ESTIMATES OF THE COSTS AND BENEFITS OF THE RULE TO CERTIFY ALTERNATIVES TO GRASS FIELD BURNING

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Summary and Conclusions

This report summarizes the basic results of Ecology's analysis of the probable costs and probable benefits of the certification rule and explains how those estimates were generated. After considering both the quantifiable and qualitative costs and benefits and the specific directives of the statute being implemented, Ecology has determined that the probable benefits exceed the probable costs.

Summary of Quantified Costs and Benefits

	Low estimate	**High Estimate**
Incremental Benefits	$3.9 million	$9.9 million
Incremental Costs	$4.0 million	$6.0 million

Ecology estimates that the probable economic costs of the proposed certification rule range from **$4.0** million to **$6.0** million. These estimates compare the pre-rule situation (restricted burning on two-thirds of the grass acres in production) with the burning prohibition under the certification rule. Because of the uncertainty about grower responses to the rule, Ecology estimated the probable costs by examining two possible scenarios. In the first or "zero-out" scenario, Ecology assumed that growers would not shift their grass acreage out of production. In the second or "half-out" scenario, Ecology assumed that growers would switch 50 percent (50%) of their grass acreage to an alternative crop. Direct farm level losses comprise the majority of the losses calculated for each scenario. Farm losses may come from reduced yields, increased production costs, or the reduced returns from an alternative crop. Compared to the impact of the previous burning reduction rule, growers may be particularly impacted by the loss of rotational burning as an alternative to mechanical residue management. Besides these direct farm losses, costs include environmental impacts, losses in the seed processing sector, and losses in jobs and income in the rest of the economy. Other costs include the impact of increased grass burning in Idaho and increased wheat burning in Washington State, the emotional costs of lost jobs or business income, the impact on farm worker safety, the costs of administering the program. The potential cost to consumers was considered from a qualitative perspective.

The benefit analysis estimates the value of avoided health costs due to grass smoke. Because of difficulties in estimating the values for some of the health effects, the results are also presented as a range. The lower end of this range is more certain, the higher end is less certain. The range of quantified benefits is **$3.9** million to **$9.9** million. The estimates of quantitative benefits are based entirely on avoided health costs. The estimates do not include any non-health benefits such as reduced nuisance effects, increased visibility, enhanced recreation and tourism, reduced traffic accidents, and the desirability of Spokane as a place to live. Although they were not estimated quantitatively, these qualitative benefits have real value. They often are estimated quantitatively using contingent valuation or other methods.

ESTIMATES OF COSTS

OF THE RULE TO CERTIFY ALTERNATIVES TO GRASS FIELD BURNING

Washington State Department of Ecology
Air Quality Program

MAY 21, 1998

Introduction

The purpose of an economic cost/benefit analysis is to provide a systematic and comprehensive comparison of the positive and negative impacts of a proposed program (e.g., the proposed certification rule). By conducting such a systematic and comprehensive analysis, Ecology can more accurately determine what might be sacrificed to attain the goals of the proposed program. Not only does such an accounting enable Ecology to better ascertain and understand each of the individual impacts of the proposed rule, it also enables Ecology to place those individual benefits and costs into perspective.

This report describes the basic results of Ecology's analysis of the probable costs of the certification rule and explains how those estimates were generated. A series of technical appendices contain the detailed studies that generated the data leading to these cost estimates. To account for the underlying and inherent uncertainty associated with the cost analysis, Ecology generated a range of probable cost estimates instead of a single best estimate.[1] Ecology estimates that the probable costs of the certification rule range from **$4.0** million to **$6.0** million per year. These estimates compare the pre-rule situation (restricted burning on two-thirds of the grass acres in production) with the total burning prohibition under the rule certifying alternatives to grass seed field burning.

The probable economic costs of the proposed certification rule stem from this total prohibition of grass seed field burning. The complete prohibition reduces returns for grass seed growers. Farm losses may come from reduced yields, increased production costs, or the reduced returns from an alternative crop. Besides these direct farm losses, costs include environmental impacts from increases in soil erosion, losses in the seed processing sector, and losses in jobs and income in the rest of the economy. Other costs include the impact of increased grass burning in neighboring Idaho and increased wheat burning in Washington State from shifts in grass production, the emotional costs to those who lose jobs or suffer business losses, the impact on farm worker safety from changes in farm practices, and the costs of administering the program.

Because the total burning prohibition under the proposed certification rule is projected to have a greater economic impact on a per-acre basis than the partial burning reduction under the two-thirds reduction rule, Ecology first calculated the cost of the total burning prohibition and then calculated and subtracted the cost of the two-thirds reduction rule to accurately capture the entire magnitude and range of costs associated with the proposed certification rule. The projected per-acre cost differential is primarily attributable to the availability of the rotational burning alternative under the two-thirds reduction rule which Washington State University (WSU) projected would result in higher yields and lower production costs compared to mechanical residue management. The loss of that

[1] Reflecting this inherent uncertainty, the Administrative Procedure Act calls not for an exact estimate of benefits and costs, but rather for an estimate of probable benefits and probable costs (RCW 34.05.328(1)(c)).

alternative is projected to impact not only growers, but also seed processors and the rest of the economy as the impact of reduced production and spending ripples through the economy. The loss of the rotational burning alternative is also projected to result in slightly higher environmental costs due to the projected shorter rotation lengths and increased mechanical operations associated with mechanical residue management.

Ecology's estimation of costs was primarily based on a previous study commissioned by Ecology and conducted by the Agricultural Economics Department of WSU to estimate the benefits and costs of reductions in grass seed field burning (Appendix A).[2] That study was itself based on two major sub-studies: one estimating changes in farm level costs and returns and environmental costs (Painter, Technical Report B, Appendix A), and the other estimating the impacts that reduced farm production and spending would have on the rest of the economy (Holland and Willis, Technical Report A, Appendix A). To estimate the cost of lost income and labor in both the farm and seed processing sectors, as well as in the rest of the local economy, Ecology used the enterprise budgets and input-output modeling developed by WSU to derive per-acre cost values associated with various industry impacts.[3] Those values were then applied to each of the projected impact scenarios under the proposed certification rule to build total cost estimates for job and income loss.

Since there is uncertainty about the projected impact of the proposed certification rule, Ecology's estimation of probable costs began by examining two possible scenarios for the impact of the rule. Ecology describes these scenarios next. To provide perspective, Ecology also summarizes the two most probable scenarios developed by WSU in its estimates of costs of the two-thirds reduction rule.

[2] Department of Agricultural Economics, Washington State University, *Estimates of the Benefits and Costs from Reductions in Grass Seed Field Burning,* June 1997.

[3] Development of enterprise budgets for both the farm and processing sectors and the input-output model are described in greater detail in WSU's report (Appendix A).

Grass Seed Scenarios and Summary of Results

To capture the range of probable impacts and industry adjustments to the rule certifying alternatives to grass seed field burning, Ecology developed two possible scenarios for study. First, in the **"zero-out"** scenario, Ecology assumes that growers are able to find alternatives to field burning that allow grass seed production to continue to remain competitive. Consequently, growers are projected to not shift their grass acreage out of production in this scenario. Compared to both field burning and rotational burning, mechanical residue management is projected to result in both higher production costs and lower yields. Ecology further assumes in this scenario that processors are able to make up for the small reduction in Washington grass seed production attributable to the projected lower yields. In the second, or **"half-out"** scenario, Ecology assumes that growers switch 50 percent of their grass seed acreage to wheat production while experiencing a reduction in grass seed yield and an increase in production cost in their remaining non-burn grass acreage. Ecology further assumes in this scenario that grass seed processors are able to replace some, but not all, of the lost Washington seed production with increased imports. A more complete description of the assumptions associated with each scenario is presented in the next section.

WSU also identified two scenarios as representing the most likely outcomes of the two-thirds reduction rule and used those scenarios to establish a range of their best estimate of costs. First, in the **"zero-out"** or **"rotational burning"** scenario, growers were assumed to innovatively adapt to the rule change. To represent this innovation, WSU used a scenario of rotational burning. Even though production costs were projected to increase and yields to decrease compared to field burning, production costs were projected to be lower and yields to be higher compared to mechanical residue management. Moreover, because of the availability of rotational burning in this scenario, growers' per-acre net returns are higher than the returns in Ecology's zero-out scenario. WSU further assumed in this scenario that processors would be able to make up for the small reduction in Washington grass seed production attributable to lower yields by increasing imports of seed. In the second or **"half-out"** scenario, WSU assumed that growers would switch 50 percent of their impacted grass seed acreage out of production while experiencing a reduction in grass seed yield and an increase in production cost in their remaining non-burn grass acreage. WSU further assumed that growers would respond to the rule using only current technology and farming practices. Moreover, because WSU assumed that rotational burning would not be utilized in this scenario, growers' per-acre net returns are roughly equivalent to those in Ecology's half-out scenario. WSU further assumed in this scenario that grass seed processors would be able to replace some, but not all, of the lost Washington seed production with increased imports. A more complete description of the assumptions associated with each of WSU's scenarios is presented in the next section and in Appendix A.

Zero-Out Scenario

1. Impact of the Total Prohibition of Grass Seed Field Burning – Assumptions:

Based on the assumption that growers will innovatively adapt to the certification rule, Ecology assumes that growers will find a way in the long run to produce grass seed that allows the crop to remain competitive and to stay in production. Even though growers are prevented from using the innovative practice of rotational burning because of the general burning prohibition, growers may nevertheless develop other innovative farm practices to adjust to the proposed rule. For example, growers in irrigated areas may convert to less aggressive, proprietary seed varieties to both increase yields and reduce production costs.[4] In addition, as growers learn how to properly apply mechanical residue management techniques, Ecology projects that growers will obtain higher yields in the long run than previously projected by WSU.[5] The assumption that growers will not switch grass acres to an alternative crop is further supported by the results of the 1998 Grass Seed Growers Survey (Appendix B). The results of that survey show that while dryland acreage decreased between 1996 and 1997, irrigated acreage actually increased, resulting in a total net increase of 0.4 percent in grass acreage (Appendix C).

Ecology further assumes in this scenario that processors are able to make up for the small reduction in Washington grass seed production attributable to the projected lower yields. Consequently, processing plant production levels remain unaffected.

a. Grower Impact:

- Growers produce approximately 95 percent of the 60,220 grass acres currently in production (94 percent of dryland and 98 percent of irrigated) under mechanical residue management techniques. Compared to field burning, this results in a small reduction in average yields and higher per-acre production costs.
- Growers continue to produce approximately five percent of the 60,220 grass acres currently in production (six percent of dryland and two

[4] Air Quality Program, Washington State Department of Ecology, *Certifying Alternatives to Grass Seed Field Burning: Final Report*, May 1998.

[5] Id. Based on a review of research conducted on grass seed yields (180 cases/studies), Ecology projects that growers will obtain significantly higher yields than originally projected by WSU in its cost analysis. While WSU projected an average yield penalty of 28% compared to field burning, Ecology projects an average yield penalty of 16%. Id. To obtain these comparatively higher yields requires proper use of the mechanical residue management techniques. Because growers may experience comparatively lower yields during a projected adjustment period, Ecology conservatively assumes for the purposes of this cost analysis that growers will incur the 28% yield penalty projected by WSU.

percent of irrigated) using field burning. This assumes that growers obtain waivers after making the required showing.

- Growers shift none of the grass acres currently in production (dryland or irrigated) to a less profitable wheat rotation.

Table 1. Zero-Out Scenario – Projected Grower Adjustments (acres)

	Dryland	%	Irrigated	%	Total	%
BASELINE	39,143	100%	21,077	100%	60,220	100%
Shifting to wheat	0	0%	0	0%	0	0%
Grass [Burn, Waivers]	2,395	6.1%	481	2.3%	2,876	4.8%
• Extreme Conditions	391	1.0%	211	1.0%	602	1.0%
• Slope	2,004	5.1%	470	1.3%	2,274	3.8%
Grass [Non-Burn]	36,748	93.9%	20,956	97.7%	57,344	95.2%

b. Processor Impact:

- In-state processors are able to compensate for reduced production levels by finding additional sources of supply. Therefore, processor economic impact is zero.

2. Impact of the Two-Thirds Reduction Rule – WSU's Assumptions:

Based upon the assumption that growers will innovatively adapt to the rule change, WSU assumed that growers would find a way to produce grass seed that would allow the crop to compete for land, labor, and capital. For its analysis, WSU assumed that growers would adjust to the rule by using rotational burning. Under rotational burning of grass fields, farmers would burn all grass acres, but burn each field only every other year. Non-burn technologies would be employed in the alternate year. Though rotational burning was projected to produce lower yields compared to field burning, it was projected to produce higher yields when compared to mechanical residue management. Furthermore, by using rotational burning, WSU projected that grass acreage could be maintained at pre-rule levels. Because grass production is reduced minimally in this scenario, processors are unaffected.

a. Grower Impact:

- Growers produce 100 percent of the 60,220 grass acres currently in production (both dryland and irrigated) using rotational burning. Rotational burning is used on all grass acres, including exempted acres. Compared to field burning, this results in a small reduction in average yields and higher per-acre production costs. Compared to mechanical residue management, rotational burning results in higher average yields and lower per-acre production costs.

- Growers shift none of the grass acres currently in production (either dryland or irrigated) to a less profitable wheat rotation.

Table 2. Zero-Out Scenario – Projected Grower Adjustments (acres)

	Dryland	%	Irrigated	%	Total	%
BASELINE	39,143	100%	21,077	100%	60,220	100%
Shifting to wheat	0	0%	0	0%	0	0%
Shifting to idle	0	0%	0	0%	0	0%
Grass [Rotational Burn]	39,143	100%	21,077	100%	60,220	100%
• Burn	11,743		7,026			
• Exemption	1,305		0			
• Non-burn	26,095		14,051			

b. Processor Impact:

- In-state processors are able to compensate for reduced production levels by finding additional sources of supply. Therefore, processor economic impact is zero.

3. Impact of the Certification Rule – Summary of Results:

Table 3 shows Ecology's calculation of probable costs under the zero-out scenario. The first column shows Ecology's estimate of the impact of the total prohibition of grass seed field burning. The second column provides a revised estimate of the impact of the two-thirds reduction rule. Both of these estimates of probable costs are relative to a baseline of unrestricted burning on all grass acreage in production. The third column shows Ecology's estimate of the impact of the certification rule. This last estimate of probable costs compares the pre-rule situation (restricted burning on two-thirds of grass acres in production) with the total prohibition of grass seed field burning under the certification rule. In the **zero-out scenario**, Ecology estimates that the probable cost of the certification rule is approximately **$6.0 million**.

As indicated by the results in Table 3, the estimated impact of the certification rule is greater than one-third of the impact of the total prohibition of grass seed field burning and greater than the entire impact of the two-thirds reduction rule. The lack of proportionality between these impacts results primarily from the different assumptions made by WSU and Ecology in their respective zero-out scenarios. WSU assumed that growers would innovatively adapt to the two-thirds reduction in grass seed field burning in the zero-out scenario by using rotational burning. By using rotational burning, WSU projected that growers would obtain higher yields and incur lower production costs compared to mechanical residue management. Even though Ecology also assumed that growers would innovatively adapt to the certification rule, such innovation is not projected to occur in the short-run.

Because the option of rotational burning would no longer be available under certification rule, growers are projected to incur higher costs and to obtain lower net returns on a per-acre basis than under the previous rule. Consequently, the marginal impact of the certification rule is projected to be greater than the impact of the two-thirds reduction rule even though only a third of grass acres are impacted.

Table 3. Zero-Out Scenario – Estimates of Probable Costs ($)

	Impact of the Total Prohibition of Grass Seed Field Burning	**Impact of the 2/3 Reduction Rule**	**Impact of the Certification Rule**
Farm sector			
• Lost income	7,759,225	3,000,000	4,759,225
• Lost employment	-32,669	0	-32,669
Environmental	41,789	0	41,789
Processing sector			
• lost income	0	0	0
• lost employment	0	0	0
Rest of economy			
• lost income	927,187	360,000	567,187
• lost employment	494,500	192,000	302,500
Other costs			
• shifted smoke	0	0	0
• wheat burning	0	0	0
• farm worker safety	123,360	82,240	41,120
• emotional	587,218	228,000	359,218
• administrative	320,000	320,000	0
Total	**10,220,609**	**4,182,240**	**6,038,369**

Half-Out Scenario

1. Impact of the Total Prohibition of Grass Seed Field Burning – Assumptions:

Based on the assumption that growers will not innovatively adapt to the certification rule, Ecology assumes that growers will shift 50 percent of their grass seed acreage to wheat production while experiencing a reduction in grass seed yield and an increase in production costs in their remaining non-burn acreage.

The half-out assumption is supported by grower projections in response to the 1998 Grass Seed Growers Survey. Even though Ecology observed many inconsistencies in grower responses,[6] the consistent responses still indicate that some grass acreage is likely to shift out of production because of the certification rule. Specifically, of those growers that responded, 34 percent stated both that they would shift their acreage out of grass production and that they would not contract to buy new equipment necessary for mechanical residue management (Appendix B). Ecology also considered actual grower projections from both oral and written comments indicating that several growers intended to shift their acreage out of grass production. Combined, this evidence suggests the likelihood of a partial, though not total, shift out of grass production, at least in the short-run.

Ecology further assumes in this scenario that Washington grass seed processors will be able to partially offset a portion of the production decrease resulting from reduced grass seed acreage and/or reduced yields on mechanically managed acres by developing alternative sources of supply from outside the state.

a. Grower Impact:

- Growers produce approximately 45 percent of the 60,220 grass acres currently in production (44 percent of dryland and 48 percent of irrigated) under mechanical residue management. Compared to field burning, this results in a moderate reduction in average yields and higher per-acre production costs.
- Growers produce approximately five percent of the 60,220 grass acres currently in production (six percent of dryland and two percent of irrigated) using field burning. This assumes that growers will be able to obtain waivers after making the required showing.
- Growers shift the remaining 50 percent of grass acres in production (dryland and irrigated) to a less profitable wheat rotation.

[6] Several respondents, for example, answered that they would tear out their grass in response to the certification rule. But some of these same respondents also indicated that they would make a financial investment in equipment necessary for mechanical residue management (Appendix B).

Table 4. Half-Out Scenario – Projected Grower Adjustments (acres)

	Dryland	%	Irrigated	%	Total	%
BASELINE	39,143	100%	21,077	100%	60,220	100%
Shifting to wheat	19,571.5	50%	10,538.5	50%	30,110	50%
Grass [Burn, Waivers]	2,395	6.1%	481	2.3%	2,876	4.8%
• Extreme Conditions	391	1.0%	211	1.0%	602	1.0%
• Slope	2,004	5.1%	470	1.3%	2,274	3.8%
Grass [Non-Burn]	17,176.5	43.9%	10,057.5	47.7%	27,234	45.2%

b. Processor Impact:

- In-state processors are assumed to compensate for 50 percent of the lost grass seed supply in Washington by finding out-of-state suppliers (Oregon and Idaho).

2. Impact of the Two-Thirds Reduction Rule – WSU's Assumptions:

Based upon the assumption that growers would not innovatively adapt to the rule change, WSU assumed that growers would shift 50 percent of their grass seed acreage to wheat production while experiencing a reduction in grass seed yield and an increase in production costs in their remaining non-burn acreage. WSU further assumed that Washington grass seed processors would be able to partially offset a portion of the projected decrease in production resulting from reduced grass acreage and/or reduced yields on mechanically managed acres by developing alternative sources of supply from outside the state.

a. Grower Impact:

- Growers produce approximately 32 percent of the 60,220 grass acres currently in production (32 percent of dryland and 33 percent of irrigated) under mechanical residue management. Compared to field burning, this results in a moderate reduction in average yields and higher per-acre production costs.
- Growers produce approximately 36 percent of the 60,220 grass acres currently in production (37 percent of dryland and 33 percent of irrigated) using field burning. A portion of the dryland acreage burned is exempted acreage.
- Growers shift 32 percent of the 60,220 grass acres currently in production (29 percent of dryland and 33 percent of irrigated) to a less profitable wheat rotation.
- Growers in dryland areas shift 3.2 percent of their acres to idle.

Table 5. Half-Out Scenario – Projected Grower Adjustments (acres)

	Dryland	%	Irrigated	%	Total	%
BASELINE	39,143	100%	21,077	100%	60,220	100%
Shifting to wheat	11,156	28.5%	7,026	33.3%	18,182	30.2%
Shifting to idle	1,240	3.2%			1,240	2.1%
GRASS [Burn]	13,048	33.3%	7,026	33.3%	20,074	33.3%
GRASS [Burn, Exemption]	1,305	3.4%			1,305	2.2%
GRASS [Non-Burn]	12,395	31.7%	7,026	33.3%	19,421	32.3%

b. Processor Impact:

- In-state processors are assumed to compensate for 50 percent of the lost grass seed supply in Washington by finding out-of-state suppliers (Oregon and Idaho).

3. Impact of the Certification Rule – Summary of Results:

Table 6 shows Ecology's calculation of probable costs under the half-out scenario. The first column shows Ecology's estimate of the impact of the total prohibition of grass seed field burning. The second column provides a revised estimate of the impact of the two-thirds reduction rule. Both of these estimates of probable costs are relative to a baseline of unrestricted burning on all grass acreage in production. The third column shows Ecology's estimate of the impact of the certification rule. This last estimate of probable costs compares the pre-rule situation (restricted burning on two-thirds of grass acres in production) with the total prohibition of grass seed field burning under the certification rule. In the **half-out scenario**, Ecology estimates that the probable cost of the certification rule is approximately **$4.0 million**.

As indicated by the results in Table 6, the estimated impact of the certification rule is approximately one-third of the impact of the total prohibition of grass seed field burning and approximately one-half of the impact of the two-thirds reduction rule. Unlike in the zero-out scenario, the impact of the two-thirds reduction rule and the certification rule are roughly proportional because both WSU and Ecology assumed in their respective half-out scenarios that innovative farm practices, such as rotational burning, would not be adopted by growers in the short-run. Consequently, per-acre net returns are roughly equivalent under both rules.

Table 6. Half-Out Scenario – Estimates of Probable Costs ($)

	Impact of the Total Prohibition of Grass Seed Field Burning	Impact of the 2/3 Reduction Rule	Impact of the Certification Rule
Farm sector			
• lost income	7,279,562	4,960,000	2,319,562
• lost employment	242,182	160,000	82,182
Environmental	471,784	270,000	201,784
Processing sector			
• lost income	389,942	252,000	137,942
• lost employment	352,299	225,000	127,299
Rest of economy			
• lost income	1,022,003	690,000	332,003
• lost employment	604,315	408,000	196,315
Other costs			
• shifted smoke	486,000	324,000	162,000
• wheat burning	625,540	413,925	211,615
• farm worker safety	61,680	41,120	20,560
• emotional	681,335	460,000	221,335
• administrative	320,000	320,000	0
Total	**12,536,642**	**8,524,045**	**4,012,597**

General Assumptions and Analysis

The probable economic costs of the proposed certification rule stem from the prohibition of grass seed field burning. The prohibition of grass seed field burning reduces returns for grass seed growers. Farm losses may come from reduced yields, increased production costs, or the reduced returns from an alternative crop. Besides these direct farm losses, costs include environmental impacts from increases in soil erosion, losses in the seed processing sector, and losses in jobs and income in the rest of the economy. Other costs include the impact of increased grass burning in neighboring Idaho and increased wheat burning in Washington State from shifts in grass production, the emotional costs to those who lose jobs or suffer business losses, the impact on farm worker safety from changes in farm practices, and the costs of administering the program.

Direct Farm Costs

Direct farm level losses comprise the majority of the losses calculated for each scenario. Direct farm losses are calculated as reductions in returns to management, capital, and land. WSU's primary method for estimating farm level financial costs was the farm budget approach. As discussed more thoroughly in Appendix A, WSU developed enterprise budgets based upon a history of farm budget research. In particular, WSU relied upon a multi-state research project entitled "Bluegrass Seed Production Without Open Field Burning" conducted by Washington State University, the University of Idaho, and Oregon State University on non-burning methods for producing both dryland and irrigated Kentucky bluegrass (STEEP project #PSES 061-K534). To maintain consistency with and the integrity of WSU's analysis, Ecology utilized the same enterprise budgets developed by WSU.

Direct farm level losses may come from reduced yields, increased production costs, or the reduced returns from an alternative crop. Consequently, actual losses will depend on specific grower adjustments to the certification rule. For those grass acres that remain in grass production under mechanical residue management, growers will obtain lower yields and higher production costs, resulting in lower per-acre net returns. For those grass acres that are switched to an alternative crop, such as wheat, growers may also obtain lower per-acre net returns. Whether wheat production actually results in lower net returns depends, in part, on the relative prices of wheat and grass seed. For the purposes of its study, WSU assumed that wheat production was less profitable than grass seed production using open field burning.

For the enterprise budgets, WSU determined typical yields for both dryland and irrigated acreage using results of three years of on-farm field trials and input from growers. For grass acreage converting to mechanical residue management, WSU calculated that yields would decline by 31 percent in dryland areas and 23 percent in irrigated areas, resulting in an average decline of 28 percent. WSU also determined the price of different types of bluegrass seed. Based on the 1991-1995 average price and the typical differential for proprietary varieties, WSU estimated a price of $0.80 per pound for common and $0.85

for proprietary varieties of bluegrass seed. WSU also estimated that mechanical residue removal would increase per-acre production costs by $70. For a more complete analysis and discussion of these estimates, please refer to Appendix A.

Irrespective of specific grower adjustments to the certification rule, losses in grower income will also depend on the total amount of grass seed acreage affected. WSU estimated that 60,220 acres were in grass seed production in 1996. (See Appendix A.) In February 1998, Ecology, in cooperation with Washington State University – Social and Economic Sciences Research Center, initiated a survey of 194 permitted grass seed growers in Washington State. Results of that survey are included in Appendix B – 1998 Grass Seed Growers Survey. The data indicates that while dryland acreage decreased, irrigated acreage actually increased, resulting in a total net increase in grass acreage of 0.4 percent. A summary of actual industry adjustments occurring between 1996 and 1997 are located in Appendix C – Industry Adjustments (1996-97). Based on the results of that survey, Ecology continues to assume that 60,220 acres remain in grass seed production, despite the internal shift between dryland and irrigated areas.

Projections of future grower adjustments to the certification rule and the resulting impacts of those adjustments are discussed in the previous section. Ecology estimates the farm sector will incur income losses of about $4.8 million in the zero-out scenario (Table 3) and about $2.3 million in the half-out scenario (Table 6).

Farm Sector Job Losses

As discussed by WSU in its report (Appendix A), studies of costs and benefits usually do not count the secondary loss of jobs and the ripple effect of lost income in the rest of the economy. Comments received at hearings and obtained in various surveys, however, indicated that people were quite concerned about the potential economic impact on the local economy of any losses to the grass seed industry. Consequently, WSU proceeded to examine the secondary impacts more closely. To capture these secondary impacts, WSU used a regional economic impact or "input-output" model. Based on renewed public comment and concern regarding the potential impact on the local economy of the proposed certification rule, Ecology used the same regional impact model in its analysis to capture those costs.

Ecology used WSU's input-output model to estimate the potential losses of jobs in the farm sector. Estimates of potential job loss generated by the model are net values. The input-output model calculates not only the number of jobs lost in shifting out of grass production, but also the number of jobs gained by replacing grass production with, for instance, wheat production. The model estimates potential, not actual job losses because the model assumes that all unemployed workers remain permanently unemployed. Actual job loss depends on rates of reemployment. WSU assumed that 50 percent of workers remain permanently unemployed. To maintain consistency with and the integrity of WSU's analysis, Ecology makes that same assumption.

In the zero-out scenario, Ecology estimates a small increase in employment because implementation of mechanical residue management actually increases the number of jobs in the farm sector based on WSU's model. The increase in jobs results in a net economic benefit of $32,669 (Table 3). In the half-out scenario, though, Ecology estimates some net job loss. If about half of these workers are rehired, then the economy will suffer a total loss of about $242,182 (Table 6).

Environmental Costs

The environmental impact of the certification rule depends on two categories of changes. First, grass acreage shifting to wheat production or other annual crops results in a moderate increase in soil erosion, producing both on-site and off-site environmental impacts and costs. The on-site costs of soil erosion are borne by farmers in the form of reduced productivity or soil quality. The off-site costs are borne by the local community in the form of reduced water and air quality. Both farmers and the local community bear the cost of cleaning sediment from ditches. Based upon an extensive review of the available scientific literature, WSU estimated the total cost of these on-site and off-site soil erosion impacts, in both dryland and irrigated acreage, at $15 per acre. (See Appendix A.) To maintain consistency with and the integrity of WSU's analysis, Ecology makes the same assumptions regarding per-acre and per-ton costs of soil erosion.

For dryland acreage, WSU estimated that switching to alternative crops would cause an increase in soil erosion of three tons per acre, including two tons per acre of water erosion and one ton per acre of wind erosion. Based on a review of the scientific literature, WSU estimated the value of water erosion to be $5 per ton, a value on the high end of the established range. More specifically, WSU estimated the cost of off-site impacts to be at least $3.05 per ton and the cost of on-site impacts to be at least $1.50 per ton. Because wind erosion damage had not been quantified in this format, WSU also used the $5 per ton estimate as a proxy for the cost of wind erosion impacts. Thus, for dryland acreage, the total cost of soil erosion, including both on-site and off-site impacts, was estimated to be $15 per acre, including $10 per acre of water erosion and $5 per acre of wind erosion. (See Appendix A.)

For irrigated acreage, WSU estimated that switching to alternative crops would also cause an increase in soil erosion of three tons per acre, primarily from an increase in wind erosion. Because wind erosion rates vary dramatically depending on the crop chosen to replace bluegrass, WSU could not predict with any certainty an average figure for the change in wind erosion. For example, while fields switching to alfalfa may experience no additional wind erosion, fields switching to other crops may experience significant increases in wind erosion. Thus, in the absence of any specific information on wind erosion quantities or values, WSU used the same $15 per acre estimate for environmental damages as was used in the dryland areas. Again, the cost estimate includes both on-site and off-site impacts. (See Appendix A.)

In an attempt to more accurately capture the entire range of environmental impacts associated with a shift to annual crops, Ecology added a specific calculation for the impact of increased tillage operations. An increase in such operations results in increased particulate matter (PM) emissions or "dust." For the half-out scenario, Ecology estimated that an increase in such operations would result in 119.4 tons of soil loss. Valued at $5 per ton, this represents an added cost of $597.

Second, grass acreage converting to mechanical residue management techniques results in a slight increase in soil erosion. The slight increase in erosion is caused by shorter rotations and increased tillage and other mechanical operations on grass fields. Shorter rotations, in particular, result in greater exposure of grass fields to higher erosion rates. The total cost of such soil erosion depends on the number of acres remaining in grass under mechanical residue management. The number of acres remaining in grass production depends on the scenario examined. In the half-out scenario, Ecology estimates that an additional 3,908 tons of soil erosion will occur on those grass acres remaining in production. In the zero-out scenario, Ecology estimates that an additional 8,358 tons of soil erosion will occur on those grass acres remaining in production. Valued at $5 per ton, this results in additional environmental costs of $19,537 to $41,789.

Returning to Table 3, Ecology estimates that implementation of the certification rule will result in only a small increase in environmental impacts under the zero-out scenario because the bluegrass industry keeps the same amount of land in bluegrass. The estimated cost of $41,789 is based entirely on the impact of converting to mechanical residue management. In the half-out scenario, Ecology estimates a somewhat larger environmental impact because growers not only convert to mechanical residue management, but also shift a substantial portion of their grass acreage to wheat production. On a per-acre basis, shifting to wheat production causes a larger environmental impact than conversion to mechanical residue management. These combined environmental impacts in the half-out scenario lead to an environmental damage assessment of $201,784 (Table 6).

Direct Processor Costs

Any loss in grass seed production in Washington State would reduce the supply of raw materials for seed processors. Consequently, the impact of the certification rule on the processing industry depends on whether processors can replace the reduced supply of raw materials from other sources. WSU assumed that seed processors would replace 50 percent of the lost seed supply by finding out-of-state suppliers from Idaho and Oregon (Appendix A). To maintain consistency with and the integrity of WSU's previous analysis, Ecology makes the same assumption.

As discussed by WSU in its report, the impacts to the processing industry would not be counted in a typical cost/benefit analysis. Such analyses generally assume unemployed capital and labor are immediately reemployed. WSU chose not to make that assumption. Instead, WSU proceeded to calculate the potential losses to the processing industry

through the use of enterprise budgets. To estimate the direct impact on the processing industry, WSU conservatively assumed that processors would lose 90 percent of the productivity of their capital. To maintain consistency with and the integrity of WSU's previous analysis, Ecology again makes the same general assumption.

In the zero-out scenario, Ecology estimates that the processing industry will suffer no direct losses because grass production will be maintained at almost the same levels as before the certification rule (Table 3). Based on the assumption that processors can replace only 50 percent of their lost seed supply in the half-out scenario, Ecology estimates that the processing industry will incur income losses of $137,942 (Table 6).

Processing Sector Job Losses

As with the farm sector, job losses in the processing sector would not be included in a typical cost-benefit analysis because such analyses generally assume that all unemployed labor is immediately reemployed elsewhere in the local or regional economy. Instead of making that same assumption, WSU attempted to capture any potential job loss in the processing sector by utilizing an input-output model. To address the public's continued concern regarding the potential economic impact of the proposed certification rule on the local economy, Ecology used the same regional impact model in its analysis. To account for rates of reemployment, WSU assumed that labor in the processing sector is like labor in the farm sector and that 50 percent of the workers who lost their jobs would be reemployed. To maintain consistency with and the integrity of WSU's previous analysis, Ecology makes that same assumption.

In the zero-out scenario, Ecology estimates no job loss because grass production will be maintained at almost the same levels as before the certification rule, enabling processors to maintain current supplies of seed (Table 3). Because processors can replace only half of their lost seed supply in the half-out scenario, Ecology estimates that the processing sector will suffer some job loss. If about half of those workers who lose their jobs are rehired, then the economy will suffer a loss in the half-out scenario of about $127,299 (Table 6).

Costs to the Rest of the Economy

As discussed in WSU's report (Appendix A), the reduced economic activity in both the farm and processing sectors can lead to reduced economic activity elsewhere. Total (potential) impacts of a change in final demand include the "ripple" effects of spending in the economy as well as the direct effect on the target industry.

The "ripple" or secondary economic effects include both "indirect" and "induced" effects. Changes in grass seed production and processor sales will result in changes in what growers and processors will buy from other industries. These are called indirect effects. The reduced income of owners and laborers in the target industry will also result in lower spending in the local consumer markets. These are called induced effects. Both of these

secondary economic impacts may be offset, however, by growth in other parts of the local economy or by increases in the economies of other regions.

To estimate these secondary impacts, WSU conservatively assumed that 60 percent of the capital and 20 percent of the labor released in the general economy because of the lost grass seed production will remain permanently unemployed. Even though these estimates of permanent unemployment are lower than for the target industry, these assumptions are nonetheless conservative because cost-benefit analyses generally assume all unemployed labor and capital is immediately reemployed elsewhere in local or regional economy. Again, to maintain consistency with and the integrity of WSU's previous analysis, Ecology makes the same assumptions.

Based on these assumptions, Ecology estimates that the local economy in the zero-out scenario will suffer a combined impact of $869,687 divided between lost business income and lost jobs (Table 3). In the half-out scenario, Ecology estimates that the local economy will suffer a combined impact of $528,318 divided between lost business income and lost jobs (Table 6).

Other Costs

In addition to the aforementioned costs, Ecology has estimated several other potential costs of the certification rule. One such potential cost is the impact of shifts in grass production to other regions. In particular, Ecology assumes that 50 percent of lost Washington State grass seed production will shift to either Idaho or Oregon, that 50 percent of that production will occur in northern Idaho, and that 100 percent of those Idaho grass seed fields will be burned. Based on these assumptions, Ecology estimates that the benefits obtained by northern Idaho households from reduced smoke from Spokane county growers will be offset by approximately 25 percent. Depending on whether Idaho growers will be able to continue to burn their grass fields, Ecology's estimate may be quite conservative. If Idaho growers were to become subject to more stringent regulations at either the federal or state level, then the health benefits to northern Idaho households would be offset by less than the estimated 25 percent.

Based on Ecology's current set of assumptions, though, it is estimated that northern Idaho households will suffer an increase in health costs of $162,000 in the half-out scenario due to the shifted smoke (Table 6). However, the certification rule still results in a total net reduction in health costs for northern Idaho households because of the total net reduction in grass burning in the region. In the zero-out scenario, Ecology estimates no additional health costs attributable to shifted smoke because the scenario assumes that growers will not shift any of their grass acreage out of production (Table 3).

Another potential cost is the health impact of any shift of grass acreage to wheat production in Washington State. Whether households actually incur additional health costs depends entirely on both the number of acres shifting and the percentage of those acres that are actually burned. Based on available information, including permitted 1997

non-grass acreage, Ecology estimates that of those grass acres shifting to wheat production, only 2.1 percent of the shifted dryland acreage and 8.34 percent of the shifted irrigated acreage will be burned.[7] Based on these estimates, any shift in grass acreage to wheat will cause a reduction in total health benefits of 4.28 percent . Accordingly, in the half-out scenario, Ecology estimates that the health benefits of the certification rule will be offset by an additional $211,615 in health costs (Table 6). In the zero-out scenario, Ecology estimates no additional health costs attributable to additional wheat burning because the scenario assumes that growers will not shift any of their grass acreage to wheat production (Table 3). For a more detailed analysis, please refer to Appendix D – Health Costs of Smoke from Grass Acres Shifting to Wheat.

Another potential cost is the change accident rates for farmers as they change production practices. Farming is a high-risk occupation and changing practices would change accident rates. In this case, farm worker safety may be affected by additional equipment hours and by using equipment on steep slopes. Because the certification rule includes a waiver for steep slopes under certain conditions, this analysis assumes no increase in accidents from steep slopes. But because of the increased use of mechanical residue management, there will be a significant increase in the number of hours that employees use equipment. Based upon available information, Ecology estimates that the conversion to mechanical residue management will result in a 57 percent chance of losing 10 worker days and a 2.6 percent chance of serious injury. In the zero-out scenario, the certification rule yields a cost of $590 for the 57 percent chance of lost worker days and $40,800 for the 2.6 percent chance of serious injury, yielding a total cost of $41,120 (Table 3). In the half-out scenario, growers will utilize mechanical residue management on only half of their grass acres currently in production. Accordingly, Ecology estimates that the cost of the potential change in accident rates in the half-out scenario is half of that estimated for the zero-out scenario, yielding a total cost estimate of $20,560 (Table 6). For a more complete discussion of this issue, please refer to Appendix E – Farm Worker Safety Calculations.

Another potential cost is the lost utility or “pain and suffering” of people who lose a job or suffer business losses. As discussed by WSU in its report (Appendix A), such losses are generally excluded from economic analyses due to the lack of reliable data. Despite lacking such reliable data, though, WSU chose to account for this potential cost by adding a penalty of five percent of income and labor losses. This penalty was also included as part of the “potential” job and income losses to account for emotional losses incurred by even those who, for example, lose a job and then are quickly rehired. To maintain consistency with WSU’s analysis, Ecology includes the same five percent penalty as part of our cost calculations (Tables 3 & 6).

Another cost is for administration of the rule. Ecology estimates that a total of four FTEs (Full Time Equivalent) will be required to administer the certification rule, resulting in a

[7] For more detailed calculations and discussion of these estimates, please refer to the report prepared by Ecology in March 1998 for the proposed certification rule, entitled “Environmental Evaluation of Proposed Certified Alternatives to Grass Seed Field Burning.”

total cost of $320,000, including overhead and associated costs. The Rule Development Plan estimated that three Ecology staff would work full time during the season to administer and enforce the rule, as well as to oversee delegated agencies. Additional staff from the delegated agencies will also work to administer the rule. Based on Ecology's actual experience in implementing the two-thirds reduction rule, Ecology has also adjusted WSU's original estimate of $160,000 upward to $320,000 or four FTEs (Tables 3 & 6).

Another potential cost is the cost to consumers of any long-term increase in the price of Kentucky bluegrass seed caused by a reduction in supply of that seed. Whether prices will actually change in the long run will depend on whether the certification rule causes reductions in grass seed production in Washington State, whether any such reductions in supply are replaced by out-of-state suppliers, and whether substitutes for Kentucky bluegrass exist for consumers. Because Ecology lacks the necessary information to accurately determine the price elasticity of demand for Kentucky bluegrass, Ecology assumed throughout its analysis that prices would remain constant in the long run. The assumption of constant prices throughout the economic analysis was also necessary to maintain consistency with the input-output modeling. (See Appendix A.) Based then on the assumption that prices do not change, there is no cost to consumers. Even if prices were assumed to increase, the net effect of any such increase on the economy is uncertain, because any price increase impacting consumers would be at least partially, if not totally, offset by a revenue increase to growers. For additional discussion of these issues, please refer to Appendix F – Losses to Consumers from Increased Grass Seed Prices.

ESTIMATES OF BENEFITS

OF THE RULE TO CERTIFY ALTERNATIVES TO GRASS FIELD BURNING

Washington State Department of Ecology
Air Quality Program

MAY 21, 1998

Introduction

This report explains how Ecology has estimated the quantitative and qualitative health benefits of the certification of alternatives to grass seed field burning. Wherever it is possible to quantify benefits with a reasonable method Ecology has done so. Ecology used conservative assumptions in several instances in order to avoid overstating the benefits.

The report discusses the nature of the data used to generate the estimates and the relative level of uncertainty for the values assigned to such benefits. The table of benefits lists the estimated values for each category of benefit in approximate order of the degree of certainty, from the most certain to the most uncertain. There are several health endpoints for which values could not be quantified; these are described in a separate section as unquantified health benefits.

Health Benefits

Ecology quantified low benefits of **$3.9** million and high benefits of **$9.9** million. The values that contribute to these totals can be found in Table 2. The table of quantified benefits (Table 2) is separated into two sets of values. Health impacts from mortality and illness requiring hospitalization are quantified based on the estimated spikes for Benton, Asotin and Spokane counties. The remaining values are estimated for exposure in the affected counties outside of the three counties with monitors based on Asotin level exposure or Spokane level exposure. These provide the high (Spokane) and low (Asotin) estimated values. These estimated values have a high level of uncertainty because the actual particulate matter (PM) levels are not known. The use of a range is a reasonable way to approach this uncertainty.

Quantitative health impacts

The benefits can be divided into four categories. The categories are arranged with the best estimates first and the more uncertain estimates last.

1. The first category (Box 1 in Table 1 below and Quantitative Benefits in Table 2) is the health endpoints that were covered in the Abt study.[8] These health endpoints for Spokane, Benton and Asotin are based on modeled PM_{10} daily exposure that was checked against hourly $PM_{2.5}$ data.[9] Only a small part of health effects could be estimated this way due to limitations in Ecology's monitoring data. The health end points considered were mortality and illness that requires hospitalization. The list of effects that could be quantified in this manner is shorter than the list of health

[8] Abt memo [98], see table 8 for the dollar values of the health endpoints.
[9] See Table 3.

endpoints that must be given qualitative consideration. These health endpoints can be estimated based on estimated average daily PM_{10} exposures due to grass seed field burning.

2. The second category (Box 2 in Table 1 and extrapolated benefits in Table 2) is values extrapolated from the values in the Abt study. These are high and low values for possible mortality and hospitalized illness in the remaining exposed population outside of Spokane, Benton and Asotin Counties. The high values are generated by assuming the remaining population is exposed to the same spikes that residents of Spokane County experience. The low values are generated by using the extrapolated PM_{10} spikes for Asotin County. Point estimates were not generated because Ecology does not have average daily PM_{10} data attributable to grass seed field burning for these counties.

3. The third category (Boxes 3 and 4 in Table 1 and approximated values in Table 2) is health endpoints that do not result in hospitalization for which the EPA estimated benefits are based on particulate other than PM_{10}. Ecology does not have the correct total suspended particulates (TSP), $PM_{2.5}$ or other estimates of particulate exposure for these health endpoints. For these health endpoints Ecology assumed that the percentage of the national benefits attributable to these illnesses would be consistent with the percentages for residents here. The extrapolated values were based on the national percentages as a function of the Abt values at the high and low levels of exposure. Point estimates were not estimated because Ecology does not have the appropriate monitoring data to estimate these health endpoints. This kind of extrapolation is subject to greater uncertainty than the first two categories.

4. The final category is values that were not quantified. These included health endpoints in the EPA study that were estimated based on more than one pollutant and impacts that do not relate to health.

Table 1. Which health impacts were quantified?

	Population with modeled exposure	Population with no exposure information
Health impacts that are known given the modeled exposure	1. Spokane, Benton and Asotin Counties	2. Other counties quantified with a high level of uncertainty
Health impacts that are less certain given the modeled exposure	3. All affected counties quantified with a high level of uncertainty	4. All affected counties quantified with a high level of uncertainty

Table 2: Partial estimation of annual health benefits characterized by uncertainty

		Population	% of total value for national PM-10 analysis	Relative value	1996 dollars based on the estimated level of exposure in Spokane	1996 dollars based on extrapolated level of exposure in Benton	1996 dollars based on the extrapolated level of exposure in Asotin
Quantified value for mortality and illness resulting in hospitalization		***553,700***	***60.00%***		***$ 2,947,847***	***$ 115,565***	***$ 1,021***
Extrapolated Value							
Long term mortality impacts due to short-term exposure.		1,230,700			na		na
Health effects outside of the 3 counties considered					4,868,731		35,077
	Affected population considered	553,700					
	Affected Washington population not considered	407,000					
	Affected Idaho population not considered	270,000					
	Percent of affected population not evaluated	55.01%					
Subtotal for effects leading to hospital admission or mortality @					$ 7,933,164		$ 3,099,510
Approximated Values							
Symptoms not leading to hospital admission ^							
	Acute and moderate upper and lower respiratory tract symptoms	1,230,700					
	Acute bronchitis	1,230,700	0.03%		$ 3,995		$ 1,559
	Chronic bronchitis	1,230,700	16.40%		$ 1,890,620		$ 737,967
	Asthma*	1,230,700	na				
	Shortness of breath	1,230,700	0.03%		$ 3,424		$ 1,336
	Work loss days*	1,230,700	na				
	Restricted activity days	1,230,700	0.42%		$ 48,507		$ 18,934
	Mild restricted activity days*	1,230,700	na				
Subtotal for effects not leading to hospitalization or mortality					$ 1,946,546		$ 759,796
Total of estimates that are uncertain					$ 6,815,276		$ 794,873
Total estimated values plus uncertain values @					$ 9,879,709		$ 3,859,306

All values are converted to 1996 dollars						
Total estimated values plus uncertain values @				$ 9,879,709		$ 3,859,306
^The high and low values are calculated using the correct estimated PM-10 exposures for Benton, Asotin and Spokane but extrapolating the highest exposure rate (Spokane) or the lowest exposure rate (Asotin) to the rest of the state						
* The values in the EPA section 818 document were based on more than one pollutant. The value has been left out in order to avoid overestimating impact.						
@ The total estimated values + uncertain values include the estimated values for all 3 of the counties for which estimates are available.						

Population and exposure to PM_{10}

Only 45 percent of the population exposed to grass seed field burning is covered by monitors. Monitors are situated in metropolitan centers to estimate the impact of air quality on human population. The Spokane County Air Pollution Control Authority sets the burn days in Spokane County on days when the wind is expected to take smoke away from the majority of the population. Growers in the rest of the state also try not to burn when the wind will blow their smoke directly into a neighboring city. It appears that these efforts were relatively successful as there were few documented incidences of substantive grass smoke blowing into the cities.

The success of growers in avoiding sending smoke directly into large municipalities means that it is impossible to determine the exposure levels for smaller cities and rural areas. Arguments can be made that by avoiding large municipalities the remaining population is exposed to much higher concentrations of smoke than people who live near monitors. Arguments can also be made that the greatest share of the grass seed acres are in Spokane and therefore other counties will experience less smoke.

Table 3: Estimated change in average daily PM_{10}

Date	Asotin	Benton	Spokane: SCAPCA Adjusted for anomalies
11-Aug-1997	.02	.51	3
18-Aug-1997	.01	.17	1
19-Aug-1997	.05	1.18	7
20-Aug-1997	.01	.17	1
21-Aug-1997	.01	.34	2
28-Aug-1997	.01	.17	1
08-Sep-1997	.08	1.85	11
09-Sep-1997	.02	.51	3
10-Sep-1997	.01	.34	2
16-Sep-1997	.01	.34	2
25-Sep-1997	.04	1.01	6
29-Sep-1997	.03	.67	4
01-Oct-1997	.05	1.18	7
06-Oct-1997	.03	.67	4
07-Oct-1997	.03	.67	4
08-Oct-1997	.04	1.01	6
15-Oct-1997	.01	.34	2
20-Oct-1997	.06	1.35	8

Ecology did not have information from growers on the dates the growers chose to burn their acreage in Asotin and Benton Counties. SCAPCA and Idaho DEQ did have information on burned acreage by day in Spokane and Rathdrum Prairie respectively. In addition there were few monitors outside of large municipalities. Therefore, it was not possible to directly estimate exposure outside of Spokane. Instead the Spokane data was used to estimate exposure in Benton and Asotin Counties. As a result of the unknown level of exposure, Abt did not estimate the health costs of exposure to grass seed field burn smoke for 55 percent of the population that was exposed to smoke from grass field burning.

Long term health impacts due to short-term exposure

The long-term impacts of seasonal exposure to smoke were not quantified. Most of the value in the Abt study is based on acute exposure and the mortality it creates. This may have created a small downward bias in the estimated values.

Models extrapolate a health endpoint based on specific measures of exposure. For example, chronic bronchitis can be triggered by repeated exposure to particulates. Chronic bronchitis affects an individual for years and is sufficiently disabling to carry a high cost. EPA estimated the cost of chronic bronchitis to be $260,000 per case in 1990. However the exposure/incidence relationship that has been examined in the EPA literature review is based on TSP rather than PM_{10}. Ecology did not have appropriate data for the TSP-based model used by Abt for chronic bronchitis. In the EPA evaluation of PM_{10} chronic bronchitis was 16.4 percent of the total cost of particulate exposure. Ecology's high and low extrapolations are based on this 16.4 percent figure.[10]

Unquantified health benefits

Ecology was unable to quantify some health end points. These included:

- Acute and moderate upper and lower respiratory tract symptoms
- Asthma
- Work loss days
- Mild restricted activity days

Results of modeling in counties with monitored PM_{10} values

The Abt results were based on a 100 percent elimination of grass seed field burning. Abt used 1990-dollar values. The quantified values estimated by Abt were reduced five percent to allow for burning on steep slopes and where extreme conditions exist.[11]

[10] See Table 2. [Editors note: The original footnote referenced Table 5. The correct reference is to Table 2.

[11] The losses from shifted smoke due to grass acres being converted to wheat and due to grass acres being shifting to Idaho were calculated and are in assumptions part of the final spreadsheet. The cost team calculated the losses from shifted smoke in Idaho separately and the early estimates, derived from adjustments to the 1996 CVM analysis, were larger than the shifted smoke losses based purely on health

Ecology indexed the values to 1996 dollars so that they are comparable to the dollar estimates in the cost analysis.[12] For example, the Abt results for Spokane were $2,491,338. After indexing and reducing the values five percent, the estimate is $2,947,847. The total adjusted benefit for the three counties (adding the top line in table 2) is $3,064,433.

Table 4:
Monetized benefits for a 100% elimination of grass seed field burning in 1990 values

Health Endpoint	Spokane County	Benton County	Asotin County
Premature mortality	$2,491,338	$97,613	$862
Hospital admission for "all respiratory illness"	$3,239	$154	$1
Hospital admission for ischemic heart disease	$2,075	$98	$1
Hospital admission for congestive heart failure	$1,508	$71	$1
Total	$2,498,159	$97,936	$862

Qualitative Benefits

The quantified benefits include only avoided health costs. There are other benefits to reduced smoke in the air. These include the improved visibility, enhanced appeal for tourism industries, enhanced recreational experiences, reduced nuisances, reduced possibility of traffic accidents from obscured vision, enhanced livability and attractiveness of Spokane and other cities. Ecology has previously used contingent value surveys to capture these kinds of values, but that was not done for this rule. Consequently, the quantified benefits do not account for the full range of benefits.

Economists have used two methods to measure these kinds of benefits. One is the hedonic modeling method and the other is contingent valuation. These measures would include both health and these other kinds of benefits. Such studies have shown that people demand higher wages to work in places with high levels of PM. Despite the higher wages, they are also not willing to pay as much for housing in places with high levels of PM.

Bibliography for Health Benefits

The Benefits and Costs of the Clean Air Act: 1970 to 1990, EPA 410-R-97-002, October 1997, can be obtained electronically at: www.epa.gov/airprogram/oar/sect812/index.html.

effects. In order to avoid biasing the losses downward the shifted smoke was therefore counted as a quantified cost. The quantified offset to the benefits due to shifting grass acreage into wheat is also handled as a cost since it is a negative benefit.

[12] The cost analysis evaluated a 100% cut from the initial 1995 burn levels and subtracted out the 2/3rds reduction in burning from the 1996 rule. In order to be consistent across studies all values were converted to 1996 dollars.

Abt Associates Inc. Memo, “Monetized Benefit of PM-10 Burning Reductions Estimated to Result from Reductions in Grass Seed Field Burning in Spokane County, Benton County, and Asotin County” May 19, 1998.