthys cataractae
Leopard dace	-	Rhinichthys falcatus
Speckled dace	-	Rhinichthys osculus
Redside shiner	-	Richardsonius balteatus
Longnose sucker	-	Catostomus catostomiis
Bridgelip sucker	-	Catostomus columbianus
Largescale sucker	-	Catostomus macrocheilus
Mountain sucker	-	Catostomus platyrhynchus
Sand roller	-	Percopsis transmontana
Three-spine stickleback	-	Gasterosteus aculeatus
Coastrange sculpin	-	Cottus aleuticus
Prickly sculpin	-	Cottus asper
Mottled sculpin	-	Cottus bairdi
Flute sculpin	-	Cottus beldingi
Slimy sculpin	-	Cottus cognatus
Shorthead sculpin	-	Cottus confusus
Riffle sculpin	-	Cottus gulosus
Margined sculpin	-	Cottus marginatus
Reticulate sculpin	-	Cottus perplexus
Torrent sculpin	-	Cottus photheus
Northwestern salamander	-	Ambystoma gracile
Long-toed salamander	-	Ambystoma macrodactylum
Tiger salamander	-	Ambystoma tigrinum
Cope's giant salamander	-	Dicamptodon copei
Pacific giant salamander	-	Dicamptodon ensatus
Olympic salamander	-	Rhyacotriton olympicus
Ensatina	-	Ensatina eschscholtzi
Dunn's salamander	-	Plethodon dunni
Larch mountain salamander	-	Plethodon larselli
Van dyke's salamander	-	Plethodon vandykei
Western red-backed salamander	-	Plethodon vehiculum
Roughskin newt	-	Taricha granulosa

Vertebrate Species Managed by the Nongame Program
(Excluding primarily pelagic or accidental visitors)

Western toad	-	Bufo boreas
Woodhouse's toad	-	Bufo woodliousei
Pacific treefrog	-	Hyla regilla
Tailed frog	-	Ascaphus truei
Great basin spadefoot	-	Spea intermontana
Red-legged frog	-	Rana aurora
Cascades frog	-	Rana cascadae
Northern leopard frog	-	Rana pipiens
Spotted frog	-	Ran pretiosa
Wood frog	-	Rana sylvatica
Western pond turtle	-	Clemmys marmorata
Painted turtle	-	Chrysemys picta
Northern alligator lizard	-	Elgaria coerulea
Southern alligator lizard	-	Elgaria multic rinata
Short-horned lizard	-	Pehnrynosoma dougiassi
Sagebrush lizard	-	Sceloforus graciosus
Western fence lizard	-	Sceloporus occidentalis
Side-blotched lizard	-	Eta stansburiana
Western skunk	-	Eumeces skiltonianus
Rubber boa	-	Charina bottae
Racer	-	Coluber constrictor
Sharp-tailed snake	-	Contia tenuis
Ring-necked snake	-	Diadophis punctatus
Night snake	-	Hypsiglena torguata
California mountain kingsnake	-	Lampropeltis zonata
Striped whipsnake	-	Masticophis taeniatus
Gopher snake	-	Pituophis catenifer
Western terrestrial garter snake	-	Thamnophis elegans
Northwestern garter snake	-	Thamnophis ordinoides
Common garter snake	-	Thamnophis sirtalis
Western rattlesnake	-	Crotalus viridis
Red-throated loon	-	Gavia steliata
Pacific loon	-	Gavia pacifica
Common loon	-	Gavia immer
Yellow-billed loon	-	Gavia adamsii
Pied-billed grebe	-	Podilymbus podiceps
Horned grebe	-	Podiceps auritus
Red-necked grebe	-	Podiceps grisegena
Eared grebe	-	Podiceps nigricollis
Western grebe	-	Aechmophorus occidentalis
Clark's grebe	-	Aechmophorous clarkii
American white pelican	-	Pelecanus erythrorhynchos

Vertebrate Species Managed by the Nongame Program
(Excluding primarily pelagic or accidental visitors)

Brown pelican	-	*Pelecanus occidentalis*
Double-crested cormorant	-	*Phalacrocorax auritus*
Brandt's cormorant	-	*Phalacrocorax penicillatus*
Pelagic cormorant	-	*Phalacrocorax pelagicus*
American bittern	-	*Botaurus lentiginosus*
Great blue heron	-	*Ardea herodias*
Great egret	-	*Casmerodius albus*
Green-backed heron	-	*Butorides striatus*
Black-crowned night-heron	-	*Nycticorax nycticorax*
Turkey vulture	-	*Cathartes aura*
Osprey	-	*Pandion haliaetus*
Black-shouldered kite	-	*Elanus cairuleus*
Bald eagle	-	*Haliaeetus leucocephalus*
Northern harrier	-	*Circus cyaneus*
Sharp-shinned hawk	-	*Accipiter striatus*
Cooper's hawk	-	*Accipiter cooperii*
Northern goshawk	-	*Accipiter gentilis*
Swainson's hawk	-	*Buteo swainsoni*
Red-tailed hawk	-	*Buteo jamaicensis*
Ferruginous hawk	-	*Buteo regalis*
Rough-legged hawk	-	*Buteo lagopus*
Golden eagle	-	*Aquila chrysaetos*
American kestrel	-	*Falco sparverius*
Merlin	-	*Falco columbarius*
Peregrine falcon	-	*Falco peregrinus*
Gyrfalcon	-	*Falco rusticolus*
Prairie falcon	-	*Falco mexicanus*
Sandhill crane	-	*Grus canadensis*
Black-bellied plover	-	*Pluvialis squatarola*
Snowy plover	-	*Charadrius alexandrinus*
Semipalmated plover	-	*Charadrius semipalmatus*
Killdeer	-	*Charadrius vociferus*
Black oystercatcher	-	*Haematopus bachmani*
Black-necked stilt	-	*Himantopus mexicanus*
American avocet	-	*Recurvirostra americana*
Greater yellowlegs	-	*Tringa melanoleuca*
Lesser yellowlegs	-	*Tringa flavipes*
Solitary sandpiper	-	*Tringa solitaria*
Willet	-	*Catoptrophorus semipalmatus*
Wandering tattler	-	*Heteroscelus incanus*
Spotted sandpiper	-	*Actitis macularia*
Upland sandpiper	-	*Bartramia longicauda*

Vertebrate Species Managed by the Nongame Program
(Excluding primarily pelagic or accidental visitors)

Whimbrel	-	*Numenius phaeopus*
Long-billed curlew	-	*Numenius americanus*
Marbled godwit	-	*Limosa fedoa*
Ruddy turnstone	-	*Arenaria interpres*
Black turnstone	-	*Arenaria melanocephala*
Surfbird	-	*Aphriza virgata*
Red knot	-	*Calidris canutus*
Sanderling	-	*Calidris alba*
Semipalmated sandpiper	-	*Calidris pusilla*
Western sandpiper	-	*Calidris mauri*
Least sandpiper	-	*Calidris minutilla*
Baird's sandpiper	-	*Calidris bairdii*
Pectoral sandpiper	-	*Calidris melanotos*
Sharp-tailed sandpiper	-	*Calidris acuminata*
Rock sandpiper	-	*Calidris ptilocnemis*
Dunlin	-	*Calidris alpina*
Stilt sandpiper	-	*Calidris himantopus*
Buff-breasted sandpiper	-	*Tryngites subruficollis*
Short-billed dowitcher	-	*Limnodromus griseus*
Long-billed dowitcher	-	*Limnodromus scolopaceus*
Wilson's phalarope	-	*Phalaropus tricolor*
Red-necked phalarope	-	*Phalaropus lobatus*
Red phalarope	-	*Phalaropus fulicaria*
Bonapartes gull	-	*Larus philadelphia*
Heermann's gull	-	*Larus heermanni*
Mew gull	-	*Larus canus*
Ring-billed gull	-	*Larus delawarensis*
California gull	-	*Larus californicus*
Herring gull	-	*Larus argentatus*
Thayer's gull	-	*Larus thayeri*
Western gull	-	*Larus occidentalis*
Glaucous-winged gull	-	*Larus glaucescens*
Sabine's gull	-	*Xema sabini*
Caspian tern	-	*Sterna caspia*
Common tern	-	*Sterna hirundo*
Arctic tern	-	*Sterna paradisaea*
Forster's tern	-	*Sterna forsteri*
Black tern	-	*Chlidonias niger*
Common murre	-	*Uria aalge*
Pigeon guillemot	-	*Cepphus columba*
Marbled murrelet	-	*Brachyramphus marmoratus*
Ancient murrelet	-	*Synthliboramuhus antiquus*

Vertebrate Species Managed by the Nongame Program
(Excluding primarily pelagic or accidental visitors)

Rhinoceros auklet	-	Cerorhinca monocerata
Tufted puffin	-	Fratercula cirrhata
Yellow-billed cuckoo	-	Coccyzus americanus
Common barn-owl	-	Tyto alba
Flammulated owl	-	Otus flammeolus
Western screech-owl	-	Otus kennicottii
Great horned owl	-	Bubo virginianus
Snowy owl	-	Nyctea scandiaca
Northern pygmy-owl	-	Glaucidium gnoma
Burrowing owl	-	Athene cunicularia
Spotted owl	-	Strix occidentalis
Barred owl	-	Strix varia
Great gray owl	-	Strix nebulosa
Long-eared owl	-	Asio otus
Short-eared owl	-	Asio flammeus
Northern saw-whet owl	-	Aegolius acadicus
Common nighthawk	-	Chordeiles minor
Common poorwill	-	Phalaenoptilus nuttallii
Black swift	-	Cypseloides niger
Vaux's swift	-	Chaetura vauxi
White-throated swift	-	Aeronautes saxatalis
Black-chinned hummingbird	-	Archilochus alexandri
Anna's hummingbird	-	Calypte anna
Calliope hummingbird	-	Stellula calliope
Rufous hummingbird	-	Selasphorus rufus
Belted kingfisher	-	Ceryle alcyon
Lewis' woodpecker	-	Melanerpes lewis
Red-breasted sapsucker	-	Sphyrapicus ruber
Red-naped sapsucker	-	Sphyrapicus nuchalis
Williamson's sapsucker	-	Sphyrapicus thyroideus
Downy woodpecker	-	Picoides pubescens
Hairy woodpecker	-	Picoides villosus
White-headed woodpecker	-	Picoides albolarvatus
Three-toed woodpecker	-	Picoides tridactylus
Black-backed woodpecker	-	Picoides arcticus
Northern flicker	-	Colaptes auratus
Pileated woodpecker	-	Dryocopus pileatus
Olive-sided flycatcher	-	Contopus borealis
Western wood-pewee	-	Contopus sordidulus
Willow flycatcher	-	Empidonax traillii
Hammond's flycatcher	-	Empidonax hammondii
Dusky flycatcher	-	Empidonax oberholseri

Vertebrate Species Managed by the Nongame Program
(Excluding primarily pelagic or accidental visitors)

Gray flycatcher	-	Empidonax wrightii
Western flycatcher	-	Empidonax difficilis
Say's phoebe	-	Sayornis saya
Ash-throated flycatcher	-	Myiarchus cinerascens
Western kingbird	-	Tyrannus verticalis
Eastern kingbird	-	Tyrannus tyrannus
Horned lark	-	Eremophila alpestris
Purple martin	-	Progne subis
Tree swallow	-	Tachycineta bicolor
Violet-green swallow	-	Tachycineta thalassina
Northern rough-winged swallow	-	Stelgidopteryx serripennis
Bank swallow	-	Riparia riparia
Cliff swallow	-	Hirundo pyrrhonota
Barn swallow	-	Hirundo rustica
Gray jay	-	Perisoreus canadensis
Steller's jay	-	Cyanocitta stelleri
Scrub jay	-	Aphelocoma coelulescens
Clark's nutcracker	-	Nucifraga columbiana
Common raven	-	Corvus corax
Black-capped chickadee	-	Parus atricapillus
Mountain chickadee	-	Parus gambeli
Boreal chickadee	-	Parus hudsonicus
Chestnut-backed chickadee	-	Parus rufescens
Bushtit	-	Psaltriparus minimus
Red-breasted nuthatch	-	Sitta canadensis
White-breasted nuthatch	-	Sitta carolinensis
Pygmy nuthatch	-	Sitta pygmaea
Brown creeper	-	Certhia americana
Rock wren	-	Salpinctes obscoletus
Canyon wren	-	Catherpes mexicanus
Bewick's wren	-	Thryomanes bewickii
House wren	-	Troglodytes aedon
Winter wren	-	Troglodytes troglodytes
Marsh wren	-	Cistothorus palustris
American dipper	-	Cinclus mexicanus
Golden-crowned kinglet	-	Regulus satrapa
Ruby-crowned kinglet	-	Regulus calendula
Western bluebird	-	Sialia mexicana
Mountain bluebird	-	Sialia currucoides
Townsend's solitaire	-	Myadestes townsendi
Veery	-	Catharus fuscescens
Swainson's thrush	-	Catharus ustulatus

Vertebrate Species Managed bv the Nongame Program
(Excluding primarily pelagic or accidental visitors)

Hermit thrush	-	Catharus guttatus
American robin	-	Turdus migratorius
Varied thrush	-	Ixoreus naevius
Gray catbird	-	Dumetella carolinensis
Sage thrasher	-	Oreoscoptes montanus
Water pipit	-	Anthus spinoletta
Bohemian waxwing	-	Bombycilla garrulus
Cedar waxwing	-	Bombycilla cedrorum
Northern shrike	-	Lanius excubitor
Loggerhead shrike	-	Lanius ludovicianus
Solitary vireo	-	Vireo solitarius
Hutton's vireo	-	Vireo huttoni
Warbling vireo	-	Vireo gilvus
Red-eyed vireo	-	Vireo olivaceus
Orange-crowned warbler	-	Vermivora celata
Nashville warbler	-	Vermivora ruficapilla
Yellow warbler	-	Dendroica petechia
Yellow-rumped warbler	-	Dendroica coronata
Black-throated gray warbler	-	Dendroica nigrescens
Townsend's warbler	-	Dendroica townsendi
Hermit warbler	-	Dendroica occidentalis
Palm warbler	-	Dendroica palmarum
American redstart	-	Setophaga ruticilla
Northern waterthrush	-	Seiurus noveboracensis
Macgillivray's warbler	-	Oporornis tolmiei
Common yellowthroat	-	Geothlypis trichas
Wilson's warbler	-	Wilsonia pusilla
Yellow-breasted chat	-	Icteria virens
Western tanager	-	Piranga ludoviciana
Black-headed grosbeak	-	Pheucticus melanocephalus
Lazuli bunting	-	Passerina amoena
Green-tailed towhee	-	Pipilo chlorurus
Rufous-sided towhee	-	Pipilo erythrophthalmus
American tree sparrow	-	Spizella arborea
Chipping sparrow	-	Spizella passerina
Brewer's sparrow	-	Spizella breweri
Vesper sparrow	-	Pooecetes gramineus
Lark sparrow	-	Chondestes grammacus
Sage sparrow	-	Amphispiza belli
Savannah sparrow	-	Passerculus sandwichensis
Grasshopper sparrow	-	Ammodramus savannarum
Fox sparrow	-	Passerella iliaca

Vertebrate Species Managed by the Nongame Program
(Excluding primarily pelagic or accidental visitors)

Song sparrow	-	Melospiza melodia
Lincoln's sparrow	-	Melospiza lincolnii
White-throated sparrow	-	Zonotrichia albicollis
Golden-crowned sparrow	-	Zonotrichia atricapilla
White-crowned sparrow	-	Zonotrichia leucophrys
Dark-eyed junco	-	Junco hyemalis
Lapland longspur	-	Calcarius lapponicus
Snow bunting	-	Plectrophenax nivalis
Bobolink	-	Dolichonyx oryzivorus
Red-winged blackbird	-	Agelaius phoeniceus
Western meadowlark	-	Sturnella neglecta
Yellow-headed blackbird	-	Xanthocephalus xanthocephalus
Brewer's blackbird	-	Euphagus cyanocephalus
Brown-headed cowbird	-	Molothrus ater
Northern oriole	-	Icterus galbula
Rosy finch	-	Leucosticte arctoa
Pine grosbeak	-	Pinicola enucleator
Purple finch	-	Carpodacus purpureus
Cassin's finch	-	Carpodacus cassinii
House finch	-	Carpodacus mexicanus
Red crossbill	-	Loxia curvirostra
White-winged crossbill	-	Loxia leucoptera
Common redpoll	-	Carduelis flammea
Pine siskin	-	Carduelis pinus
Lesser goldfinch	-	Carduelis psaltria
American goldfinch	-	Carduelis tristis
Evening grosbeak	-	Coccothraustes vespertinus
Masked shrew	-	Sorex cinereus
Prebles shrew	-	Sorex preblei
Vagrant shrew	-	Sorex vagrans
Dusky shrew	-	Sorex monticolus
Pacific shrew	-	Sorex pacificus
Water shrew	-	Sorex palustris
Pacific water shrew	-	Sorex bendirii
Trowbridge's shrew	-	Sorex trowbridgii
Merriams shrew	-	Sorex merriami
Pygmy shrew	-	Sorex hoyi
Shrew-mole	-	Neurotrichus gibbsii
Townsend's mole	-	Scapanus townsendii
Coast mole	-	Scapanus orarius
Broad-footed mole	-	Scapanus latimanus
Little brown myotis	-	Myotis lucifugus

Vertebrate Species Managed by the Nongame Program
(Excluding primarily pelagic or accidental visitors)

Yuma myotis	-	Myotis yumanensis
Keen's myotis	-	Myotis keenii
Long-eared myotis	-	Myotis evotis
Fringed myotis	-	Myotis thysanodes
Long-legged myotis	-	Myotis volans
California myotis	-	Myotis californicus
Small-footed myotis	-	Myotis leibii
Silver-haired bat	-	Lasionycteris noctivagans
Western pipistrelle	-	Pipistrellus hesperus
Big brown bat	-	Eptesicus fuscus
Red bat	-	Lasiurus borealis
Hoary bat	-	Lasiurus cinereus
Townsend's big-eared bat	-	Plecotus townsendii
Pallid bat	-	Antrozous pallidus
Pika	-	Ochotona princeps
Pygmy rabbit	-	Sylvilagus idahoensis
Mountain beaver	-	Aplodontia rufa
Least chipmunk	-	Tamias minimus
Yellow-pine chipmunk	-	Tamias amoenus
Townsend's chipmunk	-	Tamias townsendii
Red-tailed chipmunk	-	Tamias ruficaudus
Yellow-bellied marmot	-	Marmota flaviventris
Hoary marmot	-	Marmota caligata
Olympic marmot	-	Marmota olympus
Townsend's ground squirrel	-	Spermophilus townsendii
Washington ground squirrel	-	Spermophilus washingtoni
Columbian ground squirrel	-	Spermophilus columbianus
California ground squirrel	-	Spermophilus beecheyi
Golden-mantled ground squirrel	-	Spermophilus lateralis
Cascade golden-mantled ground squirrel	-	Spermophilus saturatus
Western gray squirrel	-	Sciurus griseus
Red squirrel	-	Tamiasciurus hudsonicus
Douglas' squirrel	-	Tamiasciurus douglasii
Northern flying squirrel	-	Glaucomys sabrinus
Northern pocket gopher	-	Thomomys talpoides
Western pocket gopher	-	Thomomys mazama
Great basin pocket mouse	-	Perognathus parvus
Ord's kangaroo rat	-	Dipodomys ordii
Western harvest mouse	-	Reithrodontomys megalotis
Deer mouse	-	Peromyscus maniculatus
Northern grasshopper mouse	-	Onychomys leucogaster
Dusky-footed woodrat	-	Neotoma fuscipes

Vertebrate Species Managed by the Nongame Program
(Excluding primarily pelagic or accidental visitors)

Bushy-tailed woodrat	-	Neotoma cinerea
Southern red-backed vole	-	Clethrionomys gapperi
Western red-backed vole	-	Clethrionomys californicus
Heather vole	-	Phenacomys intermedius
Meadow vole	-	Microtos pennsylvanicus
Montane vole	-	Microtos montanus
Gray-tailed vole	-	Microtos canicaudus
Townsend's vole	-	Microtos townsendii
Long-tailed vole	-	Microtos longicaudus
Creeping vole	-	Microtos oregoni
Water vole	-	Microtos richardsoni
Sagebrush vole	-	Lagurus curtatus
Northern bog lemming	-	Synaptomys borealis
Western jumping mouse	-	Zapus princeps
Pacific jumping mouse	-	Zapus trinotatus
Porcupine	-	Erethizon dorsatum
Coyote	-	Canis latrans
Gray wolf	-	Canis lupus
Grizzly bear	-	Ursus arctos
Northern sea lion	-	Eumetopias jubatus
California sea lion	-	Zalophus californianus
Fisher	-	Martes pennanti
Wolverine	-	Gulo gulo
Spotted skunk	-	Spilogale gracilis
Striped skunk	-	Mephitis mephitis
Sea otter	-	Enhydra lutris
Harbor seal	-	Phoca vitulina
Killer whale	-	Orcinus orca
Pacific harbor porpoise	-	Phocoena phocoena
Woodland caribou	-	Rangifer tarandus

Appendix B.
Washington Department of Wildlife - Nongame Data Systems
Special Animal Species
July 14, 1988

The following is a list of species receiving special emphasis in the Nongame Program's inventory of special species. The goal is to determine the current status of these species and to consider management actions that may be appropriate to protect a species from declining in number or distribution. We encourage assistance from anyone with knowledge and interest in Washington's wildlife. To direct your efforts, we have developed the following list. Along with the names of special species, there are codes indicating the types of information considered most useful. For some species, breeding localities are of special interest. In these cases, sightings of individuals may not significantly benefit the inventory effort. However, for species about which very little is known, we often encourage reporting all observations. These have a criteria code "IO" for individual occurrence. For these species, observations of breeding sites or other types of observations are of equal, or even greater, interest. The following observation criteria codes are used in this list:

IO Individual occurrence. Any observation of the species, including tracks, scat, vocalizations, etc., is of interest.

B Breeding. Breeding sites are of interest. Observations of adults with young, adults exhibiting courtship behavior, and adults seen in appropriate habitat during the breeding season are all of interest.

RI Regular Individual occurrence. In this instance, a one-time sighting of the species at a certain locality is not considered particularly noteworthy. However, when the species is regularly seen at the same locality, the locality becomes significant and of special interest to our inventory.

RSC Regular Small Concentrations. This criterion is similar to the above definition for "regular individual occurrence". The difference involves numbers. Some species are often found in groups. For these species, groups as small as 10 individuals observed repeatedly at the same location make a site important to our inventory.

RLC Regular Large Concentrations. This criterion is defined as in the above definition for "regular small concentrations", with the exception that significance is determined by greater numbers. Usually, at least 50 individuals are necessary for a concentration to be considered "large".

CR Communal or Colonial roosts. These are sites used by at least 3 individuals for night roosting or winter hibernation. Birds often roost communally. Many bats roost in winter hibernacula or summer nursery roosts.

HO Haul Out sites. Seals regularly haul out on land. These resting and pupping sites are considered important to these species.

Washington Dept. Wildlife - Nongame Data System
Species of concern sorted phylogenetically
current as of July 14, 1988

Common name	Scientific Name	Criteria
	Molluscs	
Newcomb's littorine snail	Algamorda newcombiana	IO
Giant Columbia River limpet	Fisherola nuttalli	IO
Great Columbia River spire snail	Lithoglyphus columbiana	IO
	Beetles	
Beller's ground beetle	Agonum belleri	IO
Long-horned leaf beetle	Donacia idola	IO
Columbia River tiger beetle	Cicindela columbica	IO
Hatch's click beetle	Eanus hatchii	IO
	Butterflies	
Clodius parnassian	Parnassius ciodius shepardi	IO
Oregon swallowtail	Papilio oregonius	IO
Short-tailed black swallowtail	Papilio indra	IO
Eastern tiger swallowtail	Papilio glaucus	IO
Pink-edged sulphur	Colias interior	IO
Labrador sulphur	Colias nastes	IO
Coral hairstreak	Harkenclenus titus	IO
Sylvan hairstreak	Satyrium sylvinus	IO
Hoary elfin	Incisalia polios	IO
Thicket hairstreak	Mitoura spinetorum	IO
Dwarf mistletoe hairstreak	Mitoura johnsoni	IO
Juniper hairstreak	Mitoura siva	IO
Immaculate green hairstreak	Callophrys affinis	IO
Lustrous copper	Lycaena cupreus	IO
Edith's copper	Lycaena editha	IO
High Mountain blue	Plebejus aguilo	IO
Viceroy	Limenitis archippus	IO
California sisters	Adelpha bredowii	IO
American painted lady	Cynthia virginiensis	IO
Compton tortoiseshell	Nymphalis vau-album	IO
Oreas anglewing	Polygonia oreas	IO
Edith's checkerspot	Occidrvas editha tavlori	IO
Pallid crescent spot	Phyciodes pallida	IO
Silver-bordered fritillary	Boloria selene	IO
Meadow fritillary	Boloria bellona	IO
Freya's fritillary	Boloria freija	IO
Astarte fritillary	Boloria astarte	IO
Oregon silverspot fritillary	Speyeria zerene hippolyta	IO
Egleis fritillary	Speyeria egleis	IO
Atlantic fritillary	Speyeria atlantes	IO
Leto fritillary	Speyeria leto pugetensis	IO
Chryxus arctic	Oeneis chryxus valerata	IO
Chryxus arctic	Oeneis chryxus chryxus	IO

Washington Dept. Wildlife - Nongame Data System
Species of concern sorted phylogenetically
current as of July 14, 1988

Common name	Scientific Name	Criteria
	Butterflies (cont)	
Melissa arctic	Oeneis melissa	IO
Northwest alpine	Erebia vidleri	IO
Dun skipper	Euphyes vestris	IO
Mardon skipper	Polites mardon	IO
Long-dash skipper	Polites mystic	IO
Sonora skipper	Polites sonora	IO
Tawny-edged skipper	Polites themistocles	IO
Nevada skipper	Hesperia nevada	IO
Yuma skipper	Ochlodes yuma	IO
Garita skipperling	Oarisma garita	IO
Alpine checkered skipper	Pyrgus centaureae	IO
Pacuvius dusky wing	Erynnis pacuvius	IO
Chinquapin hairstreak	Habrodais grunus	IO
	Fish	
Pygmy whitefish	Prosopium coulteri	IO
Olympic mudminnow	Novumbra hubbsi	IO
Lake chub	Couesius plumbeus	IO
Longnose sucker	Catostomus catostomus	IO
Mountain sucker	Catostomus platyrhynchus	IO
Sand roller	Percopsis transmontana	IO
Piute sculpin	Cottus beldingi	IO
Slimy sculpin	Cottus cognatus	IO
Riffle sculpin	Cottus gulosus	IO
Margined sculpin	Cottus marginatus	IO
Reticulate sculpin	Cottus perplexus	IO
	Herptiles	
Tiger salamander	Ambystoma tigrinum	IO
Cope's giant salamander	Dicamptodon copei	IO
Olympic salamander	Rhyacotriton olympicus	IO
Dunn's salamander	Plethodon dunni	IO
Larch mountain salamander	Plethodon larselli	IO
Van dyke's salamander	Plethodon vandykei	IO
Woodhousels toad	Bufo woodhousei	IO
Spotted frog	Rana pretiosa	IO
Western pond turtle	Clemmys marmorata	IO
Leatherback	Dermochelys coriacea	IO
Green sea turtle	Chelonia mydas	IO
Loggerhead sea turtle	Caretta caretta	IO
Southern alligator lizard	Elgaria multicarinata	IO
Sharp-tailed snake	Contia tenuis	IO
Ring-necked snake	Diadophis punctatus	IO
Night snake	Hypsiglena torguata	IO

Washington Dept. Wildlife - Nongame Data System
Species of concern sorted phylogenetically
current as of July 14, 1989

Common name	Scientific Name	Criteria
	Herptiles (cont)	
California mountain kingsnake	Lampropeltis zonata	IO
Striped whipsnake	Masticophis taeniatus	IO
Pacific gopher snake	Pituophis melanoleucus catenifer	IO
	Birds	
Common loon	Gavia immer	B
Horned grebe	Podiceps auritus	B
Red-necked grebe	Podiceps grisegena	B
Western grebe	Aechmophorus occidentalis	B
Clark's grebe	Aechmophorus clarkii	B
American white pelican	Pelecanus erythrorhynchos	B,RSC
Brown pelican	Pelecanus occidentalis	RSC
Brandt's cormorant	Phalacrocorax penicillatus	B
Great blue heron	Ardea herodias	B
Great egret	Casmerodius albus	B
Green-backed heron	Butorides striatus	B
Black-crowned night-heron	Nycticorax nycticorax	B
Trumpeter swan	Cygnus buccinator	RSC
Aleutian canada goose	Branta canadensis leucopareia	RI,IO
Turkey vulture	Cathartes aura	B,CR
Osprey	Pandion haliaetus	B
Bald eagle	Haliaeetus leucoceuhalus	B,RSC,CR
Northern goshawk	Accipiter gentilis	B
Swainson's hawk	Buteo swainsoni	B
Ferruginous hawk	Buteo regalis	B
Golden eagle	Aquila chrysaetos	B
Merlin	Falco columbarius	B
Peregrine falcon	Falco peregrinus	B,RI
Gyrfalcon	Falco rusticolus	RI
Prairie falcon	Falco mexicanus	B
Sage grouse	Centrocercus urophasianus	B
Sharp-tailed grouse	Tympanuchus phasianellus	B
Sandhill crane	Grus canadensis	B,RLC
Snowy plover	Charadrius alexandrinus	B
Black-necked stilt	Himantopus mexicanus	B,RSC
Upland sandpiper	Bartramia longicauda	B,RI
Long-billed curlew	Numenius americanus	B,RSC
Caspian tern	Sterna casnia	B
Arctic tern	Sterna paradisaea	B

Washington Dept. Wildlife - Nongame Data System
Species of concern sorted phylogenetically
current as of July 14, 1988

Common name	Scientific Name	Criteria
	Bird's (cont)	
Forster's tern	Sterna forsteri	B
Black tern	Chlidonias niger	B
Marbled murreiet	Brachyramphus marmoratas	B
Yellow-billed cuckoo	Coccyzus americanus	B,RI
Flammulated owl	Otus flammeolus	B,RI
Snowy owl	Nyctea scandiaca	RI
Boreal owl	Aegolius funereus	B
Burrowing owl	Athene cunicularia	B
Spotted owl	Strix occidentalis	IO
Barred owl	Strix varia	B
Great gray owl	Strix nebulosa	IO
Black swift	Cypseloides niger	B
Vaux's swift	Chaetura vauxi	B
Lewis' woodpecker	Melanerpes lewis	B
White-headed woodpecker	Picoides albolarvatus	B,RI
Three-toed woodpecker	Picoides tridactylus	B,RI
Black-backed woodpecker	Picoides arcticus	B,RI
Pileated woodpecker	Dryocopus pileatus	B
Gray flycatcher	Empidonax wrightii	B
Ash-throated flycatcher	Myiarchus cinerascens	B
Streaked horned lark	Eremophila alpestris strigata	B
Purple martin	Progne subis	B
Boreal chickadee	Parus hudsonicus	B
Western bluebird	Sialia mexicana	B
Sage thrasher	Oreoscoptes montanus	B
Loggerhead shrike	Lanius ludovicianus	B
Green-tailed towhee	Pipilo chlorurus	B,RI
Oregon vesper sparrow	Pooecetes gramineus affinis	B
Sage sparrow	Amphispiza belli	B
Grasshopper sparrow	Ammodramus savannarum	B
Lesser goldfinch	Carduelis psaltria	B,RI
	Mammals	
Preble's shrew	Sorex preblei	IO
Pacific water shrew	Sorex bendirii	IO
Merriam's shrew	Sorex merriami	IO
Pygmy shrew	Sorex hoyi	IO
Keen's myotis	Myotis keenii	B,IO
Long-eared myotis	Myotis evotis	B,CR
Fringed myotis	Myotis thysanodes	B,CR
Long-legged myotis	Myotis volans	B,CR
Small-footed myotis	Myotis leibii	B,CR
Western pipistrelle	Pipistrellus hesperus	B,CR
Red bat	Lasiurus borealis	B,IO
Townsend's big-eared bat	Plecotus townsendii	B,CR

Washington Dept. Wildlife - Nongame Data System
Species of concern sorted phylogenetically
current as of July 14, 1988

Common name	Scientific Name	Criteria
	Mammals (cont)	
Pallid bat	Antrozous pallidus	B,CR
Pygmy rabbit	Sylvilagus idahoensis	IO
Red-tailed chipmunk	Tamias ruficaudus	IO
Washington ground squirrel	Spermophilus washingtoni	IO
Western gray squirrel	Sciurus griseus	IO
Brush prairie pocket gopher	Thomomys talpoides douglasi	IO
White salmon pocket gopher	Thomomys talpoides limosus	IO
Shelton pocket gopher	Thomomys mazama couchi	IO
Roy prairie pocket gopher	Thomomys mazama glacialis	IO
Cathlamet pocket gopher	Thomomys mazama louiei	IO
Olympic pocket gopher	Thomomys mazama melanops	IO
Tenino pocket gopher	Thomomys mazama tumuli	IO
Ord's kangaroo rat	Dipodomys ordii	IO
Northern grasshopper mouse	Onychomys leucogaster	IO
Kincaid's meadow vole	Microtos pennsylvanicus kindaidi	IO
Gray-tailed vole	Microtos canicaudus	IO
Sagebrush vole	Lagurus curtatus	IO
Northern bog lemming	Synaptomys borealis	IO
Gray wolf	Canis lupus	IO
Grizzly bear	Ursus arctos	IO
Northern sea lion	Eumetopias jubatus	RSC
California sea lion	Zalophus californianus	RSC
Fisher	Martes pennanti	IO
Wolverine	Gulo gulo	IO
Sea otter	Enhydra lutris	B,RI,RSC
Harbor seal	Phoca vitulina	RSC,HO
Lynx	Lynx canadensis	IO
Gray whale	Eschrichtius robustus	IO
Sei whale	Balaenoptera borealis	IO
Finback whale	Balaenoptera physalus	IO
Blue whale	Balaenoptera musculus	IO
Hump-backed whale	Megaptera novaeangliae	IO
Black right whale	Balaena glacialis	IO
Killer whale	Orcinus orca	IO,RSC
Pacific Harbor porpoise	Phocoena phocoena	IO
Dall's porpoise	Phocoenoides dalli	IO
Sperm whale	Physter catodon	IO
Columbian white-tailed deer	Odocoileus virginianus leucurus	IO
Woodland caribou	Rangifer tarandus	IO

Appendix C.
Washington Dept. of Wildlife - Nongame Program - Data current: April 10, 1989
Species Vulnerable to Extirpation - Sorted by Status
SE means species classified as Endangered In Washington by Commission
ST means species has been listed as Threatened by WDW policy #602 only
PE, PT, or PS means species may be a possible candidate for Endangered, Threatened, or Sensitive classification.

Leatherback *Dermochelys coriacea*	SE
American white pelican *Pelecanus erythrorhynchos*	SE
Brown pelican *Pelecanus occidentalls*	SE
Peregrine falcon *Falco peregrinus*	SE
Sandhill crane *Grus canadensis*	SE
Snowy plover *Charadrius alexandrinus*	SE
Upland sandpiper *Bartramia longicauda*	SE
Spotted owl *Strix occidentalis*	SE
Gray wolf *Canis lupus*	SE
Grizzly bear *Ursus arctos*	SE
Sea otter *Enhydra lutris*	SE
Gray whale *Eschrichtlus robustus*	SE
Sel whale *Balaenoptera borealis*	SE
Fin whale *Baleonoptera physalus*	SE
Blue whale *Balaenoptera musculus*	SE
Hump-backed whale *Megaptera novaeangliae*	SE
Black right whale *Balaena glacialis*	SE
Sperm whale *Physeter macrocephalus*	SE
Woodland caribou *Rangifer tarandus*	SE
Columbia River tiger beetle *Cicindela columbica*	PE
Yellow-billed cuckoo *Coccyzus americanus*	PE
Oregon silverspot fritillary *Speyeria zerene hippolyta*	ST
Western pond turtle *Clemmys marmorata*	ST
Green turtle *Chelonia mydas*	ST

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Species Vulnerable to Extirpation - Sorted by Status

SE means species classified as Endangered In Washington by Commission
ST means species has been listed as Threatened by WDW policy #602 only
PE, PT, or PS means species may be a possible candidate for Endangered, Threatened, or Sensitive classlflcation.

Bald eagle Hallaeetus leucocephalus	ST
Ferruginous hawk Buteo regalls	ST
Pygmy rabbit Sylvilagus ldahoensis	ST
Giant Columbla River limpet Fisherola nuttalli	PT
Great Columbia River spire snail Lithoglyphus columbiana	PT
Chinquapin hairstreak Habrodals grunus	PT
Larch mountain salamander Plethodon larselli	PT
Loggerhead Caretta caretta	PT
Common loon Gavia immer	PT
Townsend's big-eared bat Plecotus townsendii	PT
Beller's ground beetle Agonum belleri	PS
Long-horned leaf beetle Donacia idola	PS
Hatch's click beetle Eanus hatchii	ps
Olympic mudminnow Novumbra hubbsi	PS
Dunn's salamander Plethodon dunni	PS
Van dyke's salamander Plethodon vandykei	PS
Spotted frog Rana pretiosa	PS
California mountain kingsnake Lampropeltis zonata	PS
Striped whipsnake Masticophis taeniatus	PS
Brandt's cormorant Phalacrocorax penicillatus	PS
Northern goshawk Accipiter gentilis	PS
Swainson's hawk Buteo swainsoni	PS
Golden eagle Aquila chrysaetos	PS
Sage grouse Centrocercus urophasianus	PS

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Washington Dept. of Wildlife - Nongame Program - Data current: April 10, 1989

Species Vulnerable to Extirpation - Sorted by Status

SE means species classified as Endangered In Washington by Commission
ST means specles has been listed as Threatened by WDW policy #602 only
PE, PT, or PS means species may be a possible candidate for Endangered, Threatened, or Sensitive classification.

Sharp-tailed grouse Tympanuchus phasianellus	PS
Marbled murrelet Brachyramphus marmoratus	PS
Flammulated owl Otus flammeolus	PS
Burrowing owl Athene cunicularia	PS
Vaux's swift Chaetura vauxi	PS
Lewis' woodpecker Melanerpes lewis	PS
White-headed woodpecker Picoldes albolarvatus	PS
Pileated woodpecker Dryocopus pileatus	PS
Purple martin Progne subis	PS
Western bluebird Sialia mexicana	PS
Sage thrasher Oreoscoptes montanus	PS
Loggerhead shrike Lanius ludovicianus	PS
Green-tailed towhee Pipilo chlorurus	PS
Sage sparrow Amphispiza belli	PS
Merriams shrew Sorex merriami	PS
Pygmy shrew Sorex hoyi	PS
Western gray squirrel Sciurus griseus	PS
Fisher Martes pennanti	PS
Pacific harbor porpoise Phocoena phocoena	PS

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