Washington State Climate Change Response Strategy

Interim Recommendations of the Natural Resources: Working Lands and Waters Topic Advisory Group

February 2011

Natural Resources: Working Lands and Waters
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Introduction

Climate change may have significant implications for Washington's working lands and waters. Our ability to adapt to the expected changes will have significant impacts on the viability of the economies that rely on our states robust natural resource base.

Natural Resources: Working Lands and Waters Topic Advisory Group (TAG)

The work of the Natural Resources (working lands and waters) TAG sought to address the challenges brought about by climate change in a manner that ensured the protection of Washington's natural resources, fostered rural economic development, positioned the state to take action that minimizes the negative impacts from climate change and, where possible, maximize those changes. The work was done using the best available data while addressing the specific concerns of Washington residents as they relate to the state's working lands.

The TAG brought together representatives of Washington's forest, agriculture, environmental and policy communities to develop a cohesive strategy that has practical applications and addresses the environmental, social, and economic needs of the state as they relate to adapting to climate change on our working lands and waters. The group intended to develop a plan that outlined actions to address climate change impacts anticipated on Washington's working lands.

Early in the process, the TAG determined that it would be beneficial to break into four smaller sub-groups to explore more deeply the four topic areas that emerged as priorities:

- **Fire Management.** Changes in summer precipitation and temperature could significantly increase the risk of wildfire on both forest and rangelands in many areas of the state. This impact will likely not only be confined to Washington but the Western United States as well, impacting our current suppression capabilities.

- **Pests and Disease**s. Forests stressed by climate change will be more vulnerable to mountain pink beetle outbreaks and will result in increased tree mortality. Climate changes will likely favor the life cycle of both insects and weeds thereby increasing the potential for damage to Washington's agricultural and forest industry. Changes in marine water chemistries and a raise in water temperatures, put Washington's shellfish and aquaculture industry at risk

- **Water Availability.** It is predicted that areas of water limited forests will increase by a minimum of 32% by the 2020s and an additional 12% in both the 2040s and 2080s. This will have a significant impact in the productivity of forested areas and will require changes in forest management. The decrease in predicted snow pack will have profound effects in some agricultural areas in the state. Those areas that rely on irrigation from melting snow pack during the growing season will likely experience shortages without modifications to current water management systems and improvements in water supply and infrastructure. Additionally, as population increases and water availability is reduced, competition for diminished resources between municipal, industrial, and agricultural interests will become acute.

- **Genetic Preservation and Development**. It is important that efforts be made to mitigate the impacts of climate change on ecosystem functions to the greatest extent possible. Activities that seek to ensure the perpetuation of genetic resources in the state will need to be explored. As the

affects of climate change are experienced, it may no longer be economically rational to raise traditional agricultural and forest commodities. Various valuable tree species, too, may not be viable in a climate challenged environment. Additionally impacts to both livestock and shellfish production could be affected.

The groups were authorized to invite topical experts to assist in the identification of key risks and the development of adaptation strategies. All of the groups did this in an effort to ensure that recommendations were based on sound science, were consistent with other compatible efforts, and provided opportunities for topical experts to weigh in.

In addition to the four major topic areas, the TAG determined that several factors should be considered by all four sub-groups in their work to develop recommendations:

- **Avoided land conversion.**
  Recommended actions needed to support existing efforts to preserve and protect Washington's existing working forests and agriculture lands.

- **Land-use management.**
  Recommended actions needed to address, where appropriate, how land-use management decisions could help or hinder adaptation strategies.

- **Inter-agency collaboration (federal, state, local).**
  To eliminate redundancy in efforts, recommended actions needed to identify opportunities for agencies to collaborate and build on one another's efforts.

- **East/West Cascades differences.**
  Differences in culture, economics and politics between communities in Eastern and Western Washington needed to, the greatest extent possible, be considered and integrated into recommendations.

- **Major catastrophic events.**
  In addition to long-term planning, strategies for dealing with catastrophic events needed to be included in the recommendations.

- **Global and local economic factors.**
  Global and local economic issues play a significant role in the activities that occur on Washington's working lands. It was important to take this into account when developing strategies for adapting to climate change.

TAG 4 met approximately eight times between March 2010 and January 2011. In addition to whole tag meetings, sub-groups met intensively during this time (some as often as every week for periods of active strategy development). The success of this effort rests on the willingness of both the TAG members and the other professionals that offered their time and expertise to this process.

Key Vulnerabilities and Risks

Fire Management

Washington has over 22 million acres of forested land, more than half of the total land area (DNR 2007). Approximately 44% of forest land is in Federal ownership, while 13% is in State and local ownership, and 43% in private (Campbell *et al.* 2010). Fire plays a critical ecological role in many of Washington's forest types, particularly in the fire-adapted dry forests east of the Cascades. However, over a century of fire suppression, extensive logging, and overgrazing have resulted in forest conditions in many areas that are currently at an increased risk of unnaturally severe and extensive disturbance from fire, insects, and disease (Hessburg and Agee 2003; Hessburg *et al.* 2005; Franklin *et al.* 2008). When such disturbances do occur, they can result in significant ecological, social, and economic impacts. For example, on average, $28 million is spent annually suppressing wildfires on state and private forestland in Washington (Cline 2010 *cited in* DNR 2010). However, the true costs of such wildfires in the western U.S. may be from 2 to 30 times greater than such estimates based solely on suppression costs (WFLV 2010), while it is impossible to accurately quantify the myriad adverse environmental and social impacts.

Anticipated Impacts

Excerpted from the WACCIA Executive Summary

Forest fires, insect outbreaks, tree species ranges and forest productivity are closely tied to climate. Profound changes in forest ecosystems are possible given the magnitude of projected climate changes. The combined climate change impacts on tree growth, regeneration, fire, and insects will fundamentally change the nature of forests, particularly in ecosystems where water deficits are greatest. Many impacts will likely occur first in forests east of the Cascade crest, but forests west of the Cascades will likely experience significant changes in disturbance regime and species distribution before the end of the 21st century.

- Due to increases in temperature and decreases in summer precipitation, the area burned by fire regionally (in the U.S. Columbia Basin) is projected to double or triple (medium scenario, (A1B)), from about 425,000 acres annually (1916-2006) to 0.8 million acres in the 2020s, 1.1 million acres in the 2040s, and 2.0 million acres in the 2080s. The probability that more than two million acres will burn in a given year is projected to increase from 5% (1916-2006) to 33% by the 2080s. Fire regimes in different ecosystems in the Pacific Northwest have different sensitivities to climate, but most ecosystems will likely experience an increase in area burned by the 2040s. Year-to-year variation will likely increase in some ecosystems.
- Due to climate related stress in host trees (e.g., lodgepole pine, ponderosa pine, western white pine, whitebark pine) mountain pine beetle outbreaks are projected to increase in frequency and cause increased tree mortality. Mountain pine beetles will reach higher elevations due to increasing elevation of favorable temperature conditions as the region warms. Conversely, the mountain pine beetle will possibly become less of a threat at middle and lower elevations because temperatures will be unfavorable for outbreaks. Compared to historical conditions, other species of insects (such as spruce beetle, Douglas-fir bark beetle, fir engraver beetle, and western spruce budworm) may be more successful depending on favorable climatic conditions and host-tree stress.
- The amount of habitat with suitable climate for pine species susceptible to mountain pine beetle will likely decline substantially by mid 21st century. Much of the currently climatically suitable habitat is in places likely to be less suitable for pine species establishment and regeneration, and established trees will be under substantial climatic stress. The regeneration of pine species after disturbance will likely be slowed, and may be infrequent in some locations.

- The area of severely water-limited forests is projected to increase by at least 32% in the 2020's, and an additional 12% in both the 2040s and 2080s. Douglas-fir productivity varies with climate across the region and will potentially increase in wetter parts of the state during the first half of the 21st century but decrease in the driest parts of its range. Geographic patterns of productivity will likely change; statewide productivity will possibly initially increase due to warmer temperatures but will then decrease due to increased drought stress. It is important to note that changes in species mortality or regeneration failures will possibly occur before the point of severe water limitation (annual precipitation is exceeded by summer potential evapotranspiration.

Significant uncertainty remains surrounding additional forest-related climate change impacts and the recommendations section of this document identifies specific areas of future research.

Existing Recommendations and Concurrent Efforts

On average, $28 million dollars is spent annually in the state to suppress wildfires on state and private lands (Cline, 2010). As mentioned earlier, as the region begins to see the impacts of climate change, the risk for more severe and more frequent forest fires is expected to increase. Managing wildfires must play a central role in Washington's climate adaptation strategy, as millions of acres and human property are at risk and will be at greater risk of being negatively impacted if it's not.

The impacts of climate change on Washington's forests have been recognized as a priority in other planning efforts in the state. It is the intent this group to build on existing work and, to the greatest extent possible, harmonizes recommendations with existing literature and concurrent efforts. This will help to ensure consistency and to provide policy makers with clear and concise paths forward. The following will provide brief summaries of existing work and efforts that are currently underway in Washington that have influence on the recommendations set forth in this chapter.

2008 Preparation and Adaptation Workgroups: "Leading the Way: Preparing for the Impacts of Climate Change in Washington"

Washington State has recognized the need to strategically plan for the impacts of climate change for some time. In 2008, multiple stakeholder groups were convened, led by the Washington State Department of Ecology, to develop a plan to prepare for the impacts of climate change. The final report, "Leading the Way: Preparing for the Impacts of Climate Change in Washington," in its chapter on forestry, provided a list of action items that the group identified as being effective first steps in preparing for the changes expected in Washington's environment.

The following, excerpted from the final report, provides a summary of the recommendations related to wildfire in Washington's forests:

> "The increased temperature and dryness, combined with widespread areas of dead or damaged trees due to insect infestations, and again combined with uniform and overcrowded forest conditions; make these forests vulnerable to the spread of large and/or severe forest fires. The high density of trees, especially dead or dying trees, contributes forest fuels that allow fires to burn hotter and spread farther more quickly. Recent large fires in Eastern Washington may be evidence of this trend, although large fires also burned in prior decades. Larger and more severe wildfires also emit more carbon dioxide into the atmosphere, which further worsens climate change. Carbon dioxide emissions from wildfires in Washington have been found to be significant compared to total emissions from fossil fuel burning in the state. Forest fires could also contribute to human health problems, primarily smoke inhalation, and to damage to houses and public facilities.
>
> 1. Forest health and fire strategy recommendations

- 1.1 Provide comprehensive data and information to landowners, policy makers, and the public about existing and developing forest health and fire hazard conditions.
- 1.2 Use new state authority to create forest health scientific advisory committees to assist decision-makers in responding to extreme forest health and fire hazard problems.
- 1.3 Fully fund and implement on-the-ground pilot programs.
- 1.4 Provide public financial and technical assistance to owners of small forestland parcels.
- 1.5 Implement an active communication and education strategy.
- 1.6 Foster a collaborative atmosphere across multiple jurisdictions, landowners, and stakeholders to promote agreement on forest health and fire hazard response approaches.
- 1.7 Improve coordination of regulatory requirements to remove unnecessary barriers while ensuring program objectives are being met.
- 1.8 Engage the private sector as a partner through market and investment opportunities."[1]

DNR's Strategic Plan 2010-2014: The Goldmark Agenda

The Department of Natural Resources launched its 2010-2014 Strategic Plan in April 2010. In the plan, climate change is identified as a major area of focus for the agency's work over the next number of years. A major goal of the plan (Goal V) is to "develop renewable energy resources on state lands, address climate change, and create renewable energy jobs." In the first year of the plan, the agency is tasked with developing a climate change adaptation strategy. As part of this effort, the plan identifies that the following outcomes be achieved:

1. Develop staff education efforts regarding scientifically sound adaptation information and priorities in partnership with university and other scientists.
2. Participate in an integrated monitoring program with other entities and identify the most vulnerable situations and trigger points for change in management actions.
3. Incorporate climate change adaptation considerations in all relevant agency programs, including attention to ecological interactions, species genetics and adaptiveness, migration pathways, response to major disturbance events, and management of human infrastructure.
4. Coordinate with other state and federal agencies, tribal governments, and private organizations to develop a statewide and/or broader climate adaptation strategy.
5. Link climate adaptation strategies in eastern Washington with the renewable biomass initiative.

These goals are an overlay to the existing fire and emergency response obligations. The department manages the largest on-call Fire Department in Washington and implements an active Forest Health program to respond to forest health crises (with a focus on Eastern Washington).

Statewide Forest Resource Assessment and Strategy for Washington State

The 2008 Farm Bill required state forestry agencies, if they are to continue to receive certain assistance funding for forest landowners, to conduct a Statewide Assessment and Forest Resource Strategy. The strategy, per direction in the Farm Bill, was to be comprised of three components: Statewide Assessment of Forest Resources, Statewide Forest Resource Strategy, and an Annual Report on Use of Funds. The Department of Natural Resources completed their assessment and strategy in June 2010.

[1] "Leading the Way: Preparing for the Impacts of Climate Change in Washington." Preparation and Adaptation Workgroup, 2008.

The assessment and strategy identify six major issues for forestry in Washington State, and cite climate change as a significant threat to all of them. Wildfire hazard reduction and forest health restoration are central among the assessment and strategy issues. Three categories of forests have the greatest risk of wildfire: eastern Washington dry forests; mountain gap wind zones; and the San Juan Islands. As policies and programs are developed to address the wildfire impacts a changing climate is certain to have, it will be important to focus those efforts on the region's most vulnerable to the impacts. For example, from among the nearly 9 million acres of forested land in eastern Washington, 6.2 million are at moderate or high departure Fire Regime Condition Class. When these areas experience wildfire in the future, fires have a greater potential to be large and severe – so much so that key ecosystem components may be lost altogether.

The assessment provides a number of "opportunities" for work to address the challenges posed by wildfires, challenges that will only increase as climate change impacts continue to be seen across the state. The opportunities outlined in the assessment include:

- Improve fire prevention and suppression.
- Protect, assist and educate populations in the wildland-urban interface.
- Reduce fuel loads in Eastern Washington forests.
- Restore ecological integrity, appropriate density, structure and species composition to overstocked Eastern Washington forests.
- Integrate fuel reduction activities with forest health improvement actions.
- Partner with multiple landowners and managers to achieve landscape-scale forest health and restoration objectives.
- Use prescribed fire to restore and maintain fire-resistant stand conditions.
- Maintain and develop forest markets and infrastructure.

Over a five-year time horizon, the strategy focuses core funding for wildfire hazard reduction projects in the Spokane-area, Upper Yakima, Wenatchee, Entiat, Chelan and Okanogan watershed resource inventory areas (WRIAs). Forest health restoration work will be focused in the Colville, Lower Spokane, Middle Lake Roosevelt, and Kettle WRIAs.

The strategy also cites opportunities to expand the application of forest restoration concepts and piloting forest treatment prescriptions aimed at climate adaptation. Revisiting and adapting treatment design on an ongoing basis to insure that the desired outcomes are still being achieved is another strategic provision.

A critical data gap identified throughout the assessment and strategy's discussion of climate change threats is the need for broad-scale vulnerability analyses that can guide managers toward forests that are likely to experience the most dramatic changes.

USFS Climate Change Activities

The Washington Office of the US Forest Service recently sent out for review a draft Strategy for responding to climate change. The vision of this strategy looks a future in which:

- Forests Grasslands and human communities that depend on them successfully adapt (within their capabilities) to the changing climate.
- Through management and collaborative efforts with partners, forests and grasslands help to mitigate global climate change.
- New scientific findings, tools and technology increase our understanding of climate change impacts, adaptation and mitigation options and the risk of uncertainties that accompany our choices.

- New and stronger partnerships are forged that address climate change issues related to forests and grasslands.
- Citizens are knowledgeable about climate change and its impacts on ecosystems and landscapes important to them. They are prepared to participate in decisions and actions affecting landscapes that include their regions and grasslands.

In order to achieve this vision the agency is looking at specific objectives in three specific focus areas:

1. Assess current risks, vulnerabilities and gaps in knowledge and policies.
2. Engage internal and external partners to seek solutions.
3. Manage for resilient ecosystems, including associated human communities, through adaptation and mitigation strategies.

Region 6 of the Forest Service, which includes both Oregon and Washington, is working together with the Oregon and Washington BLM to develop:

1. A business needs assessment to determine gaps in knowledge related to climate change issues.
2. Prioritized actions needed for the respective agencies to address climate change. These actions include research priorities that develop tools for projecting changed fire regimes for ecosystems that occur across Oregon and Washington.

Information for this section comes from US Forest Service Draft Paper "US Forest Service Strategy for responding to climate change" dated April 22, 2010 and from an internal draft Climate Change Business needs assessment dated April 15, 2010.

Firewise (NWCG)

Firewise is a program sponsored by the National Wildfire Coordinating Group (NWCG).[2] Members of the NWCG are responsible for wildland fire management in the United States. They represent the USDA-Forest Service, the Department of Interior, the National Association of State Foresters, the U.S. Fire Administration and the National Fire Protection Association. The NWCG's Wildland/Urban Interface Working Team directs the Firewise program. In Washington State, the program is administered through DNR. Several local conservation districts implement Firewise activities with landowners in their district area.[3]

The national Firewise Communities program is a multi-agency effort designed to reach beyond the fire service by involving homeowners, community leaders, planners, developers, and others in the effort to protect people, property, and natural resources from the risk of wildland fire - before a fire starts. The Firewise Communities approach emphasizes community responsibility for planning in the design of a safe community as well as effective emergency response, and individual responsibility for safer home construction and design, landscaping, and maintenance. Currently, there are 44 recognized Firewise Communities in Washington State and many others across the state working toward the same goal.

National Fire Plan Cohesive Wildfire Management Strategy

In 2010, the U.S. Congress required the U.S. Forest Service and Department of Interior to submit a report that contains a cohesive wildfire management strategy. The strategy is being updated from prior versions in an effort led by the Wildland Fire Leadership Council, an intergovernmental committee of Federal, state, tribal, county, and municipal government officials convened by the Secretaries of the Interior, Agriculture, and Homeland Security dedicated to consistent implementation of wildland fire

[2] For more information, visit http://www.firewise.org/ Site last visited July 13, 2010.
[3] For one example, see http://www.skagitcd.org/firewise Site last visited July 13, 2010.

policies, goals, and management activities across jurisdictions. The strategy will provide oversight to ensure policy coordination, accountability, and effective implementation of Federal Wildland Fire Management Policy and related long-term strategies to address wildfire preparedness and suppression, hazardous fuels reduction, landscape restoration and rehabilitation of the Nation's wildlands, and assistance to communities.

The law requires that the strategy address:

- Reducing wildfire costs, losses, and damages.
- Reinvesting in non-fire federal programs.
- Assessing risk to communities.
- Appropriate wildfire responses, such as decisions about when and whether to take full suppression actions as opposed to letting fires burn for resource benefit.
- Prioritizing wildfire fuels reduction product funding.
- Assessing impacts of climate change.
- Study effects of invasive species.

Genetic Preservation and Development Background

Excerpted from the WACCIA Executive Summary

2.2. Climate and Changes in Species Biogeography

We assessed the potential for climate to alter important PNW tree species distributions by using spatially explicit projections from recently published analyses of climate and species responses for western North America (Rehfeldt et al., 2006). Specifically, we were most concerned with the potential for climatic stress on regeneration or mortality in Douglas-fir forests and the potential for stress in three species susceptible to the mountain pine beetle (lodgepole pine, *Pinus contorta*; ponderosa pine, *Pinus ponderosa*; and whitebark pine, *Pinus albicaulis*) in the PNW. Other species range changes are also important, but a full assessment is beyond the scope of this project. We focused on Douglas-fir because it is widespread and economically important and on the pine species because of their potential for interaction with the mountain pine beetle, particularly in forests east of the Cascades. For each species, we used Rehfeldt et al. (2006) grid maps of potential future habitat based on climate and combined these to develop summary maps of areas where climate is likely to exceed Rehfeldt et al.'s (2006) estimates of the tolerances of Douglas-fir. We used a similar approach to assess areas of change in pine species richness for the end of the 2040s-2060s (Rehfeldt's analyses are for the 2030s and 2060s). After Rehfeldt et al. (2006), we assumed that areas with ≥ 75% agreement among statistical climate/species models represented climatic conditions where the species was likely to occur. We assumed that areas with < 75% but ≥ 50% agreement were potential areas of future occurrence but where climatic variability might put the species at some risk, and we assumed that areas with <50% agreement were unlikely to have sustained climatic conditions appropriate for species persistence and regeneration after disturbance.

3.2. Climate and Changes in Species Biogeography

By the end of the 2060s, independent species range modeling based on IPCC scenarios (a medium emissions scenario for both HadCM3 and CGCM2, Rehfeldt et al. 2006) suggests that climate will be sufficiently different from the late 20th century to constrain Douglas-fir distribution (Figure 5). This is probably due to increases in temperature and decreases in growing season water availability in more arid environments (e.g., in the Columbia Basin) but could be due to other variables in less arid parts of the species' range. About 32% of the area currently classified as appropriate climate for Douglas-fir would be outside the identified climatic envelope by the 2060s, and about 55% would be in the 50%-75% range of marginal climatic agreement among models. Only about 13% of the current area would be climatically suitable for Douglas-fir in >75% of the statistical species models. The decline in climatically suitable habitat for Douglas-fir is most wide-spread at lower elevations and particularly in the Okanogan Highlands and the south Puget Sound / southern Olympics.

Climate is likely to be a significant stressor in pine forests in the Columbia Basin and eastern Cascades as early as the 2040s, particularly in parts of the Colville National Forest, Colville Reservation, and central Cascades (Figure 6). Of the area that is climatically suitable for at least one pine species, only 15% will experience climate consistent with no net loss of species; 85% will be outside the climatically suitable range for one or more current pine species (74% loss of one species, 11% loss of two species, <1% loss of three species).

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The following, excerpted from the final report, provides a summary of the recommendations related to "genetic preservation and development" in Washington's forests:

> "Projected 21st century changes in temperature and precipitation will affect forests differently depending on their elevation and proximity to the coast. The main impacts will be changes in tree growth, changes in establishment and regeneration, changes in disturbance regimes, and eventually, changes in species composition and range. Some of these impacts have already been observed and are consistent with observed increases in temperature.
>
> Increased summer temperature may lead to non-linear increases in evapotranspiration from vegetation and land surfaces. This effect would be worsened by possible decreases in growing season rainfall. Lower water availability, in turn, would decrease the growth, vigor, and fuel moisture of lower elevation forests (e.g., ponderosa pine, Douglas-fir and western hemlock) while increasing growth and regeneration in high elevation forests (e.g., subalpine fir, Pacific silver fir, and mountain hemlock).
>
> Higher temperatures would also affect the range and speed up the reproductive cycle of climatically limited forest insects such as the mountain pine beetle. Other insects and pathogens, whose northern or elevation ranges were previously limited by temperature, can be expected to expand northward and upslope. Lower water availability also increases the vulnerability of individual trees to insect attack. Higher temperatures or lower summer rainfall would likely increase the area burned by fire and fire frequency in both eastern and western Washington. Mountain Pine Beetle outbreaks in British Columbia and Idaho have resulted in large and possibly unprecedented landscape-scale mortality of forests. Fire severity may also increase, depending on site-level fuel characteristics.
>
> The distribution and abundance of plant and animal species will likely change over time, given that paleoecological data show their sensitivity to climatic variability. This change may be difficult to observe at local scales or in short time frames, except in cases where large-scale disturbances such as fire, insect outbreaks, or windstorms have removed much of the overstory, thereby "clearing the slate" for a new cohort of vegetation. The regeneration phase will be the key stage at which species will compete and establish in a warmer climate, thus determining the composition of future vegetative assemblages and habitat for animals.

3. Species physiology, ecology, and distribution strategy

_ *3.1. Focus initially* on both commercial and non-commercial forest tree species.

_ *3.2. Develop a better understanding* of likely impacts of climate change on tree species and evaluate strategies to minimize or adapt to those risks.

_ *3.3. Keep forestland managers*, policy makers, and the public informed with the current state of knowledge and the range of adaptation strategies being considered.

4. Commercial timber management strategy

_ *4.2. Improve scientific research* into commercial tree species' physiological responses to climate change.

_ *4.4. Implement a genetic* conservation program.

5. Protected areas and habitat strategy

_ *5.1. Complete a vulnerability* assessment to identify species, habitats, landscapes, ecosystem functions, and cultural resources that may be most sensitive to climate change.

_ *5.4. Attempt to maintain* dominant native tree and shrub species, and promote species and stand structural and landscape diversity.

_ *5.7. Develop guidelines for experimental translocation* of individual species or genetic material in special circumstances."

Water Availability Background Information

Demand for water for municipal and industrial use, and for food production, is increasing rapidly as the world population and affluence grows, despite limited supplies of potable water. At the same time, climate change is affecting water supplies, food production and population distribution globally. Within this context, water availability in the Western United States is becoming a critical issue. Shifts in population, have created new demands for water to service municipal, industrial, agricultural, and environmental needs. The problems in fulfilling these needs are becoming more acute due to the current and potentially future effects of climate change. In Washington State it is estimated that over 5,700 Mgal/d of water is used with more than 60 percent used for irrigation purposes [1].

Surface water provides 74 percent of the irrigation water used by the state's agricultural lands, compared to 26 percent from groundwater sources [3]. This water is utilized to irrigate large tracts of agricultural lands throughout the central and eastern part of the state and is critical to the future of Washington's high value fruit and vegetable production. Likewise the slow melt of winter snows provide Washington's forest with adequate water to maintain healthy stands of economically valuable trees and supports the eco-system necessary to ward off attacks of pests species that destroy the value of the forests.

Climate change has been evident for decades and we are already adapting to its changes. Reduced snowpack, droughts and floods are becoming more frequent. This trend is predicted to continue and the impacts, environmental and economic, will be greatest on Washington's working lands, especially the agricultural lands of eastern Washington. At the same time, growing demand by other water users - municipal, industrial, recreational, and environmental – will further exacerbate water shortages. Innovative solutions to preserve adequate water supplies and adapt to reduced supply brought about by increased demand and climate change is critical and should begin immediately. The competition for water for working lands will have to be balanced with those of municipalities facing a growing population. Finally, predicted changes in climate will likely increase the risks of flooding and landslides due to higher intensity storms during winter months damaging both prime agricultural and forest lands.

Preparation and adaptation activities are generally easier to develop and implement for agricultural lands than for managed forests. Several reasons for this exist. Water delivery systems on most agricultural lands are highly managed and can be relatively easy to control. The vast majority of high value crops are grown within the confines of irrigation districts or systems which are designed to distribute water at metered amounts. Reservoirs can be lowered or raised during the year in anticipation of the upcoming seasons water needs. At least on a temporary basis alternative sources of water can be obtained (i.e. groundwater sources, leasing of water rights). Some flexibility exists to change the crop grown to accommodate anticipated water availability.

Preparation and adaptation measures for dryland agriculture and managed forests are inherently more difficult to develop and implement due to the lack of "control" that can be exercised over the available water and inability to quickly modify the species grown in working forests. The impacts from increasing temperatures and decreased water availability to forests and dryland areas have the potential for more lasting impacts [4]. Such is the case with impacts caused by spruce and pine beetle infestations in the Western United States. These infestations are likely the direct result of climate changes that result in prolonged periods of stress for the trees coupled with enhancement of conditions favorable to the life cycle of the beetle. Unlike, managed agricultural systems, the recovery period for these forests is measured in decades instead of years.

While there are inherent difficulties in exercising the degree of "control" over dryland and working forests employed in other working lands, improvements or modifications to management techniques can help to address some of the predicted challenges faced within this area. Suggestions regarding forest management and fire prevention (addressed in an accompanying white paper) can lead to a maintenance or even improvement in both water quality and quantity within the watershed and downstream users. Increased focus on forest diversity coupled with actions that modify species will also result in healthier forests and improved water quality.

Impacts of Climate Change

Washington's working lands rely heavily on natural water storage in the form of snowpack in the Cascade and Olympic Mountains and higher elevations in the north central part of the state. In years where normal snowpack is achieved, Washington's current water needs are met. Total precipitation is not expected to change significantly; however, assuming the predictions of snowpack decline are accurate we can expect snowpack reductions of to 27 – 29 percent in the 2020s to upwards of 53 -65 percent in the 2080s. Combined with predicted increases in annual runoff [2] the state may be faced with regular shortages exceeding those experienced in droughts of the 1970's and 1980's. Given these conditions Washington's working lands can expect less water in the late spring and summer for forests, farms, in-stream flows and urban uses.

Climate change predictions from the University of Washington Climate Impacts Group indicate that while Washington may expect little to no overall change in the amount of precipitation received during the 2020 – 2080 period, how that precipitation is received (rain or snow) is expected to change dramatically. This coupled with the expected demand from population growth (4 percent per year through 2030 [2], or 10 million people by 2050) stresses the need to begin planning for adequate water supplies for all sectors relying on the resource.

In previous work conducted by Washington State's Climate Action Team (2007) several assumed impacts were identified as result of changes in water supply due to climate change. They are generally the result of increases in predicted temperatures which will result in significant modifications to seasonal precipitation patterns and increased drying during the summer. Currently, predictions regarding the overall annual precipitation indicate only small changes in quantity trending towards more rainfall in the

winter months and less during late spring and summer periods. These predictions are anticipated to result in:

- Less snowpack to supply water to Washington users during the growing season. An increasing large proportion of winter precipitation will fall as rain instead of as snow, leaving less water stored in snowpack for the dry months.
- More frequent, extreme and persistent drought conditions.
- Higher intensity rainfall events, especially in Western Washington resulting in an increase in the frequency of winter/fall flood events.
- River and streams experiencing extended periods of low-flow conditions resulting in higher temperatures and concentrations of contaminants making violations of water quality standards more common.
- Reduced soil moisture and increased evaporation in non-irrigated agriculture and forest areas increasing the need for water or drought tolerate crops and increasing the risks of fire.
- Increased irrigation requirements if current crop patterns are to be maintained and crop losses are to be avoided.
- Increasing conflicts between water users (agriculture, industry, municipal, domestic, and in-stream flow) are to be expected as the demand for water increases.

Given the assumption that in many parts of the state the demand for water already exceeds available supplies, it is reasonable to expect that the competition for water will continue to increase (regardless of the effects of climate change). In order to develop strategies that address the increases in demand across all sectors it will be necessary to closely examine those assumptions regarding the states available water resources.

There is general agreement as to the storage capacity currently available in Washington State impounded reservoirs (16, 25 million/acre-ft)[4]. The estimated need for additional storage can be easily determined if the available resource only existed in surface water storage. The great unknown in the water availability equation is the current and projected abundance of groundwater that can be sustainably and economically utilized. Without a technically robust statewide study to determine what is and what is not available in the state aquifers, any climate adaptation strategy will have to, by necessity, be based upon known surface water storage capacity coupled with an assumed groundwater availability factor. If it is determined that assumptions surrounding groundwater availability is unacceptable, then a major recommendation of any climate adaption strategy related to water resources should include complete cataloguing of Washington's groundwater resources.

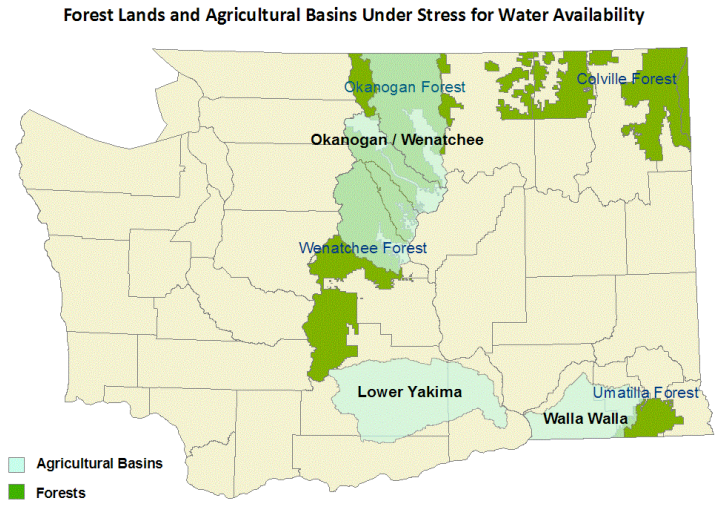
Vulnerabilities Related to Drought and Climate Change

Washington State has experienced multiple droughts since the early 1970's that have had profound effects on the state's working lands and highlighted vulnerabilities in these sectors. It is anticipated that what have been historic 50-year droughts will now occur every 10 years and what have been historic 10-year droughts will now occur about every 2 years. This being the case, it is prudent to examine how the state has addressed recent reoccurring droughts in order to begin to develop more long term actions for predicted changes in water availability as a result of climate change and the increasing demands for water.

Previously when droughts have been declared, the areas of the state most affected, from an agricultural perspective, are those snow dependant watersheds where much of the snow occurs at lower elevations. These are particularly vulnerable to warmer winter temperatures. These basins predominately are used to raise high value, water intensive crops such as tree fruit and vegetables. These areas are the Yakima Basin, and the Walla Walla and Okanogan/Wentachee River watersheds. Remedies have focused on how to maximize water availability in those areas by use of emergency permits allowing groundwater

[4] Doug Johnson, P.E., Dam Safety Supervisor, Washington State Department of Ecology

withdrawals, short term water leasing, or temporary modifications to existing water rights in order to make more water available for users for that current growing season. While these actions have addressed immediate needs, they are inadequate solutions for the more permanent changes in water availability predicted as a result of climate change.



The short and long-term effects of drought on state, federal or private forests can be forecasted by examining the results of previous droughts. Reduction in precipitation has resulted in increased vulnerability of forests to fire during the dry periods of the year. Forests in the central and eastern parts of the state are generally more vulnerable to fire than those in the western part due to lower precipitation and greater evaporation in summer which reduce soil moisture and humidity. Because of the added stress drought and reduced rainfall has on forests, populations of pests such as the Mountain Pine Beetle have begun to flourish in forests on the east side of the Cascades.

In order to begin to address longer term issues regarding water supply, it will be necessary to look beyond the effects of a year or two and factor in the increasing demands of other water users such as municipal, industrial, and environmental needs. The agricultural Preparedness and Adaptation Working Groups (PAWGs) for agricultural and forestry, in 2007 began to address some of the fundamental needs for working lands as those needs apply to water availability. The major recommendations from the Agricultural PAWG centered on the need for additional water storage facilities, improvements in water conveyance and delivery systems, and increased focus on water conservation activities.

The forestry PAWG recommendations focused on the need for additional research and information sharing related to potential changes in watershed characteristics due to climate change (increased temperature and changes in hydrologic response due to changes in precipitation patterns). In reviewing the recommendations for each PAWG it is clear that the starting line for developing recommendations for agricultural and forestry working lands is significantly different.

Discussion of Solutions to the Water Resource Dilemma

In 2007 the Preparedness and Adaptation Working Groups for agriculture, forestry and water resources developed numerous recommendations that were designed to facilitate discussions regarding overall water management in Washington given the predictions of the Climate Impacts Group. These recommendations generally fall into three categories consisting of:

- Development or modification of infrastructure
- Conservation practices and improvements in water use efficiency
- Modification of laws, regulations, and policies related to water allocation and management

In order to develop a comprehensive water management plan/strategy that addresses climate change predictions and forecasted water resource needs, elements within all three categories must be made part of the plan. Depending upon the area of the state being considered, one or more of the categories may have

a greater impact than the others. For example, within the Columbia Basin there may not be as great a need for development or modification of infrastructure as there is likely to be within the Yakima Valley. Likewise, the need for conservation practices and improvements in water use efficiency may not be as critical in the Skagit Valley as is regulation or policy reform related to water resources.

Development or Modification of Infrastructure

Generally, there are four means by which to store water for use on working lands. They are large scale reservoirs, small scale reservoirs, underground in aquifers, and within the soil column. To some extent all these methods are currently in use or are being proposed in Washington State. The need for additional storage whether it is man-made or natural and the mechanisms by which to transport water from storage facilities to points of use have been a staple of water resource and climate change planning for some time. Given the volume of water storage needed to offset snowpack losses, a combination of many large, small and micro- storage structures will be needed.

Water Storage and Retention Structures

Development of New Structures

Traditionally water resource management discussions have centered on the development of large scale reservoirs capable of multi-year drawdown and located off-stream within semi-closed basins. These divert water from major rivers during times of high flow and release it during low flow periods. During the past several decades these types of projects have hit major stumbling blocks due to the high costs of planning, siting, development and operation. For example, the proposed 1.3 million acre-ft Black Rock Reservoir near Yakima is predicted to cost $5.6 billion (YBSA, 2007). In addition to the high costs of these projects, concerns over environmental impacts, especially to water quality and fish habitats, have stalled development of new large scale projects [6], [7].

Smaller scale projects (generally those that refill each year) are currently being investigated, such as the Wymer Reservoir. This has an estimated cost of $380 million with a storage capacity of 320,000 acre-ft. While these projects have many of the same negative issues associated with larger scale projects, the development costs (generally 25 percent of large scale projects) and overall environmental impacts are deemed to be significantly less and therefore manageable. New on-stream reservoir projects have generally fallen out of favor due to the negative impacts on fish habitats and water quality.

Modification of Current Structures

As the costs (both financially and environmentally) increase for new water storage projects, modification of currently existing facilities may be an option. Generally these modifications raise the level of currently existing retention structures to increase storage capacity. In other areas of the West, modest increases in the heights of existing dams, mostly dual purpose dams supplying both irrigation hydroelectric production, are being considered. Depending upon the reservoir size, just 5 to 10 foot increases in dam height can significantly increase storage capacity at minimal cost while limiting siting concerns and additional impacts on downstream ecology. It is unclear to what extent how many existing retention structures in Washington State would be candidates for modification; however, this may prove to be an option worthy of further investigation and study.

On-Site Storage

In addition to large storage facilities, significant amounts of water can be stored on the farm for use by the farmer. These can be filled from natural precipitation or from irrigation supplies when demand is low and then used to supplement irrigation and natural precipitation during the growing season. These usually have limited environmental impact and are subject to permits by the WDOE. Many farms have already created storage ponds, and individually they may only store a few acre-feet, widespread adoption of on-site storage could significantly add to total storage capacity.

Use of Natural Structures

Another small/micro storage alternative is the use and management of beaver ponds. Like snow, these collect water which is then slowly discharged throughout the year. These are gaining the interest of researchers and water managers as important tools in maintaining water quality and quantity in streams. They are often in the upper regions of water sheds where they hold and release water allowing intermittent and ephemeral stream to flow longer and at a more constant rate which benefits forests as well as agricultural lands. Beaver ponds have many other environmental benefits as traps for sediment which reduce pollutant loads and siltation of spawning areas and provide habitats for many animals and plants. These ponds provide known benefits to the forest sectors and currently some limited benefits to the agricultural sector such as the cranberry growing areas on Washington's coast. Natural retention structures such as beaver ponds are not a total solution to the water availability issues envisioned for the future, but they may provide to be a solution in small watershed with limited working lands [7].

Forest management can influence both water quality and quantity. Maintaining forest health and reducing fire potential allows the forests to store water, reduce sedimentation and improve oxygenation and mineral removal within to the watershed. Healthy, diverse forests also reduce runoff and improve water holding capacity of the soil to recharge shallow aquifers. This improves the ability of the soil and aquifers to act as natural "reservoirs" which allow for the measured release of water to streams and lakes over the course of the year and reduce the potential for downstream flooding.

Aquifer Storage and Recovery Projects

Aquifer storage and recovery (ASR) is a proven technology for water management. It allows for the same management potentials as surface water storage without many of the negative issues, such as flooding natural habitats. In an ASR project surface spreading, infiltration pits and basins, and/or injection wells are used for recharge the aquifer during periods water availability or low demand. When needed, water is pumped from wells to irrigate crops or for other uses. Water can be stored in suitable aquifers or in other suitable geologic formations to form large subsurface reservoirs. These generally have little water loss due to very low evaporation, transpiration, seepage or contamination. The potential for ASR projects in Washington State is significant. It is estimated that 60 percent of the state is underlain by aquifers capable of yielding at least 50 gallons/minute; at least 50 percent of those aquifer may be suitable for use for ASR [8]. Aquifer storage wells are regulated in Washington State under the Underground Injection Control Rules, Chapter 173-218 WAC.

Table One: Comparison of Various Storage Options

	Groundwater Storage	Small Surface Water Reservoirs	Large Dam Reservoirs
Advantages	Little evaporation loss Siting close to use Operational efficiency Available on demand Water Quality	Ease of operation Responsive to rainfall Multiple use Groundwater recharge	Large, reliable yield Carryover capacity Low cost per volume stored Flood control and hydropower Groundwater recharge
Limitations	Slow recharge rate (infiltration) Potential groundwater contamination Cost of pumping (retrieval) Recoverability < 100%	High evaporation loss fraction Relatively high cost per acre/ft Absence of over-year storage	Complexity of operations Siting issues High initial investment costs Long planning and development time Environmental impacts

Key Issues	Declining water levels Rising water levels Management of access and use Groundwater salinization Groundwater pollution	Sedimentation Dam safety Environmental impacts	Social and environmental impacts ESA issues Sedimentation Dam safety

Conservation Practices and Improvements in Water Use Efficiency

Water use conservation in the agricultural sector generally consists of one or more of the following main elements:

- Increased crop water use efficiency
- Improved irrigation application efficiency
- Decreased crop consumptive use
- Increased delivery efficiencies
- Reduced water use through adoption of conservation measures and new technologies for water management

Water conservation practices have been steadily on the increase within the agricultural sector over the last 25 years. Practices such as irrigation scheduling, tail-water return systems, and irrigation system improvements have stabilized water consumption at approximately 3.4 ft for each acre of irrigated land. Livestock consumption has stabilized at approximately 30 Mg/d [9]. The overall value of irrigated crops in Washington State was placed at $2,295.91 per acre by the USDA in 2007, with 1.67 million acres of irrigated farmland existing in the state.

Improved water use efficiency in its simplest form means reducing the water needs to achieve a unit of production in any given activity. Water use efficiency includes any measure that reduces the amount of water used per unit of any given activity, consistent with the maintenance or enhancement of water quality. The increasing cost of water recognized through either surface distribution systems or lifting via groundwater pumping are and will continue to stimulate adoption of conservation practices and improvement in use efficiency. In the area of water conservation and efficiency improvements (within the agricultural sector) two opportunities exist:

- Regional delivery systems
- On-farm irrigation methods

<u>Regional Water Delivery Systems</u>

Washington has thousands of miles of canals, pipes and ditches, some dating back to the late-1800s that distribute water from its source to individual farms and other users. These regional delivery systems have been significant sources of water loss either through unlined irrigation canals or reservoirs/canals that remain open and subject to evaporation. Water losses of 30-40 percent occur in some systems due to leakage and evaporation which can have significant impacts to overall water delivery. [10]. This represents a significant loss of water for agricultural production in Washington State.

Systems can be improved by re-routing canals, lining and covering canals and ditches, and/or replacing these with pipes. The costs associated with delivery system improvements, while substantial, can provide income recovery in excess of the initial improvements within a relatively short period of time. In most cases it is more practical to consider lining or piping of the canal system rather than covering. Reducing the leakage from unlined distribution system have can reduce loss by up to 25 percent in medium to large unlined system.

Canal rehabilitation to improve delivery efficiency can have unintended consequences. Leakage can be a primary source of recharge to the underlying aquifer, such as in the upper Tieton Basin in Yakima County and through the lower areas of the Columbia Basin Irrigation Project. Lining of the canal system, especially in the Tieton Basin, has lowered water levels in wells for irrigation and domestic water. This has resulted in a "shifting" of costs from the irrigation district to the private land owner who depended upon the canal leakage as a source of groundwater.

On-Farm Irrigation Methods

Once the water is delivered to the farm, the farmer has control over water efficiency – mostly by the selection and use of water delivery systems (i.e. sprinklers, ditch, micro-sprinkler etc.) and irrigation timing. Depending upon the method for delivering water to the crop efficiencies can improve from 60 to 95 percent, thus resulting in significant savings of water.

Table Two: Range of Application Efficiencies for Various Irrigation Systems
From Irrigation Management Series-Kansas State University MF-2243, May 1997

System Type	*Application Efficiency Range*
Surface Irrigation	
Border	60 – 95%
Furrow	60 – 90%
Surge	60 – 90%
Sprinkler Irrigation	
Handmove	65 – 80%
Traveling Gun	60 – 70%
Center Pivot & Linear	70 – 95%
Solid Set	70 – 85%
Micro-Irrigation	
Point source emitters	75 – 90%
Line source emitters	75 – 95%
Sub-Surface Drip	80 – 95%

Generally, higher efficiency systems are more expensive and may be impractical for some crops given the current cost of water and energy. As water becomes scarcer and prices escalate These systems will become more practical. Some of these more efficient systems may be in conflict with designs of current irrigation systems (those that have been designed based on old technologies such as the Columbia Basin system).

Irrigation timing based on soil moisture and crop needs is a second method that, used by itself or with improved water delivery technologies, can conserve water and improve efficiency. In Washington State a significant effort to integrate irrigation timing has been employed in the Columbia Basin Groundwater Management Area. Installation of moisture monitoring equipment has been installed on approximately 400,000 irrigated acres with a goal of eventually having 800,000 acres under irrigation water management technologies.

These methodologies can be developed to suit the specific crop and irrigation method employed and are developed and implemented in conjunction with the local conservation district assistance. To date it is estimated that irrigation use has declined 20 percent while crop yield has increased.

Again, implementation of improved on-farm irrigation methods will generally reduce infiltration to shallow aquifers. These may currently supply domestic water to the farm and neighbors who are not connected to public water supply systems. This may result in areas experiencing shallow water level

declines. Additionally, reducing the water applied must be accompanied with complementary changes in nutrient application to avoid the build-up of salts within the soil and reduction of crop productivity.

Other Freshwater Alternatives

As demands for water increase, they are likely to exceed the quantities of water available for human use. As demand approaches supply, alternatives that are not currently feasible many become realistic options. For example, many of the current water conservation efforts and restrictions on water use are intended to increase stream flows and improve habitats for fish and other organisms, especially during critical periods (i.e., spawning, downstream migration, etc.). However, when the river meets the ocean these functions are complete. Theoretically, fresh water could then be removed near river mouths and pumped back upstream for irrigation and other human activities without adversely affecting fish. Similarly, desalinization of saltwater near coastal communities may provide potable water for municipal use, freeing up other water for agriculture or habitat use. Again, these types of water projects may not now be feasible or acceptable, but the increasing demand for a limited freshwater resource will force consideration of a variety of alternatives that now sound like science fiction.

Modification of Laws, Regulations, and Policies Related to Water Allocation and Management

Water availability for Washington working lands is already under pressure due to urban and commercial demands. This pressure is likely to increase as climate change puts further stress on the available water resources existing within the state. Rights originally issued to assure the development of the agricultural base in the state have gradually been shifted to satisfy the needs associated with urban and commercial development and federal laws stressing the need for improved protections for endangered species. Water law in Washington allows for some shifts in beneficial use in order to meet the demands of a changing society; however, in order to meet these demands and preserve the vitality of Washington's working lands modifications to how water is allocated and managed needs to be strongly considered.

Water law in Washington and western water law in general pose challenges for water development of measures to insure future availability. The requirement to perfect a water right and demonstrate continued beneficial use is a significant obstacle to implementing water conservation and efficiency measures in the agricultural sector. For example, programs that assist agricultural water users in implementing irrigation water conservation measures will generate water for municipalities while enabling irrigators to continue in business using less water. However, the "use it or lose it" doctrine discourages these innovations because it declares that water saved through efficiency measures is not available to the irrigator or to the provider helping to conserve. Thus, no one presently has the incentive to conserve irrigation water use. There is promise that these supply-side efficiency measures can develop water at a fraction of the cost of new, large conventional supply facilities.

In order to address this issue the Washington Department of Ecology has attempted to implement water banking programs which would allow holders of large rights (in Eastern Washington that generally means an agricultural interest) to set aside some portion of that right for temporary use by others or to enhance in-stream flows for environmental interests. While that provides a temporary solution to the water availability issue it does not address long term questions that will arise if at some time the holder of that right wishes to reclaim the portion that has been banked.

<u>Water Markets and Transfer Banks</u>

With climate change and increasing populations the main influence dictating the price of water will be scarcity. As already mentioned, new water supply projects can minimize or eliminate scarcity, but an additional method is the creation of a water market to set the price more efficiently which will improve the way water is used. Development and implementation of a water market should help to stretch the state's water resources and encourage greater sharing of currently allocated water. Creation of a water market or markets to facilitate such transfers whether permanently or for a time specific duration is

essential to providing the means for such resource sharing. Washington has created the framework for a water banking system, but this system must be modified, eliminated and/or supplemented by another to obtain the level of capability needed.

There are currently a number of issues that impede the development a single water market, even at the local scale. These mostly relate to differences in groundwater and surface water access entitlements and their administration. In particular there are currently frequent incompatibilities in:

- Definition and relative securities of surface water and groundwater entitlements;
- Cost structures;
- Ownership of infrastructure;
- Physical capacity of infrastructure to deliver water to where it is to be used;
- Reporting and monitoring;
- Management plan objectives (i.e. between groundwater plans and surface water plans);
- Institutional administrative structures;
- Understanding of flow dynamics and dependent ecosystems.

Other states have developed private sector water banking networks. These range from totally private willing seller-willing buyer scenarios to state operated networks akin to the Washington system. Water markets can provide unique ways of dealing with scarcities of water, such as through dry year lease options. Used in a number of states, these leases are usually created between seasonal users (e.g. agriculture) and year round users such as municipalities. The lessee agrees to pay a sum of money to the lesser each year and in turn has the right to call in the water in times of drought. This enables agricultural users to grow crops in the years when the water is not called in by the lessee.

Water Salvaging Agreements

The concept of Water Salvaging Agreements or dry year lease options differ from water exchanges in that cooperative agreements are entered into between the holder of a water right and a party seeking to obtain water. In the case of an agricultural water user, such an agreement (contract) could be entered into with municipal water or state or local wildlife agencies such that these entities could invest in farmers' irrigation systems in exchange for some portion of the water conserved. These agreements could be permanent or temporary in nature and would not require the water right holder to give up any portion of his or her right. In order to implement this type of activity changes would have to be made to current water law in Washington State. However, the implementation of agreement such as this would serve to direct more water to growing urban needs without significantly jeopardizing future water availability for agricultural needs.

Cautionary Considerations

Implementation of water banking or other management activities must consider other impacts which fall outside issues surrounding water quantity. Among the emerging considerations is the issue of inter-basin movement of water. Movement of water from sources during periods of high flow to basins where flow is reduced or where additional storage is available may have significant consequences on habitat, endangered species and/or tribal issues. These impacts must be fully considered and addressed if a successful, comprehensive water management plan is to be accepted by all parties.

Pest and Disease Background Information

Climate change can affect play a significant role in pest and pathogens in several ways. The effect of climate change may eclipse other factors affecting the occurrence of pests and pathogens. If this is the case, the question as to how current pest and pathogen management should be modified becomes a central aspect of a climate adaption strategy for forests, agriculture and aquaculture lands.

In regards to many pest and pathogen organisms, higher temperatures may lead to accelerated disease cycles, leading to an increase in disease spread, and to increased survival due to shortened and less severe frost periods. Climate change will likely prompt changes in current farm management, which may have impacts (positive or negative) on pests and/or pathogens populations. The already existing trend to advance planting crops to bring crops early in the season to the market is done because prices are then still high, but is done also to escape plant diseases. This trend will continue when temperatures rise. The consequence will be that plant disease outbreaks will start earlier, have a longer season, resulting in more disease cycles in one vegetation season.

Currently there is a high reliance on use of chemical and biological agents to eliminate or reduce to manageable levels pest that pose a threat to commercial food and wood products. While there have been great strides in reducing the need for such agents, these still remain as the cornerstone for pest and pathogen management. Current attention as to how these tools are employed within the environment may result in limitations to their use fostering the need for new and innovative practices. This will be particularly important in dealing with unforeseen pest and pathogen outbreaks as a result of climate change.

Impacts

Washington State is predicted to experience both higher temperatures and changing precipitation patterns over the next century. These changes will likely prove increasingly favorable to new and existing forest, agriculture and aquaculture pests and diseases. Higher average winter temperatures will allow new pest species (insects, weeds, fungus, etc.) to survive the winter, while longer summers will allow these pests to complete and in some cases extend their life cycles. For example the massive population buildup of mountain pine beetle and its northward progression in the Pacific Northwest has been linked to a combination of warmer winter temperatures, reduced episodes of underbark mortality and increased drought which weakened the trees. In the last few years the potato tuber moth has become a major pest in eastern Washington.

Predicted Changes in PNW Climatic Conditions

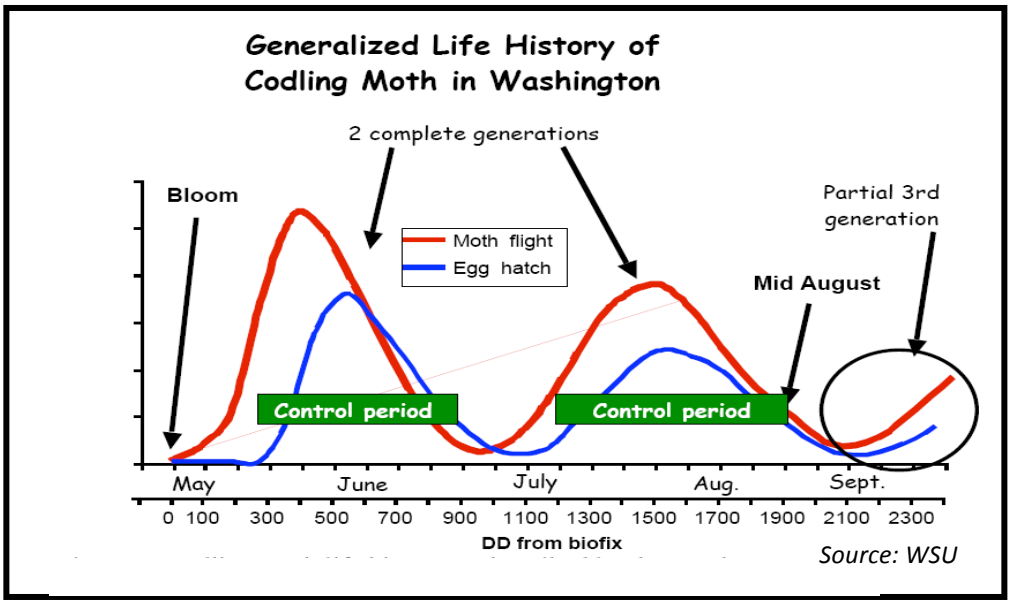
	Temperature	Precipitation
2020s		
Average	+ 2.0ºF *(1.1ºC)*	+1%
2040s		
Average	+ 3.2ºF *(1.8ºC)*	+2%
2080s		
Average	+ 5.3ºF *(3.0ºC)*	+4%

Climate – University of March 2008

Source: Impacts Group Washington

The rise in occurrence is believed to be due to longer optimum conditions for breading and warmer winter temperatures that result in significantly less die-off due to freeze kill. A generalized life cycle diagram for codling moth is presented to represent the effects of longer heating days on insect populations. With respect to aquaculture, tentative links between ocean and estuarine oxygen and temperature changes have been made on disease affecting oyster production and the rapid expansion of Spartina in Willapa Bay (Field 1997).

Extension of Codling Moth Life Cycle Due to Increased Degree Days



To date pests are controlled by a variety of means including both chemical and biological. However, as changes in climate occur that represent a more favorable ecology, it can be expected that current methods will become less and less effective (insect and weed resistance, overwhelming populations). Additionally, the collateral impacts to non-target species may prove to be substantial concerns in the future.

While changing climatic conditions are expected to result in increases in pest pressures for forestry, agriculture and aquaculture the expansion of global demand for both wood and agricultural products has opened new pathways for invasive species as well as for plant and animal pathogens that are well adapted to potential climate changes and are potentially damaging to Washington forestry and agriculture. As climate conditions change worldwide requiring more trade to address food and fiber needs here and abroad, the potential for the introduction of new pest species into Washington State may significantly increase.

Key Vulnerabilities and Risks

Within the state of Washington overall farmer or farm sector vulnerability to pest and disease is currently considered to be somewhat limited. This is due in large part to implementation of innovative pest management schemes and the availability of a wide array of chemical and biological tools to address and limit outbreaks. This includes research and development of crops that are resistant to current pest and pathogen pressures and development of chemical agents with narrow targets. However, the use and effectiveness of these tools is dependent upon forward knowledge of potential new or invasive pest species that may have significant impact to the some 300+ crops grown commercially within the state.

Currently, there is a relative balance between the current deployment on management tools and changes in the pest and pathogen populations. Acceleration of pest and pathogen populations or adaptation to current tools due to rapid changes in climatic conditions presents a significant risk of tipping the current balance.

In 2007 the Prepardness and Adaptation Workgroup developed a key list of risks related to pest and disease and climate change impacts. This list remains pertainant today.

Increased temperatures and changes in precipitation patterns will result in an expansion of areas where pests are found, longer pest life cycles, and increased losses from weeds, insects and diseases. Issues for agriculture from these impacts include:

_ *Increased cost of production* from increased pest inputs.

_ *Decreased yields and crop quality*.

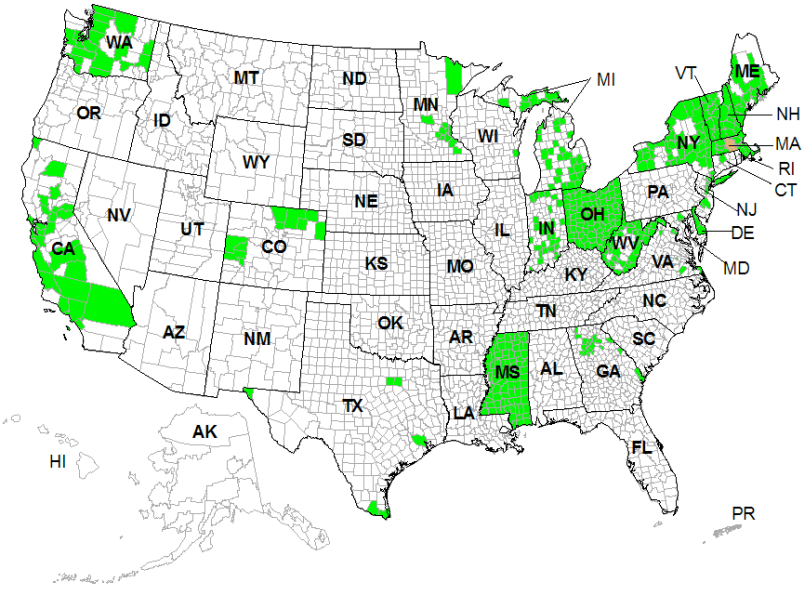
_ *Increased root-rot in perennial crops*, due to increased soil temperatures, resulting in the need to develop new "rot-resistant" varieties, or to modify current practices.

_ *Expansion of insect pests* into areas and crops in Washington not previously seen, resulting in:

- Current statewide insect monitoring program being insufficient to provide "early warning" of major pest movement
- Current integrated pest management measures potentially being insufficient for predicted expansion of new pests, and
- Increased use of pesticides to control insects and weeds

Pest populations are currently monitored on a national level by the United States Department of Agriculture through such program as the Remote Pest Identification Program, and the National Agricultural Pest Information System. While these activities aid in the tracking of pest and pest populations nationwide, they do not generally provide for timely information on a scale that is valuable to the individual grower or group of growers.

Asian Longhorned Beetle – 2009 Survey
National Agricultural Pest Information System



In 2007 the Preparedness and Adaptation Workgroup for agriculture recommended that the support be given to the Invasive Species Council to conduct an assessment of baseline conditions that would provide valuable information necessary to address questions about the extent of infestations and how they can best be managed from a statewide perspective.

The assessment would bring all the information together in one place, allowing for improved decision making by many federal, state, and local agencies. The Council would use the information to develop and implement its strategic plan, and to provide policy level planning and coordination on invasive species issues with agencies such as departments of Agriculture, Ecology and Natural Resources, Weed Boards; EPA; USDA; county governments; and Washington tribes.

The assessment, would:

_ Provide analysis of the worst invasive species in the state, the locations of the areas most affected, pathways, and resources most at risk.

_ Identify public and private efforts to prevent, control, or eradicate invasive species.

_ Bring together in one place, for the first time, the multitude of invasive species data compiled by county, state, federal, tribal, and non-governmental organizations, including GIS data created by local Weed Control Boards.

_ Identify gaps and duplication of efforts.

_ Provide critical information for the development of risk-assessment standards that will be used for meaningful priorities for preventing, controlling, and eradicating invasive species.

_ Inform public and private entities and increase their ability to coordinate efforts and resources.

Unfortunately, due to budget shortfalls a majority of this work has not been accomplished. In the absence of this action, another method that would enhance and compliment federal tracking activities is needed to provide the foundation for effective pest management planning.

The development of new and less environmentally impacting chemical control methods is the current path favored by the federal government and most state agricultural agencies. This new generation of chemical control agents is developed with targeted pests and disease in mind. This differs significantly from the historic development and application of wide spectrum pesticides that were generally more toxic to off target organisms and the environment. However, the risk of unforeseen explosions in pest and disease populations due to climate change that may not respond to current "targeted pesticides" is a factor that cannot be discounted and should be considered in the development of any adaptation strategy.

Recommended Adaptation Strategies

Fire Management Recommendations

Part A: Research and Information

Recommendation A.1: Information and Intergovernmental Collaboration

The public sector must develop adaptive capacity on two fronts: Information availability; and, the development of shared policy goals with respect to adaptation. This approach is not an end in itself, but a means of encouraging planning and action when it is justified. This recommendation recognizes the need to identify existing policies and existing science and create a mechanism for consistent communication between the two worlds. To succeed in its intent, this recommendation requires a strong focus on scientific information and data: scientifically valid information on forest health conditions (and how they vary regionally), the broader utilization of the state-and-transition model[5], identify areas where we don't have sufficient information and generate a plan to obtain the information, prioritization and vulnerability assessments, etc.

Key points of consideration:
Shared intergovernmental policy goals are important. How can new policies for resilient forests, e.g., at DNR, USFS, counties, etc. insure that all are contributing toward outcomes of shared importance? How are existing policies compatible? Adaptation will be easier if the policy playing field is clear to all observers.

Identify how the Statewide Assessment (WACCIA) plays into this process. What information are we trying to get and at what resolution? Information in the WACCIA may not fit the needs of all users, so someone needs to understand what data is in there and what could be developed from it or, especially, other sources and what that would cost.

Make sure that there are avenues of information dissemination for people that don't necessarily have good access. Attempt to ensure equal access to information, and make it understandable. Consider what information and technology transfer tools are needed to implement recommendations.

First utilize existing partnerships such as the Tapash Sustainable Forests Collaborative and the Northeast Washington Forestry Coalition that (1) have knowledge of and can relay data, information, and policy and (2) have built in mechanisms to communicate with one another: policy and information (data, science). Develop additional partnerships using demonstrated successes.

Recommendation A.2: Convene a stakeholder group that is tasked with:

1. **Facilitating the collation and dissemination of critical information to policy makers, community action groups, and landowners. This facilitation would incorporate elements of PAWG recommendations (1), (2), (4), (6) and (7) to broadly increase the availability of and access to information.**
    1. Provide comprehensive data and information to land-owners, policy makers, and the public about the existing and developing forest health and fire hazard conditions.
    2. Use new state authority to create forest health scientific advisory committees to assist decision makers in responding to extreme forest health and fire hazard problems.
    4. Provide public financial and technical assistance to owners of small forestland parcels.
    6. Implement an active communication and education strategy.

[5] Built on a forest dataset called Gradient Nearest Neighbor. It is run by the USFS PNW Research Station and can predict wildfire effects at the watershed scale under alternate future climate scenarios.

7. Improve coordination of regulatory requirements to remove unnecessary barriers while ensuring program objectives are being met.

2. **Analyzing the regulatory environment in which adaptation will occur so that (a) possible tools are maintained (e.g., prescribed fire, fuels treatment, and removing biomass and/or decreasing stand density in severely water limited forests to mitigate severe forest health problems) and (b) policies goals are shared (or at least not in conflict) among different landowners (e.g., example of wildland fire use as a permitted policy) to allow landscape level management – e.g., USFS "all lands approach".**
3. **Developing an action plan for catastrophic wildfire event.**

Recommendation A.3: Inventory existing pilot projects, identify projects that are needed, and ensure adequate funding is available for pilot projects.
Pilot projects are an essential component of forest health adaptive management and should be a method consistently implemented to test and demonstrate new authority, policy, and technology and to encourage the buy-in of stakeholders. We need to be pro-active on an on-going basis. Organizations must work together to identify pilot projects that will result in the most benefit to exploring the viability of the largest number of climate change adaptation strategies and/or that will have the most impact.

Pilot projects should be integrated into all recommendations and activities that emerge from the Fire Management group within the Natural Resources Technical Advisory Group, as a method for testing the efficacy of various strategies and to demonstrate to the public what 'successful' climate adaptation looks like.

Part 1: Identify pilot projects that are currently underway in Washington State that relate to forest health and fire management to ensure that projects are collecting relevant data and that new duplicative pilot projects are not initiated. Determine what work is already being done on a pilot scale and determine whether we are getting the data we need. If not, determine whether it is feasible for an existing project to be modified to accommodate the data needs that would be required to ensure effective testing of adaptation strategies.

Part 2: Identify the key data sets that are needed and develop a list of pilot projects based on the recommendations of the TAG's that need to be conducted prior to recommendations being implemented on a landscape level. Work with partner agencies to secure funding and, to the degree possible, apply the pilot activities across different land ownerships and forest management schemes.

Part 3: Identify and create opportunities for financial assistance to pilot programs.
Work with local, state and national partners to identify existing funding sources that are amenable to pilot scale projects related to effective fire management strategies aimed at adapting to climate change. Where there are no existing mechanisms or funding sources, work with stakeholder groups to create them.

Recommendation A.4: Engage and provide input to the Regional build-out efforts from the National Fire Plan Cohesive Wildland Fire Management Strategy.
Fire management strategies are only effective when landscape level agreement by all landholders (state, federal, SFLO, industrial land owners, others) is reached. The Cohesive strategy exists for this purpose and is linked to land management actions by major agencies, as well as agency-administered programs to assist landowners. Engagement will draw from the first iteration of the State's Comprehensive Climate Adaptation Plan.

Recommendation A.5: Develop electronic information centers across the state that summarizes regionally relevant information.
Centers will be based on feedback that is received through 'listening sessions' with residents. These sessions will ensure that information being collected is what is needed by affected communities. NOTE: This recommendation is motivated by a combination of Forestry PAWG recommendations for Forest health and fire strategy.

Recommendation A.6: Take action to (1) pre-adapt landscapes, on pilot project scales initially, to climate change and future disturbances and understand how pre-adaptation varies sub-regionally, (2) plan for responses to severe disturbance, and (3) develop information and monitoring required to incorporate this into adaptive management.
This recommendation is motivated by the understanding that disturbance area and possibly frequency and severity are likely to increase with climate change and that how we address these disturbances, both preemptively and after they happen, will determine the trajectories of our forested landscapes.

Key points of consideration:
From a scientific perspective, we know the experiments that we need to do to understand what pre-adaptation actions are effective. For example, we need to know much more than we do now about how thinning and biomass removal will affect tree vigor and response to insect (e.g., Mountain Pine Beetle) attack. This includes a need for broader understanding of how multiple insects and diseases will interact in the considerable portion of eastern Washington forests that are comprised of mixed species. Furthermore, better science is needed to understand how forests are likely to respond after inevitable severe disturbance events – which species will persist, which will regenerate, which will not. There is evidence that entirely novel, new vegetative communities could be the result (Rehfeldt et al. 2006).[6] Can a combination of thinning and prescribed fire programs make our most vulnerable forests, once they have been identified, better adapted to fire? We already know that thinning can be done in such a way that fire severity can be influenced.

Science is pointing to more active management regimes in production forests and multiple use forests to minimize the loss of canopy mortality in disturbance events. It is important to recognize that there is strong spatial variance in the degree to which this is true – the more frequent disturbance was prior to Euro-American settlement, generally, the more this management is indicated.

Pilot projects that test and demonstrate techniques for forest management and monitoring, particularly on the edges of forest types and urban/forest interface zones where they are visible and affect human values, are excellent experiments to provide data for HOW to do this and HOW to communicate it.

Pre-adaptation plans should be aimed at regeneration, tree vigor, stand density, composition and structure of forest ecosystems. Monitor closely edge or ecotones (transition zones) from wet to dry where climate effects may initially be most dramatic. These should be the focus of the initial pilot projects, designed to develop and test treatment regimes for maintaining, enhancing or restoring a resilience and healthy forest system.

It should be acknowledged that while experimental design can be deployed in the immediate-term, the results and effectiveness of the pilot projects will not be known for many years.

[6] Rehfeldt, G.E., Crookston, N.L., Warwell, M.V., and Evans, J.S. 2006. Empirical Analyses of Plant-Climate Relationships for the Western United States. International Journal of Plant Sciences. 167(6). 1123-1150.

Part B. Pilot Projects (Proof of Concepts)

Recommendation B.1: Fully Fund and Implement on the Ground Pilot Projects

Pilot projects are an essential component of forest health adaptive management and should be a method consistently implemented to test and demonstrate new authority, policy, and technology and to encourage the buy-in of stakeholders. We need to be pro-active on an on-going basis. Organizations must work together to identify pilot projects that will result in the most benefit to exploring the viability of the largest number of climate change adaptation strategies and/or that will have the most impact.

Pilot projects should be integrated into all recommendations and activities that emerge from the Fire Management group within the Natural Resources Technical Advisory Group, as a method for testing the efficacy of various strategies and to demonstrate to the public what 'successful' climate adaptation looks like. .

Part C. Increase Forest Health

Recommendation C.1: Utilize sound, science based silviculture practices to promote forests that are healthy and resilient from significant impacts of insect and disease. The objectives of these practices are they relate to climate change are:

- **Integrate wildfire management objectives with forest health restoration objectives, recognizing that often, the focus of wildfire hazard reduction actions is in close proximity to communities whereas forest health actions typically take place across broader landscapes.**
- **Manage for native species and structural diversity as current site potential and land management objectives will allow, using both historic range of variability and future climate scenarios as a guide.**
- **Where needed, utilize stand density and species management to maintain or enhance overall stand health and resiliency through increased vigor, species and structural diversity.**

Rationale: this recommendation emphasizes the need to develop resiliency and health of forests at both the stand and landscape level that will allow vegetation the ability to adapt to climate change. It recognizes that an important component of the degree to which insect and disease organisms interact with forests is closely related to overall tree vigor, species mix, and vertical and horizontal structural diversity.

Recommendation C.2: **Seek incentives to collaborate with adjacent landowners (both large and small) to affect overall landscape resiliency through the management of age class, structure, and species distribution.**

Rationale: In order to effectively adapt to changes in climate, it is important that overall forest resiliency be considered on large landscape scales. To be successful in this, collaboration across ownerships and political boundaries must be strong and should include partners from federal, state, tribal, and local governments, as well as private stakeholders.

Recommendation C.3: Adopt an "all lands" approach for allocating public funding for landowner assistance.

Washington's forest managers will play a crucial role in sustaining healthy, productive forests over time. But forest landscapes are not bounded by artificial ownership boundaries. Land ownerships of all sizes will face the same ecosystem consequences due to climate change. The difference will be in the management response by the landowners. Allocation of public funding will best be made within an "all lands" context that considers small forest landowners along with other types of forest owners, including large industrial owners, non-profits, local and state governmental agencies, DNR trust lands, tribal lands, federal lands and others. Experience suggests without this approach many small acreage landowners simply do not have the financial resources to undertake necessary silvicultural practices. Experience also shows small forest landowners to be a difficult demographic to incite toward concerted action at large scales, but direct proximity to visible, well publicized projects on federal and state lands can help. Timely

deployment of recovery and adaptation actions following a severe wildfire event, when the consequences are still fresh in mind, has also proven a successful tactic.

The 2010 Washington Statewide Forest Resource Assessment and Strategy[7] can serve as a foundation for such an approach. The assessment provides an analysis of forest conditions across ownership boundaries and delineates priority landscape areas and issues. The strategies provide long-term plans for investing state, federal and private resources where doing so will be most effective. A focus on all lands and strategically assessing the forest areas that have the greatest need or highest value will get the most value from the invested effort.

Part D: Small Forest Landowners

The Forestry Resources Preparation and Adaptation Working Group recommended "providing public financial and technical assistance to owners of small forestland parcels to encourage implementation of treatments demonstrated to be successful, and tailored to diverse landowner objectives, through science-based pilot programs."[8] Washington's legislature recognizes the importance of small forest owners and the benefits their forests provide to all Washington citizens. It has stated that all citizens must recognize small forest owners' commitment to long-term forest stewardship, and support maintenance of such forests for their present and future benefit (RCW 76.13.005). Federal programs are in place, administered by the DNR Resource Protection Division, that already assist landowners with taking these actions, increasing state funding contributions to these efforts and maintaining or improving current federal funding levels should be a priority.

Recommendation D.1: Provide technical assistance to small forest landowners through a variety of existing programs and entities.

Additional assistance for small forest landowners is needed to: 1. Help the landowner understand how the anticipated forest impacts due to climate change could impact their forest management, and 2. Provide information and assistance to implement Firewise and other management strategies to reduce potential risk from forest fires as a result of changed environments.

Recommendation D.2: Use existing channels to deliver financial and technical assistance to small forest owners.

Currently there are a number of programs available at the federal, state and local levels, as well as some Tribal programs, to provide technical and financial assistance to forest land owners. The most efficient and effective assistance approach will be one relying on the existing financial and technical assistance service delivery infrastructure that is already well-suited to help accomplish this strategy. This infrastructure includes DNR, State Conservation Commission, conservation districts, WSU Extension, local governments, and NGOs such as WFFA and WFPA. DNR currently administers four programs to deliver public financial and technical assistance to small forest owners: forest stewardship; forest health; small forest landowner office; urban and community forestry. A significant challenge lies in overcoming capacity limitations that are a function of currently available funding.

Recommendation D.3: Secure expanded and sustainable funding to broaden the scope and scale of service delivery to small forest owners and secure expanded and sustainable funding to broaden services.

Currently there are a number of programs available at the federal, state and local levels, as well as some Tribal programs, to provide technical and financial assistance to forest land owners. The most efficient and effective assistance approach will be one relying on the existing financial and technical assistance

[7] Department of Natural Resources work product to be finalized in June 2010.

[8] Leading the Way: Preparing for the Impacts of Climate Change in Washington. Recommendations of the Preparation and Adaptation Working Groups. Page 145.

service delivery infrastructure that is already well-suited to help accomplish this strategy. This infrastructure includes DNR, State Conservation Commission, conservation districts, WSU Extension, local governments, and NGOs such as WFFA and WFPA. DNR currently administers six programs to deliver public financial and technical assistance to small forest owners: Forest Stewardship; Forest Health, Fire Prevention and Fuels Reduction, Small Forest Landowner Office, Urban and Community Forestry, and Forest Legacy. Additionally, the USDA Natural Resources Conservation Service administers the Environmental Quality Incentives Program (EQIP). A significant challenge lies in overcoming capacity limitations that are a function of currently available funding. The potential to secure stable funding from non-governmental sources to expand DNR's capacity to deliver financial and technical assistance should also be explored.

The legislature should increase funding to several small forest landowner assistance programs, including: the small forest landowners office at the DNR, the Washington State Conservation Commission and the local conservations districts, and WSU Extension. Managers of these programs should also seek opportunities to partner with NGOs such as WFPA, WFFA, and the Farm Bureau. The legislature should also consider compensation opportunities for ecosystem services small forest landowners provide the public. These approaches can provide small landowners with more technical assistance, land use options, and resources, which together will reduce conversion pressures.

Part E: Avoided Conversion

The working group recognizes that conversion of working forestland to other uses presents significant challenges to the application of forest management strategies for climate change adaptation. Successful working forest and natural areas conservation efforts are a key stepping stone to enabling success in the broader array of climate adaptation and integrated fire management strategies at a landscape scale. The group also recognizes working lands conservation is an essential component to success in other related efforts such as creating and retaining green jobs, restoring Puget Sound, and mitigating climate change. Finally, the group recognizes that the challenges faced by working forests – and the array of acceptable solutions – differ among western and eastern Washington landscapes. For instance, industrial landowners account for a much higher percentage of forestlands in western Washington than in eastern Washington; federal lands account for a much higher percentage of eastern Washington forests than western Washington forests. The emphasis of many avoided conversion efforts, and their underlying strategic assumptions, has been in the developing areas of western Washington. Different approaches will be required to address avoided conversion in eastern Washington from a fire management perspective.

Due to the importance of avoiding conversion of working lands, the working group recommends that the state pursue the following strategies:

Recommendation E.1: Local governments should be encouraged to protect working forest lands through existing zoning and land use designations.

Under the Washington Growth Management Act (GMA), all counties and cities are required to designate forest lands of long-term significance for the commercial productions of timber.[9] This designation is intended to protect the economic productive value of these lands. Technical assistance should be provided to local governments to assist them in evaluating their current resource lands designations in light of the anticipated ecosystem alterations due to climate change. This evaluation should consider whether the local designations should be changed to ensure sufficient forest lands are protected from conversion if there will be changes to harvest regimes due to climate change. For example, climate change may limit the amount of timber that can be harvested from these resource areas. If this is the case, will more land need to be designated to ensure sufficient available timber.

[9] RCW 36.70A.170(1)(b)

Recommendation E.2: Pass legislation to advance new market-based approaches to working lands conservation including:

- **Forest Biomass Markets. Removing biomass from forests in ecologically sustainable ways can provide income for forest landowners while improving forest health.[10]**
- **Ecosystem Services Markets. "Ecosystem services" refers to the natural resource values forests provide, such as water purification, wildlife habitat, wetland protection, and carbon sequestration. Ecosystem services markets refers to the system whereby a forested landowner can sell "credits" reflecting the value of these services in the forest, and the credits are sold to another entity who must mitigate for impacts to similar services elsewhere. Legislation would be required to facilitate this system in Washington.[11]**
- **Enable infrastructure funding for urban transfer of development rights receiving areas**
- **Provide counties with better ways to achieve conservation through cluster developments**

In 2007 and 2009, the legislature passed legislation to enable and advance transfer of development rights in Washington State and the central Puget Sound region. Transfer of development rights is a new market-based tool that allows landowners to realize development value and conserve their property while directing growth to areas designated for additional development. Numerous counties in the state have TDR programs in place, and dozens of transfers have occurred conserving tens of thousands of acres. In rural areas, counties also have various approaches to encourage cluster development to conserve open space. While these approaches do leverage market forces to achieve some conservation, counties are looking for authorization for strategies that would promote greater avoided conversion avoidance benefits in the rural development that is occurring. The 2008 Climate Action Team Forest Sector Workgroup noted the potential forest carbon benefits of better guiding growth in rural lands.

The legislature should pass legislation enabling new infrastructure financing options for cities participating in a transfer of development rights marketplace. HB 2850 proposes this linkage in King, Pierce, and Snohomish Counties. The bill was introduced in the 2010 session, and legislators are expected to reintroduce the proposal in 2011. The legislature should also look for opportunities to enable counties to achieve more permanent working lands conservation by linking TDR to fully contained communities, urban growth boundary expansions, or other forms of new rural development.

Recommendation E.3: Support state and federal working lands conservation programs.
Several existing state and federal programs provide resources and tools for avoiding conversion of forestland to other uses. Avoided conversion likely increases the capacity of forest and agricultural systems to fix CO2 and also provide more land management options in adaptation to the impacts of climate. As public conservation resources are limited, especially in the current fiscal environment, it is important to use them strategically and efficiently. Furthermore, limitation on the availability of public and philanthropic conservation dollars place additional importance on the role of innovative market-based approaches in achieving landscape-scale conservation.

There are also several federal, state and local programs to assist landowners in enhancing the economic productivity of their working forests. When forest lands is economically viable to retain as forests, the landowner has the economic incentive to continue in forestry. If the landowner can make more money through development, they will be more likely to convert the land. By providing a variety of marketing and economic options for the landowner, the likelihood of conversion for economic reasons are reduced.

[10] *Statewide Forest Resource Assessment & Strategy for Washington State*, Washington State Department of Natural Resources, June 2010, Section A, p 30.
[11] *Statewide Assessment Strategy*, Section A, p 30

Conservation programs allow the landowner to place forest lands in a more protected status but still have some harvest value.

The legislature should support and implement recommendations from the DNR 2010-2014 strategic plan Goal III: Preserve Forest Cover and Protect Working Forests and Agriculture Lands from Conversion. The legislature should also support the Washington Wildlife and Recreation Program, which provides funding for projects that reduce fragmentation and conserve farms and forests. At the federal level, Washington State should advocate for increased Land and Water Conservation Fund and Forest Legacy Program funding, which support working forest conservation easements and acquisitions. The state's federal delegation should also work to pass the Community Forestry Conservation Act, a bill that would authorize tax-exempt revenue bonds for working forest conservation. This bill (HR3302, S1501) has support from the Washington Department of Natural Resources, the Washington Forest Protection Association, and numerous local and national conservation groups.

Recommendation E.4: Provide financial and technical assistance to all landowners to assist them in the management of their lands, and in the marketing of the forest products to ensure the landowners remain economically viable in forestry.

Small forest landowners play an important role in sustaining working forests and open space in forested landscapes. Maintaining this land use preserves very low density development in these areas minimizing the fire risks and suppression cost of more dense rural residential development. However, small forest landowners face a unique set of challenges. They are not able to take advantage of the economies of scale of large timber companies and therefore incur higher operating cost. Concerns from the proximity of neighbors are amplified in small parcel landscapes. Resource protection set asides from harvest combined with property lines often creates a complex geometry which takes a larger percentage of land out of production. An economic sized forest ownerships also present the owner with difficult financial choices for subdividing into yet small parcels. Technical and financial assistance can play an important role in implementing landscape-scale conversion avoidance strategies.

The legislature should increase funding to several small forest landowner assistance programs, including: the small forest landowner office at the DNR, the Washington State Conservation Commission and the local conservation districts, and WSU Extension. Managers of these programs should also seek opportunities to partner with NGOs such as WFPA, WFFA, and the Farm Bureau. The legislature should also consider compensation opportunities for the ecosystem services small forest landowners provide the public. These approaches can provide small landowners with more technical assistance, land use options, and resources, which together will reduce conversion pressures.

Recommendation E.5: Coordinate with other groups advancing avoided conversion strategies

Other stakeholder groups in Washington State are working on strategies that involve or relate to avoiding conversion of forestland. The Puget Sound Partnership's Action Agenda Priority A1 is to protect intact ecosystems, and mentions the need to conserve working lands and implement transfer of development rights and other conservation tools. The state's Forest Carbon Offset Workgroup, convened by the Department of Ecology and the Department of Natural Resources, will discuss avoided conversion strategies that

The state should ensure coordination among these various stakeholder groups. Draft recommendations from a given group should be distributed to other groups and leaders from stakeholder various groups should meet or otherwise communicate findings, priorities, and recommendations.

Part F: Trust management

Recommendation F.1: DNR should evaluate the existing management strategies, including ecosystem and habitat plans, for state trust lands and evaluate these strategies in the context of anticipated climate change impacts.

Rationale:

Current research on climate change impacts to the forest environment indicates the potential for alteration in forest landscapes. As indicated elsewhere in this document, the combined climate change impacts on tree growth, regeneration, fire, and insects will fundamentally change the nature of forests. The existing *Policy for Sustainable Forests*, completed in December 2006, acknowledges the potential impact of climate changes and includes the policy that the department "will incorporate cost-effective forest health practices into the management of forested state trust lands to reduce or prevent significant forest resource losses from insects, disease, animals, noxious weeds and other similar threats to trust assets".[12] However, more information on the impacts to forests due to climate change may have become available since the completion of the Policy. Because of this, it is recommended the Board of Natural Resources should pursue an evaluation of the Policy to determine the potential impacts to the long-term management of state trust lands in light of the current understanding of climate change impacts. This recommendation is consistent with the Policy, which states as a policy on implementation and modification, "the department will recommend changes in policy to the Board of Natural Resources due to changes in law, scientific knowledge, new information or other circumstances".[13]

Part G: Prescribed Fire

Recommendation G.1: Increase the capacity, and resources of land managers to increase the use of both wildfire and prescribed fire to promote forest health and sustainability of fire-adapted forest types on all lands.

Recommendation G.2: Convene a multi-stakeholder group (incl. WDOE, WDNR, USFS, and USEPA etc.) to identify current and projected barriers to increasing the extent of prescribed burning in relation to state smoke management guidelines and national ambient air quality standards. Scope of discussions should also include the carbon emissions accounting of prescribed fire as opposed to alternatives such as uncontrolled wildfires.

[12] *Policy for Sustainable Forests*, Washington State Board of Natural Resources, December 2006, p.32
[13] Id, at p.50

Genetic Preservation and Development Recommendations

Part A: Continue current practices useful for adapting to change

Recommendation A.1: In reforestation activities, landowners should maintain species and genetic diversity across their ownerships. This should help buffer against changes. Some landowners may choose to plant different species or seed sources in separate planting blocks, while others may prefer to intermix them. There are tradeoffs associated with the arrangement of diversity, and the best choice will depend upon the circumstances of the landowner.

Recommendation A.2: Washington Department of Natural Resources (WDNR) and other resource agencies in Washington should cooperate with and support existing USDA Forest Service (USFS) efforts to build disease resistance in 5-needle pines and other tree species with serious disease issues. The USFS is the leader in the region for programs of selection, testing and breeding to identify and develop disease resistant trees. WDNR actively cooperates in this work by maintaining a breeding orchard, establishing field trials, and sharing data. Continued support of this work is essential to maintaining these species in our forests.

Recommendation A.3: Washington Department of Natural Resources and other natural resource organizations should continue to be active in breeding, testing & selection programs, such as those operated by the Northwest Tree Improvement Cooperative and the Inland Empire Tree Improvement Cooperative. Cooperative members should ensure that testing incorporates adaptation strategies by incorporating greater geographic diversity into tests and assessing adaptive traits such as cold-hardiness and drought tolerance. The ongoing testing of seed sources across the forest land base provides a reliable source of feedback about which sources are performing best as the climate begins to change. This allows gradual adjustments to seed orchards that should be helpful to keeping forests adapted through moderate levels of change.

Part B. Assess vulnerabilities and prioritize efforts

Recommendation B.1: Create a gene conservation plan that deals with climate change for tree species in Washington, including an inventory of significant gene conservation resources (e.g. seed collections, seed orchards, archive plantings). The gene conservation plan should consider the vulnerabilities of tree species to a wide range of risks, and address the reality that "protected areas" may not be a stable place for the trees currently growing there to exist.

Recommendation B.2: Use models of vegetation changes in Washington under various climate scenarios to help rank species or populations in terms of vulnerability to climate change. At present, there is enough uncertainty with these models that they should be used only to assess the relative vulnerability of various species. As the uncertainty is reduced over time, models must be able to reflect population differences within tree species to be truly useful for making decisions about what species and seed sources are likely to be adapted in the future.

Recommendation B.3: Use GIS map layers showing different types of risk factors in Washington (e.g. fire, insects, disease, land conversion) to help prioritize work. Although this information needs to be developed outside of the forest genetics community, it will be important for prioritizing geographic areas where genetic resources are most at risk.

Recommendation B.4: Conduct a vulnerability assessment for tree species in eastern Washington. The USDA Forest Service has assessed vulnerability of various western Washington tree species to climate change. This kind of work needs to be extended to trees east of the Cascade Mountains. Effects of

climate change are expected to be more pronounced in eastern Washington, so a vulnerability assessment for tree species there is an important foundational step for further planning.

Part C. Begin active adaptation steps, including monitoring to drive decisions

Recommendation C.1: Create a cooperative tree seed bank to provide for recovery from large-scale disturbance, such as fire or insect outbreaks. This may begin with a "virtual" seed bank created with cooperative agreements among landowners who maintain seed inventories and are willing to make that seed available in the event of disturbance. It will also need to include a collection and storage program to cover seed needs not addressed by current seed inventories. The coordination of this effort should reside in a stable institution that already has the infrastructure and knowledge base to conduct this work, and can easily provide seed to landowners who need it. Washington Department of Natural Resources is a good location for this work to be centered.

Recommendation C.2: Forest landowners should implement monitoring programs to detect problems with tree growth, phenology, reproduction, or tree health. These may include monitoring already being done as part of the forest landowner's operational programs (e.g. regeneration surveys), existing inventory programs (e.g. Forest Inventory and Analysis Program in the USDA Forest Service), or could include new monitoring systems. Pilot-scale projects are encouraged to evaluate the usefulness of any new systems.

Recommendation C.3: Washington Department of Natural Resources should modify seed transfer guidelines for Washington to account for the projected effects of climate change. Geographically defined zones should be replaced with climatically defined zones. Seed transfer should be implemented using a framework that: 1) accounts for the uncertainty of climate projections and the uncertainty of resulting effects on forest trees, 2) uses a scientifically-based risk management framework that considers the risk of inaction, and 3) yields information that will allow forest geneticists to improve seed transfer guidelines over time.

Recommendation C.4: Land management agencies should incorporate into their operational planting programs a: 1) wide range of transfer distances to varying degrees, 2) robust system for tracking the seedlots used in operational plantations, and 3) monitoring system for tracking the performance of seedlots in relation to transfer distance.

Water Availability

Part A. Development of Additional Storage

Additional storage will have to be a component of any comprehensive water management strategy. However, it is not likely that "mega projects" will be viewed as favorable in the near future because of their cost and environmental impacts. Therefore, the state should accelerate its current activities devoted to evaluating sites for the development of small and medium size reservoirs that will benefit multiple water users, such as agricultural, environmental, commercial, and recreation (see Appendix One.) There is a current reluctance to commit funds for these types of projects given current budget conditions. However if an investment is not made in a relatively short time, the costs of declining water availability will significantly impact the state's ability to compete economically and will result in detrimental impacts to the environment. Recommendations related to development of additional storage are:

Recommendation A.1: Secure a reliable funding base to develop surface and groundwater storage projects;

Recommendation A.2: Continue to invest in comprehensive water resource planning efforts similar to the Yakima River Basin Enhancement Project Workgroup;

Recommendation A.3: Promote projects that focus on conjunctive use of both surface and groundwater resource storage;

Recommendation A.4: Focus on storage projects that are moderate in size and that provide both economic and environmental benefits; and

Recommendation A.5: Assess potential for modifications of current storage facilities to increase overall storage capacity and enable "capture" of runoff earlier in the season.

Part B: Promote the Enhancement of Water Distribution Systems

There is currently an effort by utilities to improve water distribution systems and reduce water loss due to leakage and/or evaporation. Given the fact that between 20 – 30 percent loss can be expected through leakage of unlined canals or compromised rural/urban deliver system, cutting that loss can contribute significantly to increasing the available water for all competing uses. The issue of cost to enact those improvements will eventually take care of itself due to the ultimate rise in the price of water, but there is merit in implementing those improvements as soon as possible through development of state or federal grants or imposing assessments on users of water from system needing improvements to reduce water loss. Recommendations to promote enhancement of water distribution systems are:

Recommendation B.1: Develop funding mechanisms to enable implementation of improvements to distribution systems, including both urban water supply and rural irrigation supply systems. These may include modifications to current rate structures or state/federal grant or loan programs;

Recommendation B.2: Focus improvements on aging systems where loss is greatest; and

Recommendation B.3: Where improvements result in declining water levels within private wells (previously supplied by system leakage) establish loan programs that allow for deepening of wells if necessary.

Part C: Promote Implementation of On-Farm Conservation and Efficiency Measures
Implementation of these types of measures has proven successful in areas of the state like the Columbia Basin Groundwater Management Area. The initial costs associated with implementation of irrigation water management and/or improved irrigation technologies have been somewhat offset by increased yields and cost share programs supported by state and federal dollars and maybe enhanced by focused tax incentives. Current programs related to climate change/water conservation within the US Department of Agriculture and or US Bureau of Reclamation should be examined as a possible source for cost share funds. Specific recommendations include:

Recommendation C.1: Improve access and delivery of water-efficiency information, voluntary water audit programs, and on-site technical assistance provided through Cooperative Extension, Natural Resources Conservation Service and other agricultural outreach efforts.

Recommendation C.2: Continue to invest in improvements and expansion of online data dissemination systems like AgWeatherNet (AWN) to provide farmers and foresters with immediate meteorological and hydrological information on climate, soil conditions, and crop water requirements. Expansion of network to cover additional forest lands will have added benefit to forest management officials.

Recommendation C.3: Provide tax exemptions or other incentives for the purchase of efficient irrigation equipment to help offset capital investments for these systems.

Part D: Modification of Laws, Regulations and Policies
Modify existing water law to allow market forces to drive the price of water and incentives to distribute and use water more effectively. However, a free market for water favors large, wealthy users, such as residential and municipal users over other, less wealthy users, such as food producers, especially as populations grow. Water markets can be an important tool, but they must be carefully crafted to achieve societal goals and not create an imbalance in the delicate economy of Eastern Washington in particular. To address this issue the concept of Water Salvaging Agreements should be investigated along with other water markets, salvaging agreements, or other "transfer" mechanism changes to current laws, regulations, and policies the following recommendations are made:

Recommendation D.1: Develop and promote healthy water markets within Washington State that provide protection of adequate supplies for agriculture and environmental needs;

Recommendation D.2: Develop new legal mechanisms by which municipal water or state or local wildlife agencies could invest in farmers' irrigation systems in exchange for some portion of the water conserved;

Recommendation D.3: Conduct a comprehensive review of Washington water law in the context of current and future growth and climate change effects and provide recommendations for action.

Part E: Cataloguing the Available Resource
There is currently insufficient data to create an accounting of water supply and demand that would allow creation of a multi-year water budget. There are measures of surface water resources including stream flows and reservoir capacity, but not of the quantity of water available from snowpack. The quantity of water available statewide from other sources, primarily groundwater, is also unknown. Without an inventory of the total water supply, including seasonal availability, it is not possible to formulate a comprehensive strategy for water use and conservation. Nor is it possible to develop strategies for conjunctive use of surface and groundwater that recognize the interconnection of each. Additionally, there is a lack of a consistent and accurate estimate of actual water use by all sectors within the state. The

lack of understanding of the current "usable reservoir" coupled with the inability to accurately account for water use will significantly hamper the ability to manage water in a sustainable manner in the future. In light of these facts it is recommended that:

Recommendation E.1: Washington state embarks on activities designed to determine the total quantity of the available resource; this includes a cataloguing of all known surface and groundwater sources;

Recommendation E.2: Washington state develops accurate methodologies using satellite imagery and other technologies to determine water use in un-metered areas;

Part F: Other Potential Solutions

Within this paper several potential proposals were touched upon that could provide various degrees of relief to the water availability dilemma posed by both population growth and predicted climate change effects. As previously noted in the paper, one potential solution for increasing water availability in forest areas and small agricultural basins is the promotion of habitat for beavers and beaver dams. While this may initially sound farfetched beaver dams are currently providing a year-around solution for forest and agricultural working lands in small portions of the state (coastal cranberry growing areas). While not discussed to a great extent, land use actions can have profound effects as far as water conservation and availability is concerned. State and local restrictions on the conversion of forest and agricultural lands can improve both water quantity and quality and improvement habitat for various species. Partnerships with research institutions, conservation organizations, and governmental agencies should be fostered to develop other unique and possibly promising solutions to the question of further water availability and climate change.

Recommendation F.1: Promote better combined land and water planning on both a state and local level;

Recommendation F.2: Encourage protection of prime agricultural and forest land from urban and suburban development through state and local land use regulations;

Recommendation F.3: Investigate and establish other mechanisms that encourage water-use efficiency to achieve broader social or environmental benefits; and

Recommendation F.4: Encourage the development of projects that merge natural ecosystem occurrences with local water storage and delivery systems

Recommendation F.5: Develop and implement improved forest management techniques that result in a reduction of fire, and an increase of forest diversity to improve water holding capacity in the upper watersheds for the benefit of downstream working lands.

Pest and Disease Recommendations

The development and implementation of a pest and disease tracking system accessible to agriculture and aquaculture is the foundation of an climate adaptation strategy. While these systems currently exist at various levels they are not generally friendly to the forester, farmer, or aquaculturalist. Additionally, there is significant need for improvement in education and information dissemination related to pest and disease occurrence and climate change.

Recommendation 1.
Improve monitoring and identification networks for invasive species entering Washington lands and waters. In 2007 the PAWG recommended supporting the actions of the Invasive Species Council to establish and baseline of invasives funding for that effort appears to be lacking. We would recommend that funding for this activity commence and consideration be given to linking Washington State University in this effort to ensure that improvements in population monitoring of existing commercially relevant species within the state occur.

Recommendation 2.
Refine and support interstate system to track and monitor pest and disease movement. It may be necessary to examine current state and federal tracking activities and evaluate where such activities can be merged or where opportunities exist to compliment activities. The results of these actions must be packaged in such a way that recommends, etc. are easily conveyed to foresters, farmers, and aquaculturalists.

Recommendation 3.
Further develop control technologies for new pests and population expansions of current pests. These activities largely fall to two entities, research institutions and pesticide registrants. It is likely that due to Washington status as a minor crop state more interest will be shown by the state and regional research institutions than private enterprise. This however, may not be the case in the areas of forestry and aquaculture were Washington is a significant market.

Recommendation 4.
Invest resources in control options for emergency situations. As noted previously, there has been a significant move to develop more protective chemical control agents than has previously been utilized. Chemical and biological agents are now developed with targeted species in mind instead of wide spectrum pesticides that potentially impact much more than the species of concern. However, in the case of population's explosions (where climate change raises the risk) there is a potential for the "new" pesticides to be less than effective in controlling an outbreak that could result in economic loss or threats to human health. A forward thinking adaptation strategy should have provisions that allow for limited production of effective yet admittedly environmentally harmful agents. These agents would only be used in the event of real economic or human health emergencies ans under strict state and federal control.

Recommendation 5.
Channel resources into tools that enhance the land owners ability to manage changing pest populations (i.e. WSU's Decision Aid System). This recommendation goes beyond those made in recommendation one in that in addition to tracking pest and disease movement, these resources can provide for tailored alternatives to manage pest populations. Coupled with this recommendation is the need to improve on site delivery of educational materials to land owners and managers related to climate change and pest impacts.

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