The Impact of Environmental Costs on a Cost-Benefit Analysis of a Crop Rotation Decision Between Field Burning and Chemical Methods of Field Sanitization

by

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Because field burning is increasingly restricted by the Oregon Legislature, local grass seed farmers are turning to alternative practices. These are performed in order to sanitize fields from disease and pests, to remove the harvest's residue (straw and stubble), and to encourage regrowth, while avoiding field burning. One such practice is increased pesticide use. This paper attempts to determine if growing crops requiring increased pesticide use, as compared to growing crops requiring field burning, is cost-effective when all costs including environmental impacts are included. In particular the analysis provides an example of decision making within a context of visible and less visible environmental costs.

The study finds that growing crops requiring chemical methods of field sanitization are more cost-effective than crops requiring field burning. Perennial

ryegrass--a crop treated with pesticides--has operating income before taxes of $213.24 per acre in production years. The next best alternative, fine fescue grass seed--a crop that is both burned and treated with pesticides--has operating income before taxes of $68.13 per acre in production years.

The pollution cost data suggests that visible forms of pollution are costlier than less visible forms; crops using field burning have the highest environmental cost, $33.20 per acre. Legislation, then, is correctly limiting the practice with the most impact. The tradeoff to avoid field burning is only an increase in pesticide applications of 0.03 pounds of active ingredient per acre. So, not only does the more visible field burning impose a $12.01 per acre impact on the health of citizens of the Willamette Valley, but farmers must also apply the less visible pesticides to their fine fescue fields to control weeds and disease, at a cost of $21.19 per acre.

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I. INTRODUCTION

This study compares the cost effectiveness of field burning to chemical methods of field sanitization. The paper examines the impact of environmental costs on a cost-benefit analysis of a crop rotation decision for an agricultural firm. In particular the analysis provides an example of decision making within a context of visible and less visible environmental costs.

Farmers across the Willamette Valley have long since used the practice of field burning as a means to lower the costs of field sanitation, fertilization and tillage. But state and federal regulations have increasingly limited the acreage they can burn (Statesman Journal, 29 July 1997). Growers have been forced to find other techniques to sanitize their fields from disease and pests, to remove the harvest's residue (straw and stubble), and to encourage regrowth.

As field burning is phased out, farmers have turned to using additional pesticides, in the hopes of attracting less public attention and criticism. However it is not clear whether these practices are less harmful to the environment than field burning, or just less visible. As legislation influences the increased use of pesticides, what is the impact of the resulting behavior on farmers, society, and the environment? If environmental costs are factored in, what becomes the most cost-effective means of sanitizing a field, removing the residue and encouraging regrowth for the next year's harvest?

This study takes data from four main sources. Revenues and expenses borne by the farmer are taken largely from Enterprise Budgets, produced by the

Oregon State University Extension Service. Specific figures on pesticide usage and cost were obtained from Paul Camuso, a field specialist for a local farmers cooperative. An Oregon Department of Environmental Quality study is the source of the field burning pollution cost estimate, which was determined by valuing the amount of airborne, particulate emissions from field burning. Finally, the pesticide pollution cost data was adapted from research by Pimentel et al. In his study, Pimentel valued the pesticide pollution effects on humans, domestic animals, bees, aquatic life, crops, groundwater, fish and wildlife, microorganisms and invertebrates and the government.

Yet in taking data from these sources, there are limitations. Both pollution estimates fail to account for all of the impacts attributable to the respective pollution. The field burning estimate only looks at human health effects, omitting any valuation of the effect on the environment--i. e. fish and wildlife. The pesticide pollution estimate does include the pesticide pollution effects on humans, domestic animals, bees, aquatic life, crops, groundwater, fish and wildlife, microorganisms and invertebrates and the government, but does not consider suspected long-term effects, such as male fertility or reproductive problems. Failing to include these impacts understates the pollution estimate for both sources.

Using these best estimates, though, the study finds that growing crops requiring chemical methods of field sanitization are more cost-effective than crops requiring field burning. Perennial ryegrass--a crop treated with only pesticides--has operating income before taxes of $213.24 per acre in production years. The next best alternative, fine fescue grass seed--a crop that is both burned and treated with pesticides--has operating income before taxes of $68.13 per acre in production years. Because farmers still have to apply some pesticides on crops that are burned after harvest, to fully control weeds and disease, there is added expense in pollution costs as well as chemical and application costs for those crops that are burned. Additionally, when farmers grow crops that do not have to be burned, they have to apply only marginally more pesticides. The amount of pesticides applied to a fine fescue field is not very much less than what is applied to perennial ryegrass fields in production years (4.03 versus 4.06 lbs. per acre).

The pollution cost data suggests that visible forms of pollution are costlier than less visible forms. Crops using field burning have the highest environmental cost, $33.20 per acre. Legislation, then, is correctly limiting the practice with the most environmental impact.

It was originally assumed that there was a tradeoff not to practice field burning. But the tradeoff to avoid field burning is only an increase in pesticide applications of 0.03 pounds of active ingredient per acre. So, not only does the more visible field burning impose a $12.01 per acre impact on the health of citizens of the Willamette Valley, but it does not sanitize the field absolutely. Farmers must also apply a relatively large amount of the less visible pesticides to their fine fescue fields to control weeds and disease, which creates a pesticide pollution cost of $21.19 per acre. This means that fine fescue fields are creating pollution in at least two ways--from field burning and from pesticide usage.

But there is some advantage in the establishment years for fine fescue. Only 2.70 pounds of pesticide active ingredient are applied per acre, as compared to 6.13

pounds for perennial ryegrass; perennial ryegrass has about 3.4 more pounds of active ingredient applied per acre than fine fescue. This high application rate for perennial ryegrass establishment results in the highest estimated pesticide pollution cost, $32.24 per acre.

Crops that are treated only with pesticides had pollution estimates, ranging from $11.78 to $21.36 per acre in production years. It should be noted that meadowfoam had a low estimated environmental impact from pesticide use, $11.78 per acre, but this was not because of lesser impact relative to usage, but rather limited applications arising from a lack of pesticides labelled for use on meadowfoam.

The decision to practice field burning or use an additional amount of pesticides is currently very important for a farmer. After enduring public scrutiny over the past three decades for field burning, farmers are now being targeted for their pesticide application practices as well. New research, such as the Willamette River Basin Water Quality Study, and increased media attention, like the NBC documentary and public debate "The Willamette River: Currents of Change", are focusing attention on agricultural pollution from pesticides. Just as public opinion demanded more laws regulating field burning in the 1970s and 1980s, it appears that a movement is growing to further restrict pesticide usage. Thus, farmers need to show themselves as wise and prudent in their farming decisions and practices, in order to demonstrate to the public that they are aware of the concern and acting responsibly.

The study is organized as follows. Section two provides background information on the grass seed industry in Oregon and in section three the specific crops to be studied are discussed. Following that, a literature review examines the influential research and past studies upon which this study is based. Section five is the identification of likely costs and benefits in growing the three crops. Section six is the collection of the specific cost and revenue data to be used. The cost-benefit analysis follows in section seven. Section eight deals with suggestions for the future. Finally, based on the analysis, conclusions are made in section nine.

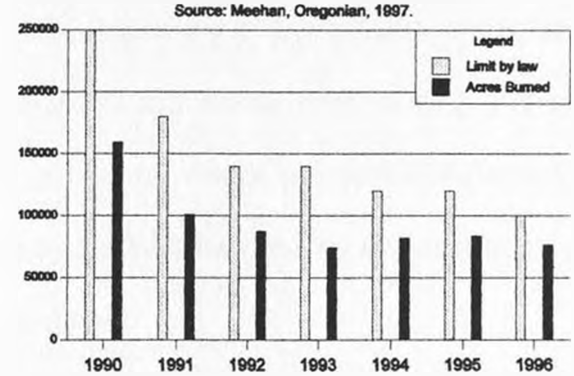
II. BACKGROUND

Grass seed in Oregon is a major cash crop. Ranked only behind nursery products, grass seed crops were the number two agricultural commodity produced in Oregon. Grass seed farmers produced crops valued at $316 million in 1996, up $80 million since 1995 (Gravelle B6). Oregon grows a half-dozen major varieties and dozens of minor ones. Leading the world in grass seed production, Oregon grass seed has seven percent more pure live seed than that produced in other climates (Oregon Seed Council 1). Grass seed farmers have used Oregon's mild, temperate climate as a competitive advantage. As Meehan writes, "wet, mild winters and warm, dry summers make the Willamette Valley the world's best ground for grass seed" (Meehan A1).

But as field burning is increasingly restricted, this competitive advantage has lessened. State regulations in Oregon have set ceilings on the amount of acres that can be burned each year. The Oregon Department of Environmental Quality controls the burning and prioritizes burns based on several factors, such as the slope of the ground.

Field Burning Phase-Down

Source: Meehan, Oregonian, 1997.



Grass seed is produced in other states and foreign countries, such as England, Denmark, Holland, Poland, New Zealand, Argentina, and Chile, where field burning is practiced without restriction. This makes the postharvest operations very important to the Oregon grass seed farmer, because they directly affect both the purity and quality of the crop.

III. STRUCTURE OF THE STUDY

There is no individual crop which farmers choose to either burn or treat with pesticides. Growers will almost always perform the "ideal" postharvest operation for each crop, and the ideal postharvest operation varies for each crop. Therefore, in order to compare field burning versus pesticide usage, three representative crops were chosen that are either burned or treated with pesticides.

My study is structured as a rotation decision for a farmer in the Silverton Hills area of the Willamette Valley. This farm will be assumed to be 1500 acres in size, with annual sales of approximately $1 to $2 million. In addition, this farm is moderately diversified, primarily growing grass seed and some row crops, such as corn and green beans. I will investigate three crops that this farmer might choose to grow.

The farming of these three crops differs primarily in the farmer's operations after the harvest. These postharvest operations can include field burning, baling, propaning, flailing and the application of pesticides. These are performed to remove the straw and stubble from the field, sanitize the field from pests, and promote regrowth for the next year. The three crops are:

1) <u>Fine fescue grass seed</u>. Fine fescue is a variety of grass seed that has been found to only be grown effectively through the practice of field burning (Gringrich, Personal Communications). Otherwise harvests are characterized by both low quality and low yield. In addition to field burning, some herbicides and fungicides are used to control both

grassy and broadleaf weeds.

2) Perennial ryegrass seed. Perennial ryegrass is another variety of grass seed, that, unlike fine fescue, produces well without the practice of field burning. After harvest, the straw is custom baled, the stubble flail chopped, and an increased amount of herbicides and fungicides are applied (Gringrich, Personal Communications).

3) Meadowfoam seed. Desirable for its biodegradable seed oil that is used in "natural" cosmetics, meadowfoam is a well-suited rotation crop for a grass seed farmer. It grows on similar land, has a similar cost of production and an earlier harvest than grass seed, allowing farmers to stagger the harvests. Most importantly, farmers can grow meadowfoam for a year between two stands of grass and use herbicides to kill grassy weeds, rather than field burning. The meadowfoam plant is a broadleaf, so farmers can use herbicides that target grassy weeds, particularly annual bluegrass--one of the problem weeds for grass seed farmers. Then, after the harvest of meadowfoam, the farmer can plant back to grass in a "sanitized" field, free of annual bluegrass (Liess E2).

In looking at these three crops, I will look at the "farmer's" costs and revenues, as well as some factor for the environmental costs related to the farming practices for each crop.

One limitation of the study is the different end uses for the three crops. Meadowfoam seed's extracted oil is used in "natural" cosmetics, while both grass crops' seed is used in private lawns, playing fields, parks and golf courses. These different uses would influence the comparison if relative demand for each product were to change, affecting the relative prices of the products. The comparisons in this study are based upon the prices as of March 1998.

Another limitation of the study is that the relevant revenues used in the comparison are computed with prices based on current levels of supply and demand. Of course, if this comparison finds one crop to have much higher profits, this may increase relative supply for this product, thereby lowering the relative price for this product.

IV. LITERATURE REVIEW

Previous research can be grouped into four categories. First, some authors have done similar studies, that examine, for instance, the different alternatives to field burning. The second group is scientific analyses that look at the effects of field burning and pesticide application. Thirdly, some studies have attempted to rank pesticide pollution based on environmental impact. Finally, there is the literature that estimates costs for farmers and for the environment to grow the three crops. This is the source of most of the data for the study's cost-benefit analysis.

Similar Studies

A similar study that examines the alternatives to field burning is Farmer Alternatives to Field Burning: An Economic Appraisal by Frank S. Conklin (1971). The postharvest procedures have been studied extensively, in the hopes of finding a more environmentally friendly, less visible alternative to field burning, that is still similar in cost. Conklin discusses all of the feasible alternatives within the main approaches: alternative land use, soil incorporation of residues, mobile field sanitization, and mechanical residue removal followed by field sanitation. For each, the farmer's cost per acre is determined. Conklin (1971) found that the most feasible and attractive alternative to field burning may be mechanical residue removal, if an active market could be found for the grass residue. Not included are a discussion of the differences in yields, environmental costs related to each practice, or a scientific evaluation of the alternatives. Conklin (1971) provides a pattern on which I can similarly structure my study. I can extend this previous study by looking at the relative differences in yields and environmental costs for the alternatives.

Scientific Analyses on Field Burning and Pesticide Usage

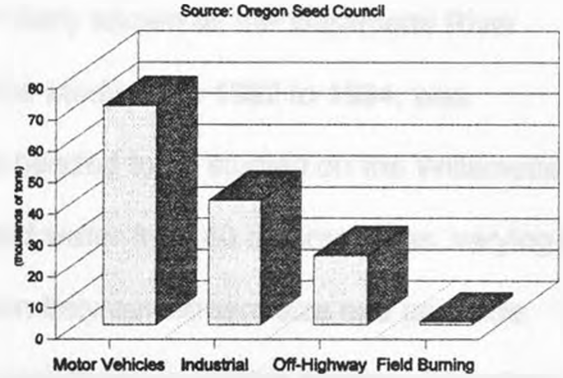
Scientific analysis of field burning has been done in "Agricultural Field Burning in the Willamette Valley", which looks at field burning and its impact on the environment. First, the "post-harvest burning of straw and stubble is important for the control" of a number of diseases of perennial grass seed crops (OSU 3). This is accomplished by the intense heat of the fire. In addition, field burning removes the residues (straw and stubble left after harvest) effectively and inexpensively, destroys weeds and weed seeds, lowers the cost of nitrogen fertilization "by eliminating residues that would otherwise require nitrogen in their decomposition", and finally maintains yields as "thinning" is provided (OSU 4). Unfortunately, field burning has little effect on some types of pests, such as cut worms; is harmful to wildlife, including the destruction of habitat; pollutes the air; and destroys residues that could be incorporated back into the soil, generally considered beneficial as long as the volume of material is not too large.

With the practice of field burning, it is assumed that approximately 3,000 to 5,000 pounds of residue are burned per acre, depending on seed variety (OSU 6). Much of this material returns to the field, but according to the Air Resources Center at OSU, "on the basis of controlled burning tests, indications are that carbon particulate (larger soot particles and smaller suspended material) emissions from grass seed...are in the 10- to 20-pound range per ton of material burned" (OSU 7). This means that carbon emissions can be anywhere between 25 and 70 pounds per acre burned. Emissions are also affected by other factors besides the seed variety: higher moisture content of the straw, the presence of green regrowth, and weather conditions.

In Grass Seed...The Tiny Giant, the Oregon Seed Council (OSC) estimates these field burning emissions, relative to other smoke sources. Completed in 1973 when field burning was much more prevalent than today, the study found that compared to other sources, such as motor vehicles and industrial fuel combustion, field burning did not produce a high percentage of nitrogen oxides, sulfur oxides or particulate. In fact, field burning produced none of the approximately 57,000 tons of sulfur oxide emissions in Oregon in 1973 (OSC 3). Of the nitrogen oxides, field burning accounted for roughly 0.7% of the 148,000 tons of emissions (OSC 3). Finally, only 5.6% of the 150,000 tons of particulate emissions are attributed to field burning. Yet, the OSC's source, the Department of Environmental Quality, suggests that this residue figure is actually much lower, because "most

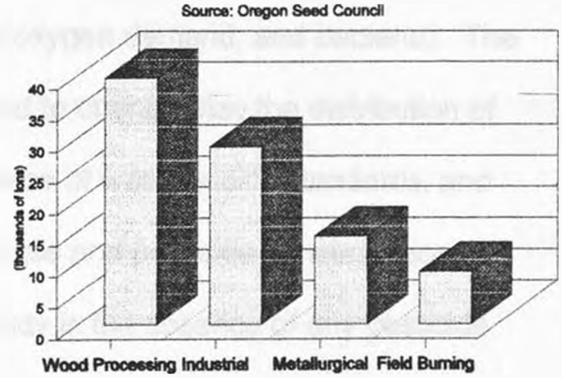
Nitrogen Oxides Emissions, 1973

Source: Oregon Seed Council



Particulates Emissions, 1973

Source: Oregon Seed Council



particulate fall back onto fields" (OSC 4). These scientific analyses show that the effects of field burning have been extensively studied, in comparison with the impacts of pesticide usage.

The environmental impact of pesticides, though, have been scientifically examined in a U. S. Geological Survey, familiarly known as the Willamette River Basin Water Quality Study. Phase one of the study, from 1992 to 1994, was reconnaissance, to find where water quality needed to be studied on the Willamette River Basin. Phase two of the study sampled water from 40 different sites, varying in size. The USGS found a negative correlation between stream size and pesticide levels; higher concentrations of pesticides were found in smaller streams (Haasinein, Personal Communications). So, in phase three, 20 small streams were examined. All drained between 2.6 and 15 square miles, were on the valley floor and had little or no forested upland (Anderson et al. 17). These small streams, with diverse subbasins, were mapped, and sampled about 5 times over the course of 1996. The samples were tested using enzyme immunoassays for 86 dissolved pesticides, as well as testing conventional constituents (temperature, dissolved oxygen, pH, specific conductance, nutrients, biochemical oxygen demand, and bacteria). The primary author, Chauncey Anderson, intended to characterize the distribution of dissolved pesticides, document the exceedence of water quality standards, and study the correlation between subbasin land use and pesticide concentration.

The first finding from the Anderson study is the absence of any pesticide usage reporting requirements in the state of Oregon. It is interesting to note that a state such as Oregon, that is perceived as environmentally conscious, does not have actual data on the amount of pesticides being used. Therefore, Anderson et al. had to rely on estimates prepared for previous years by Oregon State University, which were then reviewed by extension agents, who have "first-hand knowledge of practices not accurately reflected in the published literature" (Anderson et al. 18). Yet, ultimately, the authors were not sure if the estimates closely approximated actual usage.

In the results of the Anderson study, five compounds were found to be "frequently" detected, including atrazine (99% of samples), desethylatrazine (93%), simazine (85%), metolachlor (85%), and diuron (73%) (Anderson et al. 59). The high occurrence of atrazine detection was especially surprising to the authors, contradicting its estimated decline in usage since becoming a "restricted-use" pesticide, able to be purchased and used only by licensed applicators. What the authors found out was that many farmers were either licensed applicators or contracted out their spraying operations to a licensed applicator. This resulted in a large disparity between estimated and actual usage. As Anderson writes, "frequent detections of atrazine at well over 1 ug/L (microgram per Liter) suggest that its use remains common despite current restrictions on its sale" (Anderson et al. 61).

In correlating pesticide concentration levels to land use, Anderson et al. found that the results differed between diverse and nondiverse subbasins. There was higher correlation for pesticides applied to a wide variety of crops, than for pesticides applied to a dominant crop type (such as grass seed). The correlations for pesticides applied to a dominant crop type, still "significant ($p<0.05$), however, were weak, with correlation coefficients in the range of 0.2 to 0.3" (Anderson et al. 61).

For these subbasins, correlations between concentrations and the percentage of the basin planted in agricultural or grass seed crops were higher than the correlations between concentrations and estimated application rates. This was explained by errors in estimating the application rates and actual usage for the agricultural crops.

Because land use and pesticide concentration levels in the Willamette are correlated, this suggests that applied pesticides are ultimately finding their way into the Willamette. This may have serious consequences as more and more cities, like Wilsonville, Oregon, consider the Willamette as a source of drinking water (Haasinein, Personal Communications).

Only one pesticide (chlorpyrifos) was found to exceed the State of Oregon or U.S. Environmental Protection Agency aquatic-life criteria, in three of the five samples, in which it was detected. The study notes that only 4 other pesticides have established State or Federal criteria(Anderson et al. 59). This means that the 81 other pesticides that were examined do not have criteria; "no one really knows the short-or long-term effects" of these chemicals (Haasinein, Personal Communications). These data gaps demonstrate the need for more research.

Pesticide Impact Assessment Systems

Several studies have ranked the various pesticides against each other, based on their chemical characteristics and toxicities. Lois Levitan, a professor at Cornell University, summarized and compared the various assessment systems in her paper, An Overview of Pesticide Impact Assessment Systems based on Indexing or Ranking Pesticides by Environmental Impact. There are three major fields to environmental impact assessment (EIA):

1) Decision Aids for Farmers, Farm Advisors and Other Land Managers in choosing among pest control options and evaluating the impacts of their choices
2) Policy Tools generated and used in government, industry and academia
3) "Ecolabeling" systems (also called "green labels") designed to influence consumer opinion and market behavior

These fields of EIA differ based on their target audiences and intended uses, as well as the unit of analysis, economic dimension, factors considered, format of results and method of calculation (Levitan 11). Levitan presents current assessment systems and shows their shortcomings to suggest that, in the future, "a new generation of assessment models will be able to paint a more holistic picture of environmental impacts" (Levitan 73).

One of the ranking systems, presented by Levitan, is the Environmental Impact Quotient (EIQ), developed by Kovach et al. In A Method to Measure the Environmental Impact of Pesticides, Kovach et al. demonstrates the EIQ and its formation as a farmer decision tool. The EIQ looks at the various characteristics of each pesticide, such as the associated toxicity, water solubility, and soil half-life, to show how each pesticide is chemically different. The EIQ uses these characteristics to rank pesticides in three components: farmworker, consumer and ecological. For each component, the chance of exposure is determined and multiplied by the associated risk or toxicity of exposure. The score for each of the three components is combined into an initial EIQ value. These EIQ values then are multiplied by the percent of active ingredient and rate of application to arrive at a final EIQ value that incorporates usage information. In this way, "comparisons of environmental impact between pesticides and different pest management programs can be made" (Kovach et al. 6). Thus, when different pesticides are used on two types of grass seed, one can determine which practice has more or less environmental impact.

One criticism of the EIQ is that pesticides are scored on a scale of 1 to 5, with 1 signifying a benign effect. Opponents suggest a more accurate scale would be 0 to 4, so that characteristics with no adverse environmental effect receive a 0 score. Another criticism is that the relative weightings of the farmworker, consumer and ecological components are subjective, and not based on empirical evidence. Finally, the EIQ does not take into account the manufacture or distribution of these chemicals.

Research on Costs and Benefits to Grow the Three Crops

Costs have been estimated for farmers and for the environment to grow the three crops. "Farmer's" costs have been analyzed closely in the last 20 years. Costs borne by the farmer in growing these crops have been estimated in the "Enterprise Budgets," put out by the Oregon State University Extension Office. Many of these estimates are used later in the cost-benefit analysis. These expenses include the cost for normal farming activities including stand establishment; preharvest operations, such as fertilization; harvesting operations, such as combining; and postharvest operations, such as field burning or baling.

In 1987, the Oregon Department of Environmental Quality used scientific analysis to estimate the health costs from the emissions of field burning. The DEQ quantified the presence of smoke intrusions in Western Oregon by using a nephelometer, a device that measures the intensity of light scattered from an illuminated volume of air in a blackened chamber. These nephelometers were placed around the state and operated continuously throughout the year. The DEQ attributed the emissions, by time of year, location, and meteorological conditions, to either residential wood combustion, slash burning or field burning. The smoke exposure data for field burning was then multiplied by risk factors, developed by the EPA, to come up with the number of lost work days, reduced activity days, and deaths from field burning smoke. These were valued and added to arrive at the annual costs of health effects generated by field burning. This is the only attempt to monetarily value field burning pollution, and the environmental impact estimate, $12.01 per acre, is used in the study.

The only effort to value such pesticide pollution is from David Pimentel, a professor at Cornell University's New York State College of Agriculture and Life Sciences. In "Environmental and Economic Costs of Pesticide Use", Pimentel et al. identifies the major subgroups impacted by pesticide use and comes up with a monetary cost for each. For the human health impact, Pimentel determines and then values the hospitalization, treatment, lost work and fatalities due to pesticide poisonings and related illnesses to arrive at a cost of $787 million for pesticide use in the U.S. (Pimentel et al. 752). According to Pimentel, costs for some other subgroups, such as the destruction of beneficial natural predators and parasites and pesticide resistance in pests, are absorbed by the farmer or applicator, in the form of increased pesticide usage. Pimentel then looks at other subgroups, such as domestic animals, bees, crops, groundwater, fish, birds, microorganisms and invertebrates, and government regulations cost to arrive at a total annual U.S. pesticide usage cost of $8 billion dollars, although $3 billion of that is absorbed by applicators as previously mentioned (Pimentel et al. 757). Thus, $5 billion of pesticide usage costs in the U.S. are imposed on society and environment. With approximately 500,000 tons of pesticides used in the U.S. annually, this means that every ton of pesticide applied inflicts an average $10,000 in external costs, or about $5 per pound, as stated in the analysis.

Yet Pimentel's work is not exact enough to allocate environmental costs to specific pesticides. He does not state whether the 500,000 tons of pesticides applied annually in the U.S. are the amount of active ingredient applied or if the 500,000 tons includes the weight of inerts. Pimentel also only specifies that 600 different types of pesticides were used annually (Pimentel et al. 750). As Kovach et al. and the EIQ demonstrate, all pesticides and their impacts are not alike, and consequently, their environmental costs would differ.

Summary of the Literature Review

In summary, previous research on field burning demonstrates that field burning is considered an inexpensive and effective means to sanitize fields from disease and pests, to remove the harvest's residue, and to encourage regrowth. But field burning is an identified pollutant that is releasing soot into the air and damaging the health of citizens in the Willamette Valley. Other damage from field burning includes loss of visibility, soiling of property, and destruction of habitat for fish and wildlife. Smoke from field burning has also been a factor in some major traffic accidents.

The previous literature on pesticides has shown that pesticides are an effective means to sanitize a field from disease and pests, but residue removal must also be performed. The previous literature also reflects the growing concern about the effects of pesticide usage. Many impacts, such as reproductive and male fertility problems, can only be suspected to be linked with pesticide use, although known deleterious effects of pesticide usage include the impact on human health--primarily the incidence of cancer, domestic and wild animal deaths, and groundwater contamination.

Only Conklin (1971) explicitly considers the "farmer's" cost per acre of field burning and feasible alternatives, but does not consider relative differences in yields or the relative environmental costs. By combining research on the relative environmental costs with "farmer's" costs, this study will extend on past research by being more inclusive of all costs related to the alternatives. Specifically this study will consider the economic costs and benefits for a farmer making a decision between field burning and chemical methods of field sanitization.

V. IDENTIFICATION OF LIKELY COSTS AND BENEFITS

The likely costs and benefits in growing fine fescue, perennial ryegrass, and meadowfoam are broken down into three categories: farmer's costs, field burning pollution costs and pesticide pollution costs (see Figure 1). The farmer's costs are those expenses that a farmer pays out of pocket in growing each crop. The environmental factors for this study, field burning and pesticide pollution costs, represent the indirect costs--the effect of field burning and pesticide usage on humans and the environment.

Obviously the farming of these three crops has other impacts on the environment besides those from field burning and pesticide use. Primarily these would include the pollution generated by motor vehicles, dust pollution and possible soil erosion. It will be assumed that these do not differ greatly between crops and thus not relevant to the comparison.

"Farmer's" Costs

There are several costs for the farmer in growing fine fescue, perennial ryegrass, and meadowfoam. First are costs to prepare the ground for planting by plowing and tilling the soil using tractors and implements. The costs for this would include both machinery costs--depreciation, insurance, fuel, and maintenance--and labor costs to operate the machinery. Likewise there would be costs to harvest the crops, using combines and swathers, and hauling the seed from the field to, in the case of the grass crops, a seed cleaner, to remove impurities from the seed, or, for

Figure 1: Identification of likely costs and benefits in the establishment and production of fine fescue, perennial ryegrass and meadowfoam seed. Source: OSU Extension Service, Oregon Department of Environmental Quality, Pimentel et al.

Farmer's Costs	
Machinery	*
Labor	*
Fertilizer	*
Soil Additives	*
Pesticides	*
Field Burning Costs	*
Testing and Certification	*
Overhead	*
Interest	*
Seed	*
Insurance	*
Environmental Costs	
Soil Erosion	
Dust	
Engine Emissions	
Field Burning Pollution	
Human Health	*
Fish and Wildlife	
Destruction of Habitat	
Air Pollution	
Pesticide Pollution	
Human Health	*
Fish and Wildlife	*
Aquatic Life	*
Groundwater	*
Crops	*
Male Fertility	
Reproductive Problems	

* Estimable

meadowfoam, to the buyer. Fertilization and the application of pesticides would also be costs imposed on the farmer, with expense for both the application and the chemicals applied. Postharvest activities, like field burning or flail chopping, would also create expenses. Other "farmer's" costs include a land charge, basic overhead, operating capital costs, and certification costs.

Field Burning Pollution Costs

There has been a long standing debate over the "cost" of field burning; many studies, like the Oregon Seed Council and OSU Air Resources Center reports, have been done to determine the scientific effects. They have also looked at who and what is impacted by field burning. There are some harmful effects that are fairly obvious. Examples of these include the loss of visibility, and soiling and other damage to property.

Of the other effects, the impact on human health has been studied the most. First, there is a concern that the smoke particulate can increase the effect of other pollutants. This synergistic effect may happen when carbon particulate in the smoke "both adsorb and absorb gases and mists, which may be toxic" (OSU 8). The carbon particulate can then carry these toxic gases deeper into the lungs and hold them there longer.

There is also the concern that this smoke may cause cancer, although the Oregon DEQ, in 1987, deemed the risk unquantifiable. More likely, though, the field burning smoke magnifies preexisting conditions, such as respiratory diseases. Previous studies have shown that the "health status of chronic bronchitis patients worsened with concentrations" of smoke (ODEQ 8). Field burning smoke is also suspected of impairing lung functioning. Finally, the DEQ suggests that the smoke can be fatal, with acute exposure. This assertion is based on English estimates of excess mortality from "British Smoke"--smoke from burning coal.

Other impacts, such as damage to fish and wildlife, are not as well established. Scientists are primarily concerned with the destruction of habitat. This also affects natural predators, and causes costs to increase because farmers must find other ways to control pests.

Air pollution is another harmful effect of field burning. As Brian Meehan of the Oregonian writes, "a decade ago, late summer in the Willamette Valley was marked by giant plumes of smoke and an acrid haze in Eugene" (Meehan A1). Farmers have reduced the public outcry against field burning by cutting back the number of acres burned per year, but the air pollution concern remains.

The final deleterious effect of field burning is the inestimable cost of some major traffic accidents. For instance, in 1988, field burning smoke drifted over Interstate 5, south of Albany. It resulted in a 23-car pileup, that left 7 people dead and 37 injured(Meehan A17). This tragic accident did help to push through a state law that set new limits on field burning, including a 2000-foot, no-fire zone along major roadways. Yet with the ever present possibility of changing weather conditions (i.e. wind switching direction), accidents remain a potential cost of field burning.

Pesticide Pollution Costs

Similar to the argument on the environmental costs of field burning, there is also presently a great debate considering the pollution costs of field burning. In speaking with Bill Young, Seed Production Specialist and Professor at Oregon State University, and Ron Burr, Pesticide Project Coordinator for the Oregon Seed Council, I was told that "there would be no environmental costs from pesticide usage because we must assume the chemicals are benign because of their extensive approval process" mandated by the Oregon Department of Agriculture and the U. S. Environmental Protection Agency (EPA).

Indeed, the EPA has an extensive approval process. Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the EPA is mandated to govern the registration, distribution, sale and use of pesticides. Companies must register new products and reregister existing products that were approved before current scientific and regulatory standards were formally established. The registration process may cover up to 70 different kinds of tests, depending on the type of pesticide(Miller, ace.orst.edu). These tests are performed by the manufacturer, and results are submitted to the EPA. If the EPA is satisfied with the results, then the product is approved. Otherwise more tests are ordered. This registration process can cost a manufacturer as much as $20 to $30 million initially, along with a continued yearly expense of a few hundred dollars per product (Young, Personal Communications). In addition, manufacturers may be forced to wait two to three years to obtain EPA approval (Young, Personal Communications).

Yet in claiming EPA-approved products have no environmental costs, Professor Young and Mr. Burr do not take into account that under FIFRA, the EPA does not approve products that fall under some arbitrary, "benign" effects ceiling, but rather product registration "will be granted if, after a careful consideration of health, economic, social and environmental costs and benefits, the benefits of the pesticide's use outweighs the costs of its use"(Miller, ace.orst.edu). This means that an approved product, that has undergone and passed the EPA's tests, may still have some impact on society and the environment.

This cost to society and the environment is exactly what the Environmental Impact Quotient (EIQ), and the other pesticide ranking systems outlined in Levitan's paper examine. They are concerned with the effects of the pesticides on humans, aquatic life, wildlife, insects, and plants. The notable human effects, and therefore costs, are acute and chronic toxicity, as well as reproductive, teratogenic(causing birth defects), mutagenic, and oncogenic--carcinogenic--effects (Kovach et al. 2). Although some chemicals are merely suspected, many pesticides have been linked to breast cancer, male fertility problems and have been reported to have hormone disrupting and reproductive effects (Hassanein 5).

Other groups besides humans are being impacted by pesticide use as well. Pimentel in "Environmental and Economic Costs of Pesticide Use" identifies several other affected groups: domestic animals, bees, aquatic life, crops, groundwater contamination, fish and wildlife, and microorganisms and invertebrates. To some extent, pesticides are toxic to these groups, and, in the case of groundwater contamination, impact not only humans, but also livestock bred for human consumption, as well as fish and wildlife. One local cattle rancher, Jim Hight, who grows grass and cereal fields for grazing, has never worried about field burning because the smoke disappears quickly, but wonders how pesticides "linger for so long. I can spray my fence rows one day, and three days later I can still smell the spray" (Hight, Personal Communications).

VI. COLLECTION OF COSTS AND BENEFITS DATA

This section summarizes where costs and benefits were obtained for the three categories listed above: "farmer's" costs, field burning pollution costs, and pesticide pollution costs. In addition, this section outlines the specific values to be used in the study, as well as the assumptions made to arrive at these figures.

"Farmer's" Costs

Costs borne by the farmer are largely taken from the Enterprise Budgets, distributed by the OSU Extension Service. As noted above, these budgets cover all of the preharvest, harvest and postharvest costs that a farmer pays "out of pocket", as well as noncash items such as depreciation. Revenues and costs for a farmer are shown in Appendices 1-5 for the three crops. Some assumptions were made to arrive at these costs and revenues. Key assumptions follow in the text. All other assumptions are provided in the Appendix.

Pesticide Usage

Pesticide usage and cost information is adapted from personal communications with Paul Camuso, a field specialist for a local farmers cooperative, Wilco Farmers. Camuso advises farmers on the type, amount and timing of pesticide applications. Gail Gringrich, OSU extension agent, suggested that figures could be obtained from Camuso to more accurately reflect current practice and application. The pesticide treatments, broken down by crop and year, are shown in Table 1.

Table 1: Estimated pesticide applications for fine fescue, perennial ryegrass and meadowfoam seed establishment and production per acre. All percentages are computed by weight.

Fine Fescue Establishment

Application #	Time of Year	Purpose	Pesticide	Rate/Acre	% a.e.	Total Application (lbs)
1	Pre-Planting	Weed Control	Roundup	0.5 gal	4 lb/gal	2
2	Post-Planting	Grass Control	Poast	0.25 gal	1.5 lb/gal	0.375
3	Post-Planting	Broadleaf Control	Banvel	10 oz.	4 lb/gal	0.3125
			Express	1/3 oz.	75% (by weight)	0.015625
						2.703125

Fine Fescue Production

Application #	Time of Year	Purpose	Pesticide	Rate/Acre	% a.e.	Total Application (lbs)
1	Sept-Dec	Broadleaf Control	Banvel	8 oz.	4 lb/gal	0.25
2	Sept-Dec	Grass Control	Dual	1.5 pints	8 lb/gal	1.5
		Rattail Control	Sinbar	1 lb.	80% (by weight)	0.8
			Goal	4 oz.	2 lb/gal	0.625
3	Dec-Feb	Weed Control	Poast	0.25 gal	1.5 lb/gal	0.375
4	Mar	Weed Control	Banvel	4 oz.	4 lb/gal	0.125
			Express	1/3 oz.	75% (by weight)	0.015625
5	Apr-May	Rust Control	Tilt	12 oz.	3.6 lb/gal	0.3375
						4.028125

Perennial Ryegrass Establishment

Application #	Time of Year	Purpose	Pesticide	Rate/Acre	% a.e.	Total Application (lbs)
1	Sept	Sprout Weed	Roundup	1.5 pints	4 lb/gal	0.75
		Seedling Weed	Diuron	2 lbs.	80% (by weight)	1.6
2	Oct-Nov	Postemerge Weed	Nortron	3 pints	4 lb/gal	1.5
			Bronate	0.25 gal	4 lb/gal	1
			Banvel	4 oz.	4 lb/gal	0.125
3	Feb-Mar	Broadleaf Control	Curtail M	0.25 gal	2.77 lb/gal	0.6925
			Banvel	4 oz.	4 lb/gal	0.125
4	Apr-May	Rust Control	Tilt	12 oz.	3.6 lb/gal	0.3375
						6.13

Perennial Ryegrass Production

Application #	Time of Year	Purpose	Pesticide	Rate/Acre	% a.e.	Total Application (lbs)
1	Sept-Nov	Seedling Control	Dual	1.5 pints	8 lb/gal	1.5
2	Sept-Nov	Seedling Control	Goal	10 oz.	2 lb/gal	0.15625
			Sencor	6 oz.	75% (by weight)	0.28125
3	Sept-Nov	Seedling Control	Diuron	1 lb.	80% (by weight)	0.8
4	Feb-Mar	Broadleaf Control	Curtail M	0.25 gal	2.77 lb/gal	0.6925
			Banvel	4 oz.	4 lb/gal	0.125
5	Apr-June	Rust Control	Tilt	18 oz.	3.6 lb/gal	0.50625
						4.06125

Meadowfoam Seed Production

Application #	Time of Year	Purpose	Pesticide	Rate/Acre	% a.e.	Total Application (lbs)
1	Spring	Pre-Emerge	Dual	16 oz.	8 lb/gal	1
			Roundup	0.25 gal	4 lb/gal	1
2	Late Spring	Post-Emerge	Prism	0.25 gal	0.94 lb/gal	0.24
						2.24

Source: Paul Camuso.

All herbicides and fungicides are applied as liquids or soluble powders in solution with 10 to 20 gallons of water per acre (Camuso, Personal Communications). In fine fescue, herbicides are used to control any weeds or unwanted plants, most often rattail fescue and annual bluegrass (Camuso, Personal Communications). Common weeds in perennial ryegrass are annual bluegrass and annual ryegrass (Camuso, Personal Communications). Meadowfoam is treated with Prism, to control annual bluegrass. The primary fungus problem for both grass crops is rust, although fine fescue also has choke, which cannot be treated (Camuso, Personal Communications). There are very few times that insecticides are used in grass or meadowfoam seed production.

Cropping Pattern

Budgets are based on a 1,000 to 1,500 acre farm with 500 acres in grass seed production. The fine fescue stand was assumed to have a 5-year life beyond the establishment year, while the perennial ryegrass stand has a 2-year life beyond the establishment year. Net establishment costs are amortized over the life of the stand. It should also be noted that stand life is variety-specific. Meadowfoam production was assumed to cover 150 acres, grown as a one-year rotation crop between grass seed plantings (OSU Extension Service, "Enterprise Budget: Meadowfoam Seed Production", 1).

Field Burning Pollution Costs

The factor for field burning pollution costs to be used is the results of the Oregon Department of Environmental Quality study, Preliminary Health Effects

Evaluation for Pollutants Generated by Field Burning, Slash Burning, and Residential Wood Combustion. As mentioned above, this estimates the health effects caused by field burning based on the amount of particulate in the air at certain times. This exposure is multiplied by an EPA risk factor and the exposed population of interest--the 2,100,000 people of the Oregon Willamette Valley--to arrive at a predicted rate of incidence (Table 2). This incidence, for mortality, lost work days and reduced activity days, is then multiplied by their DEQ-obtained, respective values, which are listed in Appendix 7. The DEQ finds that the estimated health effects caused by field burning in 1987 is just over $2.4 million dollars (Table 3). Since over 200,000 acres of grass seed crops were burned in 1987, this equates to an average cost of $12.01 per acre (Table 3). This amount is included in the cost comparison, shown in Table 4.

It should be noted though that this is only a portion of the external costs caused by field burning. As mentioned above, there are other costs associated with field burning: damage to property, loss of visibility, and car accidents. These costs are much harder to estimate or quantify than possible in the size and scope of this study. In any case, the environmental costs of field burning are probably higher than $12.01 per acre.

Pesticide Pollution Costs

Data for this study's environmental costs of pesticide use come from the Pimentel et al. paper, "Environmental and Economic Costs of Pesticide Use". Pimentel et al. estimate the indirect costs associated with annual pesticide use in the

Table 2: Predicted annual mortality, work loss days (WLD), reduced activity days (RAD) associated with exposure to field burning particulates.

Health Effect Evaluated:	Estimated Risk Factor:	Predicted Annual Average Exposure to Particulate Matter (ug/m^3):	Exposed Population of Interest:	Predicted Annual Number of People Affected:
Mortality	0.0000041	0.1	2,100,000	0.90
Work Loss Days (WLD)	0.0253	0.1	2,100,000	2,505.00
Reduced Activity Days (RAD) other than WLDs	0.0903	0.1	2,100,000	16,458.00

Source: Oregon Department of Environmental Quality, 1987.

Table 3: Cost calculations to arrive at the estimated health effects due to field burning per acre.

Cost Calculations for Reduced Activity Days

Population Category:	Predicted Annual Incidence:		Cost per RAD:		Resultant Cost:
Workers on Days not WLDs	6427	$	35.70	$	229,443.90
People not in work force	10031	$	17.85	$	179,053.35
Total	16458	$	24.82	$	408,497.25

Cost Calculations for Total Estimated Health Effects Due to Field Burning

Health Effect Evaluated:	Predicted Annual Incidence:		Cost per Health Effect:		Resultant Cost:
Mortality	0.9	$	2,040,000.00	$	1,836,000.00
Work Loss Days (WLD)	2500	$	71.40	$	178,500.00
Reduced Activity Days (RAD)	16458	$	24.82	$	408,487.56
Sum Total of Estimated Health Effects Due to Field Burning:				$	2,422,987.56
Number of Acres Burned in Year of Study (1987):					201,688
Cost Per Acre for Estimated Health Effects Due to Field Burning:				$	12.01

Source: Oregon DEQ, 1987.

Table 4: Cost-benefit comparison of fine fescue, perennial ryegrass, and meadowfoam seed, combining farmer's costs and pollution cost estimates.

Crop:	Fine Fescue		Perennial Ryegrass		Meadowfoam
Stand Year:	Establishment	Production	Establishment	Production	Production
			($/acre)		
Revenue:	$ -	$ 675.00	$ 720.00	$ 720.00	$ 487.50
Variable Costs:					
Machinery	$ 63.60	$ 34.93	$ 56.03	$ 43.74	$ 42.15
Labor	44.36	28.65	27.36	16.81	26.24
Fertilizer	15.75	57.01	96.10	64.48	29.90
Lime	50.00	0.00	47.00	0.00	15.00
Herbicides	57.64	78.08	115.16	57.64	50.00
Fungicides	0.00	15.92	31.80	47.70	0.00
Slug Bait	0.00	0.00	8.75	8.75	0.00
Seed	12.50	0.00	20.00	0.00	24.00
Soil Test	0.40	0.00	0.20	0.00	0.00
Bee Pollination	0.00	0.00	0.00	0.00	58.00
Seed Cleaning	0.00	42.75	72.00	72.00	11.26
Testing and Certification	0.71	5.30	7.37	6.87	0.00
Field Burning Costs	0.00	15.00	0.00	0.00	0.00
Miscellaneous Overhead	20.00	20.00	20.00	20.00	20.00
Operating Capital Interest	22.75	13.75	23.86	18.89	11.66
Total Variable Costs:	$ 287.71	$ 311.39	$ 525.63	$ 356.88	$ 288.21
Fixed Costs:					
Machinery & Equipment					
Insurance	$ 6.46	$ 5.62	$ 5.13	$ 3.47	$ 6.95
Depreciation & Interest	80.89	52.87	67.55	45.05	91.35
Land	80.00	80.00	80.00	80.00	80.00
Amortized Establishment Cost	0.00	123.79	0.00	0.00	0.00
Total Fixed Costs:	$ 167.35	$ 262.28	$ 152.68	$ 128.52	$ 178.30
Total "Farmer's" Costs	$ 455.06	$ 573.67	$ 678.31	$ 485.40	$ 466.51
Farmer's Projected Return	$ (455.06)	$ 101.33	$ 41.69	$ 234.60	$ 20.99
Pollution Costs:					
Field Burning Health Cost	$ -	$ 12.01	$ -	$ -	$ -
Pesticide Cost	14.22	21.19	32.24	21.36	11.78
Total Pollution Costs:	$ 14.22	$ 33.20	$ 32.24	$ 21.36	$ 11.78
Net Projected Return:	$ (469.28)	$ 68.13	$ 9.45	$ 213.24	$ 9.21

U.S. to arrive at a total $8 billion cost. Of that amount, $5 billion is imposed on society and the environment. Since approximately 1 billion pounds of pesticides are applied in the U. S. annually, this equates to a $5.26 per pound cost to society and the environment for application of pesticides (Table 5). This amount, multiplied by the pounds of active ingredient applied for each crop, as shown in Table 1, is included in the cost comparison in Table 4.

There are some shortcomings in using Pimentel's estimate. First, the approximation is not allocated to specific types of pesticide. Similar to activity-based costing, allocating this "overhead" to specific cost-drivers (i.e. specific pesticides) would be a more exact allocation. Otherwise, crops that use the least environmentally harmful pesticides are apportioned the same per pound rate as the most environmentally harmful chemicals.

Pimentel also does not account for some long-term effects of pesticides; there is no mention of the cost of causing male infertility or reproductive problems. Many of these effects are suspected, but are not well-documented or attributable to pesticides at this time. Failing to include these, though, may seriously understate the cost of pesticide use. Therefore, no policy changes should be made solely on Pimentel's estimate. In any case, the approximation is conservative at best; an estimate of greater than $5.26 per pound would probably be more accurate.

Table 5: Estimated environmental and economic costs of pesticide use annually in the United States to arrive at the environmental cost per pound of pesticide use.

Impacted Group	Annual Incidence	Cost/Incidence	Resultant Cost	Total Cost
Human health effects:				
Hospitalization	2,380	$ 2,840	$ 6,759,200	
Outpatient Treatment	27,000	630	17,010,000	
Lost Work	4,680	376	1,759,680	
Treatment of Cancer	10,000	70,700	707,000,000	
Fatalities	27	2,000,000	54,000,000	
				$ 786,528,880
Domestic Animal Deaths and Contamination:				30,000,000
Loss of Natural Enemies				520,000,000
Pesticide Resistance				1,400,000,000
Pollination Losses				320,000,000
Crop Losses				942,000,000
Fishery Losses				24,000,000
Bird Losses				2,100,000,000
Water Contamination				1,800,000,000
Government Regulations to Prevent Damage				200,000,000
Total Estimated Environmental and Social Costs from Pesticides in the U.S.:				$ 8,122,528,880
Less: Costs paid by applicators and farmers				
Loss of Natural Enemies				(520,000,000)
Pesticide Resistance				(1,400,000,000)
Crop Losses				(942,000,000)
Total Estimated External Costs of Pesticide Use in U.S.				$ 5,260,528,880
Divided by: Total Estimated Pesticide Usage in U.S. (in pounds)				1,000,000,000
Environmental Cost per Pound of Pesticide Use				$ 5.26
Source: Pimentel et al., 1992.				

VII. COST-BENEFIT COMPARISON OF ALTERNATIVES

Overall Comparison of Crop Profitability

By analyzing the cost-benefit comparison of the three crops in Table 4, one reaches several conclusions. First, perennnial ryegrass is by far the most cost-effective crop, with returns of $213.24 in production years. Fine fescue is second with returns of $68.13 per acre in production years. Meadowfoam seed is clearly the least cost-effective, with operating income before taxes of $9.21 per acre annually.

The results are similar when cash flows from the three crops are discounted back to arrive at a net present value (NPV), as shown in Table 6. With an interest rate of ten percent and a period of six years, perennial ryegrass has an NPV of $664.69 per acre, fine fescue $258.25 per acre, and meadowfoam $44.12 per acre.

Using either criteria, operating income before taxes or NPV, one can see that perennial ryegrass is clearly the most financially beneficial crop to the farmer. Three things help.

First, perennial ryegrass is fully productive in its first year, unlike fine fescue which is not harvested in the year of establishment. This means the field is producing income in every year. All of the crops have high establishment costs, stemming from the additional machinery and labor to prepare the field for planting. Yet for perennial ryegrass, first year revenues offset these high costs. On the other hand, having high establishment costs with no revenue in the first year, as in the case of fine fescue, is even more costly, due to the time value of money. The

Table 6: Simplified cost-benefit comparison of fine fescue, perennial ryegrass and meadowfoam including net present value calculations.

Panel A: Operating Income before Taxes for Fine Fescue, Perennial Ryegrass and Meadowfoam Seed Establishment and Production,

Crop:	Fine Fescue		Per. Ryegrass		Meadowfoam
Stand Year:	Establishment	Production	Establishment ($/acre)	Production	Production
Revenue:	$ -	$ 675.00	$ 720.00	$ 720.00	$ 487.50
Variable Costs:	$ 287.71	$ 311.39	$ 525.63	$ 356.88	$ 288.21
Fixed Costs:	167.35	262.28	152.68	128.52	178.30
Pollution Costs:					
Field Burning Health Cost	0.00	12.01	0.00	0.00	0.00
Pesticide Cost	14.22	21.19	32.24	21.36	11.78
Total Pollution Costs:	14.22	33.20	32.24	21.36	11.78
Total Costs:	$ 469.28	$ 606.87	$ 710.55	$ 506.76	$ 478.29
Operating Income before tax	$ (469.28)	$ 68.13	$ 9.45	$ 213.24	$ 9.21

Panel B: Cash Flows from Operations based on Income before Taxes Plus Amortizations

Crop:	Fine Fescue		Per. Ryegrass		Meadowfoam
Stand Year:	Establishment	Production	Establishment ($/acre)	Production	Production
Operating Income before tax	$ (469.28)	$ 68.13	$ 9.45	$ 213.24	$ 9.21
Plus Amortized Costs	0.00	123.79	0.00	0.00	0.00
Cash Flows	$ (469.28)	$ 191.92	$ 9.45	$ 213.24	$ 9.21

Panel C: NPV Calculations based on Cash Flows from Operations

Crop:	Fine Fescue		Per. Ryegrass		Meadowfoam
Stand Year:	Establishment	Production	Establishment ($/acre)	Production	Production
Cash Flows by Year					
Year 1	$ (469.28)		$ 9.45		$ 9.21
Year 2		$ 191.92		$ 213.24	9.21
Year 3		191.92		213.24	9.21
Year 4		191.92	9.45		9.21
Year 5		191.92		213.24	9.21
Year 6		191.92		213.24	9.21
Net Present Value		$ 258.26		$ 664.68	$ 44.12

assume i = 10%
n = 6 years

establishment costs of fine fescue must be recovered in subsequent years. Amortized over the life of stand--five years--at a rate of ten percent, this establishment cost equates to $123.79 per year. Even though establishment costs for perennial ryegrass are about $200 more than for fine fescue, revenues in the first year of $720 absorb these higher costs.

Perennial ryegrass is also a cost-effective choice because there is a growing market for straw. In 1996, 340,000 tons of hay were exported to Japan for use in livestock feed and another 60,000 tons were fed to cattle in the U.S.(Meehan). This demand allows the grower to "give away" the hay, if the recipient will take the straw from the field. Since farmers can have the harvest's residue removed at no charge, this greatly enhances the feasibility of ryegrass, and reduces the need for field burning.

Finally, growing perennial ryegrass does not involve using that much more pesticides than the cultivation of fine fescue. In fact, once the stands are established, both fine fescue and perennial ryegrass crops are treated with about 4 pounds of active ingredient of pesticides per acre annually. This means that perennial ryegrass has similar application, material, and environmental pesticide costs to fine fescue, but at the same time does not necessitate any field burning costs.

Analysis of Environmental Costs

This pollution cost data suggests that visible forms of pollution are costlier than nonvisible forms. Fine fescue, a crop that is field burned, has the highest overall environmental impact, $33.20 per acre--approximately 4.9% of income. Not only does field burning impose a $12.01 per acre impact on the health of citizens of the Willamette Valley, but it does not sanitize the field absolutely. Farmers must also apply pesticides to their fine fescue fields to control weeds and disease, which creates a pesticide pollution cost of $21.19 per acre. This means that fine fescue fields are creating pollution in at least two ways: from field burning and from pesticide usage. Additionally, the amount of pesticides applied to a fine fescue field is not very much less than what is applied to perennial ryegrass fields in production years (4.03 lbs. per acre versus 4.06 lbs. per acre). The tradeoff not to practice field burning is only an increase in pesticide applications of 0.03 pounds of active ingredient per acre. Thus production years of perennial ryegrass have a relatively small economic impact on the environment, $21.36 per acre--only 2.9% of income.

But there is some advantage in the establishment years for fine fescue. Only 2.70 pounds of active ingredient are applied per acre, as compared to 6.13 pounds for perennial ryegrass; perennial ryegrass has about 3.4 more pounds of active ingredient applied per acre than fine fescue. This high application rate for perennial ryegrass establishment results in the highest estimated pesticide pollution cost, $32.24 per acre. This relatively higher application for perennial ryegrass would change the comparison if cost assumptions about the environmental impact of pesticides increased (Table 7).

The farming of meadowfoam does not require the use of very many pesticides. Based on the DEQ and Pimentel values, meadowfoam production

Table 7: Sensitivity analysis for fine fescue, perennial ryegrass, and meadowfoam with estimated pesticide pollution costs tripled.

Crop:	Fine Fescue		Per. Ryegrass		Meadowfoam
Stand Year:	Establishment	Production	Establishment ($/acre)	Production	Production
Revenue:	$ -	$ 675.00	$ 720.00	$ 720.00	$ 487.50
Total Variable Costs:	287.71	311.39	525.63	356.88	288.21
Total Fixed Costs:	167.35	269.79	152.68	160.23	178.30
Total "Farmer's" Costs	$ 455.06	$ 581.18	$ 678.31	$ 517.11	$ 466.51
Pollution Costs:					
Field Burning Health Cost	$ -	$ 12.01	$ -	$ -	$ -
Pesticide Cost (x3)	42.66	63.56	96.73	64.09	35.35
Total Pollution Costs:	$ 42.66	$ 75.57	$ 96.73	$ 64.09	$ 35.35
Net Projected Return:	$ (497.72)	$ 18.25	$ (55.04)	$ 138.80	$ (14.36)

imposes the least economic impact on the environment, \$11.78 per acre--only approximately 2.4% of income. This stems from the fact that pesticide applications on meadowfoam crops are about a third to a half of what farmers put on the grass seed crops. The low application rate is, in part, because meadowfoam is considered a "minor use" crop (Camuso, Personal Communications). Pesticides manufacturers are unwilling to incur the expense of EPA approval for a product to be labelled for meadowfoam use, since it is not grown extensively. Thus only two pesticides, Dual and Prism, are registered for meadowfoam application (Camuso, Personal Communications).

This low pesticide usage could change the crop comparison, if pollution costs are higher than estimated. As shown with sensitivity analysis, if the pollution costs are assumed to be more than originally anticipated, meadowfoam becomes a relatively, better choice (Table 8). Ultimately, since science is still trying to determine all of the effects and impacts of pesticide use, it is probably wise at this time to limit its use as much as possible.

Limitations and Non-Cost Considerations

There are some limitations in calculating NPV. In order to accurately compare NPV across projects of similar timeframes, stand lives had to be equated with the time period. Therefore, it is assumed that two stands of perennial ryegrass and six stands of meadowfoam are grown consecutively in the same field. This is not something a farmer would do, because the lack of crop rotation would lower yields considerably. Yet, ultimately, the NPV analysis shows that growing perennial

Table 8: Sensitivity analysis for fine fescue, perennial ryegrass, and meadowfoam with both field burning and pesticide pollution cost estimates doubled.

Crop:	Fine Fescue		Per. Ryegrass		Meadowfoam
Stand Year:	Establishment	Production	Establishment ($/acre)	Production	Production
Revenue:	$ -	$ 675.00	$ 720.00	$ 720.00	$ 487.50
Total Variable Costs:	$ 287.71	$ 311.39	$ 525.63	$ 356.88	$ 288.21
Total Fixed Costs:	167.35	269.79	152.68	160.23	178.30
Total "Farmer's" Costs	$ 455.06	$ 581.18	$ 678.31	$ 517.11	$ 466.51
Pollution Costs:					
Field Burning Health Cost (x2)	$ -	$ 24.02	$ -	$ -	$ -
Pesticide Cost (x2)	28.44	42.38	64.49	42.72	23.56
Total Pollution Costs:	$ 28.44	$ 66.40	$ 64.49	$ 42.72	$ 23.56
Net Projected Return:	$ (483.50)	$ 27.42	$ (22.80)	$ 160.17	$ (2.57)

ryegrass provides much greater cash flows for a farmer.

This comparison does fail to look at specific pesticides. This could skew the results, because pesticides do not have the same environmental impacts. The comparison also does not look at inerts, which are applied with the pesticides. Many common inerts are suspected carcinogens, although in most cases there is a lack of scientific evidence to establish this link.

Although meadowfoam is not viewed as a "lucrative" crop by farmers, two considerations, not included in the comparison, may make it an attractive choice for a grass seed farmer (Camuso, Personal Communications). First, the cultivation of meadowfoam in one year allows for lower costs in the next year because of reduced residue disposal and ground preparation. Secondly, meadowfoam is an attractive crop to plant if a farmer has an infestation problem with annual bluegrass, specifically the Poa annua genus species.

Traditionally, growers have sprayed their grass seed crops with Nortron and Diuron to control annual bluegrass, but one particular biotype of annual bluegrass, Poa annua, has become resistant to this pesticide application practice and therefore dominant in fields that have been treated this way for years. This strain of resistant annual bluegrass has been documented much more in the southern Willamette Valley, but is an increasing problem in the northern valley as well (Camuso, Personal Communications).

To counter this, farmers can plant meadowfoam for a year, treat the crop with Prism, a herbicide that targets this biotype, and in the next year, plant back to grass seed in a field free of annual bluegrass. Farmers cannot spray their grass fields with

Prism, without damaging the crops. According to Paul Camuso, farmers with an annual bluegrass problem would be more likely to choose to plant meadowfoam (Camuso, Personal Communications).

VIII. SUGGESTIONS FOR THE FUTURE

If farmers decide to continue the use of pesticides, at the very least, they should use one of the pesticide ranking systems to determine a pesticide treatment program which has as little environmental impact as possible. These systems, such as the Environmental Impact Quotient (EIQ), are outlined by Levitan, according to target audience. They presume that some pesticides are more or less friendly to the environment. Therefore, farmers or other policy makers could select a ranking systems to help in their pesticide application decisions. In this way, farmers could at least reduce the environmental impact of pesticide use by selecting the least harmful chemicals.

Even though field burning may at first seem a worthy alternative, widespread burning, as done in the 1960s and 1970s, is probably not feasible. Bill Young, a seed specialist at OSU, states, "I think field burning has gone the way of buggy whips and high button boots. We are going to have to manage what we have with less fire." (Meehan A17). Public opposition against field burning causes farmers to concede that widespread burning is no longer possible.

In addition, many farmers on the valley floor, who have grown perennial ryegrass for some time without the practice of field burning, would not want to begin burning again (Gringrich, Personal Communications). First they would not be equipped to do so. Secondly, they do not desire the liability, poor public relations and uncertainty associated with burning (Gringrich, Personal Communications). There are no guarantees that a farmer will be allowed to burn on time. Burning on time--to avoid green regrowth--greatly affects the quality of the burn and the yields in subsequent years. Priority is given by the DEQ based on the slope of ground (i.e. farmers in the hills have first priority), because of a concern for soil erosion from plowing when field burning is not allowed.

So even if pesticide use is found in the future to be seriously harmful to the environment, increasing the current use of field burning is still probably not a viable option. But, farmers feel that field burning may always be needed as a "last resort", when a field is quite infested with weeds or disease (Liess E2).

In the future, perhaps neither widespread pesticide treatment nor field burning will be necessary, as some farmers turn to organic farming. Potatoes, "ranked 5th overall in pesticide use" for U.S. crops, typically have about 80 pounds of pesticides applied per acre (Murphy 2). But some farmers in Idaho are fine-tuning the organic production of potatoes. These farmers are growing Austrian peas as a one-year rotation crop, in a three year rotation of potatoes, peas and wheat. The peas are not harvested or sold, but rather tilled back into the soil. Thus the peas add to the soil's "fertility, and break up disease, pest and weed cycles" (Murphy 6). Some plants, such as the peas, are considered "allelopathic; they release compounds into the soil that are toxic to certain other plants" (Murphy 5). This way farmers do not have to spend as much controlling disease and pests.

One such farmer, Jamie Wood, says that he spends "about half as much on fertilizer; one-tenth the herbicide costs, and minimal insecticide costs" (Murphy 6). With such low costs, he can afford to have a third of his crops produce no income. With equivalent yields, his net returns are about the same as his neighbors, but in fact his potatoes are of higher quality, fetch a higher price, and have a higher yield (Murphy 6).

IX. CONCLUSIONS

This study compared the cost-effectiveness of field burning and chemical methods of field sanitization. It specifically examined the impact of environmental costs on a cost-benefit analysis of a crop rotation decision for an agricultural firm. The analysis provided an example of decision making within a context of visible and less visible environmental costs.

In comparing fine fescue, perennial ryegrass, and meadowfoam seed production, the study found that perennial ryegrass is clearly the most cost-effective, with operating income before taxes of $213.24 per acre in production years. There are three reasons for this. First, perennial ryegrass is productive in the year of stand establishment, meaning that establishment costs do not have to be allocated over the life of the stand. Secondly, the growing hay market allows farmers to give away their straw, if the baler will remove it from the field at no charge. Finally, as compared to the other two crops, perennial ryegrass is treated only with marginally more pesticides. This means that the pollution estimate for perennial ryegrass is very close or better than the other crops.

The pollution cost data suggests that visible forms of pollution are costlier than less visible forms. Not only does field burning impose a $12.01 per acre impact on the health of citizens of the Willamette Valley, but it does not sanitize the field absolutely. Farmers must also apply pesticides to their fine fescue fields to control weeds and disease. This means that fine fescue fields are creating pollution in at least two ways: from field burning and from pesticide usage. Additionally, once the fields are established, the amount of pesticides applied to fine fescue is not very much less than what is applied to perennial ryegrass fields in production years (4.03 versus 4.06 lbs. per acre). Thus the tradeoff not to practice field burning results in an increase in pesticide applications of 0.03 pounds of active ingredient per acre.

One limitation of the study is that the comparison of field burning to increased pesticide usage was performed across three crops. Individual differences between the three crops unrelated to environmental costs may have skewed the comparison of field burning to increased pesticide usage. Future research may try to account for this problem by determining the relevant costs and benefits of field burning or increased pesticide use for one specific crop. In this way, individual crop differences could be eliminated from the comparison, while differences between field burning and increased pesticide usage, such as crop yields, would be more evident.

APPENDIX

This appendix provides the detailed cost and benefit estimates for fine fescue, perennial ryegrass and meadowfoam seed establishment and production, as well as the assumptions necessary to arrive at these figures. Some assumptions are listed in the text. In addition, the appendix also includes supporting schedules, such as one that specifies machinery assumptions. These estimates were obtained primarily from the Oregon State University Extension Service and also from the Oregon Department of Environmental Quality. All information that is included here is summarized in the text.

"Farmer's" Cost Assumptions

Costs borne by the farmer are largely taken from the Enterprise Budgets, distributed by the OSU Extension Service. These budgets cover all of the preharvest, harvest and postharvest costs that a farmer pays "out of pocket", as well as noncash items such as depreciation. Revenues and costs for a farmer are shown in Appendices 1-5 for the three crops. Some assumptions were made to arrive at these costs and revenues.

Seed Yields

The original budgets contain "conservative" estimates of seed yields (Gringrich, Personal Communications). This is done to reflect the variability in returns for any given farmer. The yield, for all three crops, is greatly influenced by soil, weather, stand age, and the specific variety of fine fescue, perennial ryegrass, or meadowfoam (Gringrich, Personal Communications). Fine fescue yields can also be affected if a field is not burned "on time"--before there is too much green regrowth. Green regrowth lessens the effectiveness of the burn in thinning the grass to make room for new growth (Gringrich, Personal Communications). For fine fescue, yields can vary between 500 and 1,000 pounds per acre, with 750 to be used in the study (Gringrich, Personal Communications).

Some perennial ryegrass fields are established as "no-tilled" stands, in which a traditional seedbed is not prepared, but rather the seed is worked into the existing sod (Gringrich, Personal Communications). These no-tilled stands typically have lower yields. This study will assume a conventional seedbed is prepared and will yield 1,200 pounds of perennial ryegrass seed, from the range of 1,000 to 1,400 pounds (Gringrich, Personal Communications).

Meadowfoam yields vary based on location (soil), weather and variety. Meadowfoam yields range from 400 to 1,000 pounds, but 500 to 800 pounds is more accurate for a farmer in the Silverton hills area (Gringrich, Personal Communications). This study will use 650 pounds as the meadowfoam yield.

Overall, yields are lower in the Silverton hills area, as opposed to the Willamette Valley floor, because of poorer quality of soil (Gringrich, Personal Communications).

Seed Prices

In speaking with Gail Gringrich, OSU Extension Agent, I found that the prices used in the Enterprise budgets were lower than the most current quotes available. This is because of seasonal fluctuations in supply and demand; furthermore the seed market is a "buyer's" market, with many sellers and relatively fewer buyers. This often results in the farmer having to accept the price available. Prices will also vary based on quality--the purity and germination rate of the seed--and on certification of the seed, which fetches a premium price in the market.

For this study, a per pound price of $0.90 will be used from the range of $0.90 to $1.00 for fine fescue (Gringrich, Personal Communications). Perennial ryegrass is currently selling from $0.60 to $0.67 per pound, although $0.60 to $0.62 is probably more accurate (Gringrich, Personal Communications). This study will use $0.60 initially. Meadowfoam has consistently been around $0.65 per pound, and this price will be used in the study. The initial and primary use of the low-end estimates is warranted by the drastic increase in quotes, as compared to the prices used in the Enterprise Budgets for fine fescue, perennial ryegrass and meadowfoam--$0.47, $0.45, $0.65, respectively (OSU Extension Service 1).

Land

A fee of $80 was imputed to approximate the cost of owning or leasing an acre of land, suitable to the cultivation of these crops.

Labor

Labor costs, "including worker's compensation, FICA, and other payroll expenses," were valued at $10 per hour and were calculated based on machinery hours (OSU Extension Service 1). All labor was treated as a cash cost.

Capital

Opportunity costs of capital were charged at a rate of 10 percent for current and intermediate capital provided by the owner/operator (OSU Extension Service 1). Expenditures were weighted over time to arrive at an operating capital cost.

Machinery

It was assumed that the machinery complement was sufficient enough to farm the entire 1,500 acres. The breakdown on machinery costs is shown in Appendix 6.

Operations

Farming operations are shown in Appendices 1-5 in the order that they are performed.

For fine fescue, the field is worked up, sprayed with a herbicide and then planted and fertilized in May. After establishment, the field is sprayed again. Fine fescue does not produce in the first year; all establishment costs are amortized over the remaining five years of the stand. In a typical production year, the field is fertilized and sprayed twice with herbicides in the fall. Then in the spring, the field is fertilized again. Prior to harvest, the field is spot sprayed for weeds and treated with a fungicide for rust control. The field is swathed in mid-June and combined approximately two weeks after. The harvested seed is then cleaned of impurities. After harvest, the field is open field burned (OSU Extension Service 1).

For perennial ryegrass, the establishment is similar to fine fescue with a conventional seedbed prepared. Perennial ryegrass, though, is productive in its first year. After the harvest in late July, the straw is custom baled, at no charge, in return for the straw going to the baler. The remaining stubble on the field is flail chopped "to aid in surface decomposition of the remaining residue" (OSU Extension Service, "Enterprise Budget: Perennial Ryegrass Seed Production", 1). Then in the fall, fertilizer and several herbicides are applied. Slug bait is also spread in infested areas. In the spring, the crop is treated with fertilizer and herbicides again, along with two applications of fungicide, to control rust, a grass disease. Then in early July, the field is swathed and harvested in late July.

For meadowfoam, the existing grass seed crop is plowed under and a "conventional seedbed is prepared" in the fall(OSU Extension Service, "Enterprise Budget: Meadowfoam Seed Production", 1). By mid-October, the meadowfoam is planted. The crop is treated with herbicides twice, and fertilized in the spring. Two beehives are rented for pollination in May and the harvest is made in late June or early July. Costs for extracting the oil are not charged to the farmer, but are imputed in the received price. In addition, "reduced residue disposal and ground preparation is required after meadowfoam harvest as compared to grass seed harvest", but those savings would be represented in the next year(OSU Extension Service, "Enterprise Budget: Meadowfoam Seed Production", 1).

Appendix 1: Economic costs in growing fine fescue in the year of establishment, assuming a 100-acre field, in dollars per acre. Source: OSU Extension Service, Paul Camuso.

VARIABLE COST Description		Labor	Machinery	Materials	Total ($/acre)
Disk(4x)		$ 6.22	$ 17.46	$ -	$ 23.68
Lime/Dolomite (1/2 ac)		0.00	0.00	50.00	50.00
Custom Application	1.25 tons x $40/ton				0.00
Chisel Plow (2x)		3.11	9.43	0.00	12.54
Cultivate (6x)		5.32	8.52	0.00	13.84
Rock Picking		7.20	0.00	0.00	7.20
Harrow/Roller		0.72	1.17	0.00	1.89
Soil Test		0.00	0.00	0.40	0.40
Soil Test	1 acre x $0.40/acre				
Weed Control		0.67	1.70	24.25	26.62
Herbicide - Roundup	0.5 gal x $48/gal				
Surfectant	$0.25/acre				
Harrow (3x)		2.18	6.35	0.00	8.53
Cultivate (5x)		4.44	7.10	0.00	11.54
Harrow/Roller (2x)		1.77	2.34	0.00	4.11
Seed		2.66	2.80	28.25	33.71
Fine Fescue Seed	5 lb x $2.50/lb				
14-31-10 Fertilizer	0.075 tons x $210/ton				
Grass Control		0.55	1.70	20.45	22.70
Herbicide - Poast	0.25 gal x $75/gal				
Crop Oil	$1.70/acre				
Broadleaf Control		0.68	1.70	12.94	15.32
Herbicide - Banvel	10 oz. x $90/gal				
Herbicide - Express	1/3 oz. x $175/10 oz.				
Seedling Inspection	(for certification)	0.00	0.00	0.71	0.71
Pickup (off-farm)		7.34	2.58	0.00	9.92
Pickup (on-farm)		1.50	0.75	0.00	2.25
Miscellaneous Overhead		0.00	0.00	20.00	20.00
Operating Capital Interest		0.00	0.00	22.75	22.75
Total VARIABLE COST					$ 287.71
FIXED COST Description			Unit		
CASH Cost					
Machinery & Equipment Insurance			acre		$ 6.46
Land			acre		80.00
Total CASH Cost					$ 86.46
NONCASH Cost					
Machinery & Equipment Depreciation and Interest			acre		$ 80.89
Total FIXED COST					$ 167.35
Total COST					$ 455.06

Appendix 2: Economic costs and benefits, in dollars per acre, in growing fine fescue in a year of production, assuming a 500-acre field. Source: OSU Extension Service, Paul Camuso.

GROSS INCOME Description		Quantity	Unit	$/Unit	Total ($/acre)	
Fine Fescue Seed		750	lb	$ 0.90	$ 675.00	
Total GROSS INCOME						$ 675.00

VARIABLE COST Description		Labor	Machinery	Materials	Total
PREHARVEST					
Fall Fertilizer		$ 1.10	$ 0.75	$ 25.00	$ 26.85
14-31-10	0.1 tons x $240/ton				
Spreader Rental	1 acre x $1				
Fall Weed Control		0.67	1.70	45.47	47.84
Herbicide - Banvel	$5.62/acre				
Herbicide - Dual	1.5 pints x $64/gal				
Herbicide - Sinbar	1 lb. x $25.60/lb				
Herbicide - Goal	4 oz. x $36/gal				
Winter Weed Control		0.67	1.70	20.45	22.82
Herbicide - Poast	0.25 gal x $75/gal				
Crop Oil	0.25 gal x $6.80/gal				
Spring Fertilizer		0.67	1.70	33.01	35.38
12-0-0-26	110 lb x $0.09/lb				
Solution 32	25.4 lb x $0.91/lb				
Spring Weed Control (1/2 ac)		0.17	0.42	8.61	9.20
Herbicide - Banvel	4 oz. x $90/gal				
Herbicide - Express	1/3 oz. x $175/10 oz.				
Seed Certification		0.00	0.00	2.00	2.00
Spot Spraying		2.50	0.00	3.55	6.05
Rust Control (1/2 ac)		2.75	0.00	15.92	18.67
Fungicide - Tilt	6 oz. x $320/gal				
Surfectant	0.066 gal x $14/gal				
Custom Spraying	0.5 acres x $5.50				
Total PREHARVEST					$ 168.81
HARVEST					
Swathing		$ 2.73	$ 12.09	$ -	$ 14.82
Combining		8.32	12.18		20.50
Hauling		0.24	0.06		0.30
Seed Cleaning		0.00	0.00	42.75	42.75
Seed Testing and Certification Tag		0.00	0.00	3.30	3.30
Fee	7.5 cwt x $0.44				
Total HARVEST					$ 81.67
POSTHARVEST					
Open Field Burn		$ -	$ -	$ 15.00	$ 15.00
Burn Fee	1 acre x $8				
Field Registration	1 acre x $2				
Labor and Equipment	1 acre x $5				
Total POSTHARVEST					$ 15.00

Appendix 2 (continued): Economic costs and benefits, in dollars per acre, in growing fine fescue in a year of production, assuming a 500-acre field. Source: OSU Extension Service, Paul Camuso.

MISCELLANEOUS					
Operating Capital Interest	$ -	$ -	$ 13.75	$ 13.75	
Pickup (on-farm)	1.50	0.75	0.00	2.25	
Pickup (off-farm)	7.33	2.58	0.00	9.91	
Miscellaneous Overhead	0.00	0.00	20.00	20.00	
Total MISCELLANEOUS				$ 45.91	
Total VARIABLE COST					$ 311.39
GROSS INCOME minus VARIABLE COST					$ 363.61
FIXED COST Description		Unit		Total	
CASH Cost					
Machinery & Equipment Insurance		acre		$ 5.62	
Land		acre		80.00	
Total CASH Cost				$ 85.62	
NONCASH Cost					
Amortized Establishment Cost		acre		$ 123.79	
Machinery & Equipment Depreciation and Interest		acre		52.87	
Total NONCASH Cost				176.66	
Total FIXED Cost					262.28
NET PROJECTED RETURNS					$ 101.33
Breakeven Price, short-run	$ 0.42 /lb				
Breakeven Price, long-run	$ 0.76 /lb				

Appendix 3: Economic costs and benefits, in dollars per acre, in growing perennial ryegrass in the year of establishment, assuming a 500-acre field. Source: OSU Extension Service, Paul Camuso.

GROSS INCOME Description		Quantity	Unit	$/Unit	Total ($/acre)	
Certified Seed		1200 lb		$ 0.60	$ 720.00	
Total GROSS INCOME						$ 720.00
VARIABLE COST Description		**Labor**	**Machinery**	**Materials**	**Total**	
ESTABLISHMENT						
Soil Sample Test	1 acre x $0.20	$ -	$ -	$ 0.20	$ 0.20	
Disk (2x)		2.42	3.11	0.00	5.53	
Plow		2.42	3.34	0.00	5.76	
Harrow and Roll (3x)		2.42	3.48	0.00	5.90	
Custom Lime	1 acre x $47	0.00	0.00	47.00	47.00	
Harrow and Roll		0.81	1.16	0.00	1.97	
Land Level (0.5x)		0.50	0.79	0.00	1.29	
Plant		2.42	2.22	76.00	80.64	
Ryegrass Seed	8 lb x $2.50/lb					
Charcoal/Fertilizer	1 acre x $56					
Sprout Weed Control (0.5x)		0.14	0.70	9.25	10.09	
Herbicide - Roundup	1.5 pints x $48/gal					
Spray Adjuvant	$0.25/acre					
Seedling Weed Control		0.29	1.40	6.80	8.49	
Herbicide - Diuron	2 lb. x $3.40/lb					
Postemerge Weed Control		0.29	1.40	80.56	82.25	
Herbicide - Nortron	3 pints x $170/gal					
Herbicide - Bronate	0.25 gal x $56/gal					
Herbicide - Banvel	4 oz. x $90/gal					
Seedling Inspection	1 acre x $0.50	0.00	0.00	0.50	0.50	
Slug Control (0.1x)		1.10	0.74	8.75	10.59	
Slug Bait - Deadline	7 lb. x $62.50/50 lb.					
Total ESTABLISHMENT					$ 260.21	
PREHARVEST						
Fertilize - Spring		$ 0.29	$ 1.63	$ 20.50	$ 22.42	
33-0-0-12	0.1 tons x $205/ton					
Fertilize - Spring		0.29	1.63	19.60	21.52	
Urea	0.08 tons x $245/ton					
Broadleaf Weed Control		0.29	1.40	8.55	10.24	
Herbicide - Curtail M	0.25 gal x $40/gal					
Herbicide - Banvel	4 oz. x $90/gal					
Spray Adjuvant	1 acre x $0.90					
Rogue Weed		0.00	0.00	7.50	7.50	
Herbicide (Roundup)& Labor	1 acre x $7.50					
Certification Fee		0.00	0.00	2.00	2.00	
Rust Control (2x)		0.58	2.80	31.80	35.18	
Fungicide - Tilt	12 oz. x $320/gal					
Spray Adjuvant	2 acres x $0.90					
Total PREHARVEST					$ 98.86	

Appendix 3 (continued): Economic costs and benefits, in dollars per acre, in growing perennial ryegrass in the year of establishment, assuming a 500-acre field. Source: OSU Extension Service, Paul Camuso.

HARVEST						
Swathing		$ 2.68	$ 11.08	$ -	$ 13.76	
Combining		4.40	14.90	0.00	19.30	
Hauling		1.50	1.41	0.00	2.91	
Seed Cleaning		0.00	0.00	72.00	72.00	
Custom Charge	12 cwt x $6					
Certification Fee		0.00	0.00	2.40	2.40	
Seed Test		0.00	0.00	1.27	1.27	
Purity & Germ	1 acre x $1.27					
Commission Assessment		0.00	0.00	1.20	1.20	
Assessment	12 cwt x $0.10					
Total HARVEST					$112.84	
POSTHARVEST						
Custom Bale and Haul		$ -	$ -	$ -	$ -	
Flail		2.02	2.02	0.00	4.04	
Border Spray		0.00	0.00	2.50	2.50	
Herbicide & Labor						
Total POSTHARVEST					$ 6.54	
MISCELLANEOUS						
General Overhead		$ -	$ -	$20.00	$ 20.00	
Pickup		2.50	0.82	0.00	3.32	
Operating Capital Interest		0.00	0.00	23.86	23.86	
Total MISCELLANEOUS					$ 47.18	
Total VARIABLE COST						$525.63
GROSS INCOME minus VARIABLE COST						$194.37
FIXED COST Description			Unit		Total	
CASH Cost						
Machinery & Equipment Insurance			acre		$ 5.13	
Land Lease			acre		80.00	
Total CASH Cost					$ 85.13	
NONCASH Cost						
Machinery & Equipment Depreciation and Interest			acre		$ 67.55	
Total FIXED Cost						$152.68
NET PROJECTED RETURNS						$ 41.69
Breakeven Price, short-run		$ 0.44 /lb				
Breakeven Price, long-run		$ 0.57 /lb				

Appendix 4: Economic costs and benefits, in dollars per acre, in growing perennial ryegrass in a year of production, assuming a 500-acre field. Source: OSU Extension Service, Paul Camuso.

GROSS INCOME Description		Quantity	Unit	$/Unit	Total ($/acre)	
Certified Seed		1200 lb		$ 0.60	$ 720.00	
Total GROSS INCOME						$ 720.00
VARIABLE COST Description		Labor	Machinery	Materials	Total	
PREHARVEST						
Fertilize - Fall		$ 0.29	$ 1.63	$ 24.38	$ 26.30	
14-14-14	0.125 tons x $195/ton					
Seedling Control Fall #1		0.29	1.40	12.00	13.69	
Herbicide - Dual	1.5 pints x $64/gal					
Seedling Control Fall #2		0.29	1.40	18.53	20.22	
Herbicide - Goal	10 oz. x $72/gal					
Herbicide - Sencor	6 oz. x $224/gal					
Spray Adjuvant	1 acre x $0.90					
Seedling Control Fall #3		0.29	1.40	3.40	5.09	
Herbicide - Diuron	1 lb x $3.40/lb					
Slug Control (0.1x)		1.10	0.22	8.75	10.07	
Slug Bait - Deadline	7 lb. x $62.50/50 lb.					
Fertilizer - Spring		0.29	1.63	20.50	22.42	
33-0-0-12	0.1 tons x $205/ton					
Fertilizer - Spring		0.29	1.63	19.60	21.52	
Urea	0.08 tons x $245/ton					
Broadleaf Control Spring		0.29	1.40	13.71	15.40	
Herbicide - Curtail M	2 pints x $40/gal					
Herbicide - Banvel	4 oz. x $90/gal					
Spray Adjuvant	1 acre x $0.90					
Rogue Weed		0.00	0.00	7.50	7.50	
Herbicide (Roundup)& Labor	1 acre x $7.50					
Certification Fee		0.00	0.00	2.00	2.00	
Rust Control (3x)		0.58	2.80	47.70	51.08	
Fungicide - Tilt	18 oz. x $320/gal					
Spray Adjuvant	3 acres x $0.90					
Total PREHARVEST					$ 195.29	
HARVEST						
Swathing		$ 2.68	$ 11.08	$ -	$ 13.76	
Combining		4.40	14.90	0.00	19.30	
Hauling		1.50	1.41	0.00	2.91	
Seed Cleaning		0.00	0.00	72.00	72.00	
Custom Charge	12 cwt x $6					
Certification Fee		0.00	0.00	2.40	2.40	
Seed Test		0.00	0.00	1.27	1.27	
Purity & Germ	1 acre x $1.27					
Commission Assessment		0.00	0.00	1.20	1.20	
Assessment	12 cwt x $0.10					
Total HARVEST					$ 112.84	

Appendix 4 (continued): Economic costs and benefits, in dollars per acre, in growing perennial ryegrass in a year of production, assuming a 500-acre field. Source: OSU Extension Service, Paul Camuso.

POSTHARVEST					
Custom Bale and Haul	$ -	$ -	$ -	$ -	
Flail	2.02	2.02	0.00	4.04	
Border Spray	0.00	0.00	2.50	2.50	
Herbicide & Labor					
Total POSTHARVEST				$ 6.54	
MISCELLANEOUS					
General Overhead	$ -	$ -	$ 20.00	$ 20.00	
Pickup	2.50	0.82	0.00	3.32	
Operating Capital Interest	0.00	0.00	18.89	18.89	
Total MISCELLANEOUS				$ 42.21	
Total VARIABLE COST					$ 356.88
GROSS INCOME minus VARIABLE COST					$ 363.12
FIXED COST Description		Unit		Total	
CASH Cost					
Machinery & Equipment Insurance		acre		$ 3.47	
Land Lease		acre		80.00	
Total CASH Cost				$ 83.47	
NONCASH Cost					
Amortized Establishment Cost		acre		$ -	
Machinery & Equipment Depreciation and Interest		acre		45.05	
Total NONCASH Cost				$ 45.05	
Total FIXED Cost					$ 128.52
NET PROJECTED RETURNS					$ 234.60
Breakeven Price, short-run	$ 0.30 /lb				
Breakeven Price, long-run	$ 0.40 /lb				

Appendix 5: Economic costs and benefits, in dollars per acre, in growing meadowfoam, assuming a 150-acre field. Source: OSU Extension Service, Paul Camuso.

GROSS INCOME Description		Quantity	Unit	$/Unit	Total ($/acre)	
Meadowfoam Seed		750 lb		$ 0.65	$ 487.50	
Total GROSS INCOME						$ 487.50
VARIABLE COST Description		**Labor**	**Machinery**	**Materials**	**Total**	
PREHARVEST						
Flail		$ 1.51	$ 1.72	$ -	$ 3.23	
Plow		2.42	4.55	0.00	6.97	
Harrow		1.42	1.58	0.00	3.00	
Harrow & Roll		2.85	4.22	0.00	7.07	
Land Level		0.44	0.59	0.00	1.03	
Lime		0.00	0.00	15.00	15.00	
Custom	0.3 tons x $50/ton					
Ditching		1.61	2.03	0.00	3.64	
Plant		1.51	2.28	36.90	40.69	
Meadowfoam	30 lb x $0.80/lb					
15-15-15	0.06 tons x $215/ton					
Pre-Emerge Herbicides		0.19	0.92	20.00	21.11	
Dual	16 oz x $64/gal					
Roundup	0.25 gal x $48/gal					
Spring Fertilize		0.29	1.38	17.00	18.67	
33-0-0-8	0.067 tons x $250/ton					
Post-Emerge Herbicide		0.29	1.38	30.00	31.67	
Prism	0.25 gal x $120/gal					
Bee Pollination		0.00	0.00	58.00	58.00	
Bee Pollination	2 hives x $29					
Total PREHARVEST					$ 210.08	
HARVEST						
Windrowing		$ 2.19	$ 4.56	$ -	$ 6.75	
Combining		6.02	12.34	0.00	18.36	
Hauling		3.00	3.78	0.00	6.78	
Seed Cleaning		0.00	0.00	9.38	9.38	
Custom Charge	750 lb x $0.012/lb					
Loading Charge		0.00	0.00	1.88	1.88	
Custom Charge	750 lb x $0.002/lb					
Total HARVEST					$ 43.15	
MISCELLANEOUS						
General Overhead		$ -	$ -	$ 20.00	$ 20.00	
Pickup		2.50	0.82	0.00	3.32	
Operating Capital Interest		0.00	0.00	11.66	11.66	
Total MISCELLANEOUS					$ 34.98	
Total VARIABLE COST						$ 288.21
GROSS INCOME minus VARIABLE COST						$ 199.29

Appendix 5 (continued): Economic costs and benefits, in dollars per acre, in growing meadowfoam, assuming a 150-acre field. Source: OSU Extension Service, Paul Camuso.

FIXED COST Description		Unit	Total	
CASH Cost				
Machinery & Equipment Insurance		acre	$ 6.95	
Land Lease		acre	80.00	
Total CASH Cost			$ 86.95	
NONCASH Cost				
Machinery & Equipment Depreciation and Interest		acre	$ 91.35	
Total FIXED Cost				$ 178.30
NET PROJECTED RETURNS				$ 20.99
Breakeven Price, short-run	$ 0.38 /lb			
Breakeven Price, long-run	$ 0.62 /lb			

Appendix 6: Machinery assumptions used to calculate costs for the establishment and production of fine fescue, perennial ryegrass, and meadowfoam seed.

Machine	Size	List Price	Market Value	Salvage Value	Useful Life	Remaining Life
Tractor	100 hp	$ 55,000	$ 33,000	$ 11,000	6000 hr	7200 hr
Tractor	120 hp	$ 65,000	$ 42,250	$ 19,500	10,000 hr	5,000 hr
Tractor	200 hp	$ 100,000	$ 60,000	$ 20,000	6,000 hr	9,600 hr
ATV		$ 7,000	$ 4,200	$ 1,400	2,000 hr	1,200 hr
Combine (2)	14 ft.	$ 140,000	$ 84,000	$ 28,000	3,000 hr	1,800 hr
Spray Buggy		$ 60,000	$ 36,000	$ 12,000	10,000 hr	6,000 hr
Swather (2)	14 ft.	$ 56,000	$ 33,600	$ 11,200	2,000 hr	1,200 hr
Disk	20 ft.	$ 15,000	$ 9,000	$ 3,000	2,000 hr	1,000 hr
Spike-tooth Harrow	45 ft.	$ 14,000	$ 8,400	$ 2,800	2,000 hr	1,000 hr
Chisel Plow	20 ft.	$ 18,000	$ 10,800	$ 3,600	2,000 hr	1,000 hr
Drill	13 ft.	$ 10,000	$ 6,000	$ 2,000	1,200 hr	720 hr
Flail	14 ft.	$ 12,500	$ 7,500	$ 2,500	1,200 hr	720 hr
Land Leveler	24 ft.	$ 17,500	$ 10,500	$ 3,500	2,000 hr	1,200 hr
Plow-Moldboard	6-bottom	$ 13,000	$ 7,800	$ 2,600	2,000 hr	1,200 hr
Roller	15 ft.	$ 12,000	$ 7,200	$ 2,400	2,000 hr	1,000 hr
Spreader		$ 750	$ 450	$ 150	2,000 hr	1,200 hr
Pickup	3/4 ton	$ 22,000	$ 13,200	$ 4,400	100,000 mi	60,000 mi
Truck (3)	2 ton	$ 27,000	$ 16,200	$ 5,400	100,000 mi	60,000mi

Source: OSU Extension Service

Appendix 7: Cost factors used to calculate estimated health effects due to field burning.

Health Effect:	Population:	Best Estimate:	Source of Data:
Mortality	Average Person	$ 2,040,000	Math Tech, 1983
Work Loss Day (WLD)	Average Oregon Worker	$ 71.40	Oregon Employment Division, 1987
Reduced Activity Day	Workers on Days not WLDs	$ 35.70	Engineering Science and Omni Environmental Services, 1986
Reduced Activity Day	Other Population	$ 17.85	OMNI

Source: Oregon Department of Environmental Quality, 1987.

BIBLIOGRAPHY

Anderson, Chauncey, et al. Distribution of Dissolved Pesticides and Other Water Quality Constituents in Small Streams, and their Relation to Land Use, in the Willamette River Basin, Oregon. Portland, OR: United States Geological Survey, 1997.

In the third stage of the Willamette River Basin Water Quality Study, Anderson et al. measure pesticide concentration levels in the Willamette and attempt to correlate the concentrations to land use. This study presents the increasing concern that pesticide usage on farms is directly contributing to water pollution in Oregon.

Air Resources Center, Oregon State University. "Agricultural Field Burning in the Willamette Valley". Corvallis, OR: Oregon State University, 1969.

This compliation of articles begins with a summary of field burning and its historical origins in Oregon and then discusses the pros and cons of the cultural practice of burning and presents the current alternatives. Although slightly dated, the journal, especially the final article on burning emissions, will help in estimating environmental damage from field burning.

"Burnings, Complaints Lowest on Record". Statesman Journal. 11 Oct. 1997: C5.

Farmers have made efforts to reduce the acreage of fields that are burned. This article is useful because it contains the most current data on field burning. It also characterizes a willing attitude in growers to improve their practices.

Camuso, Paul. Wilco Farmers Field Specialist. Personal Communications. 1998.

Conklin, Frank S. and Douglas E. Fisher. Economic Characteristics of Farms Producing Grass Seed In Oregon's Willamette Valley. Corvallis: Agricultural Experimental Station, Oregon State University, 1973.

This studies the economic well-being of farmers so that alternative growing techniques can be better evaluated. My report may benefit from this in the thorough discussion of ways to lower costs and improve returns.

Conklin, Frank S. Farmer Alternatives to Open Field Burning: An Economic Appraisal. Corvallis: Agricultural Experimental Station, Oregon State University, 1971.

Conklin studies the lowest cost alternatives to field burning. The report is a good example of how to structure an evaluation of alternatives, by comparing similar units and time periods and looking at long-term effects and yields.

Gravelle, Marie. "Air Rules Will Help Farms, EPA Says". Statesman Journal. 29 July 1997: B6.

New EPA regulations set tighter limits on the allowable amounts of ozone and fine particulate pollution. This article is a justification of my study; farmers need to continue to find ways to comply with ever stricter laws and regulations dealing with field burning pollution.

Gravelle, Marie. "Grass Seed Now No. 2 on the Farms". Statesman Journal. 19 Sep. 1997: B6.

The article indicates the economic effects of grass seed in Oregon; it is a major cash crop. Therefore any regulatory or procedural changes to grass seed growing need to be carefully planned, as any change would most likely have an effect on the economy of Oregon.

Gringrich, Gail. Oregon State University Extension Agent. Personal Communications. 1998.

Hassanein, Neva. Northwest Coalition for Alternatives to Pesticides (NCAP) Program Associate. Personal Communications. 1998.

Hughes, Susan B. and David M. Willis. "How Quality Control Concepts Can Reduce Environmental Expenditures". Journal of Cost Management. Summer 1995: 15-19.

Applying the total quality management (TQM) movement to environmental costs, Hughes and Willis mandate that poor quality will cost more in the long run. Therefore it is better to produce high quality initially; prevention is most cost-effective.

Johnson, L. Todd. "Research on Environmental Reporting". Accounting Horizons. September 1993: 118-123.

Environmental reporting is becoming an ever larger issue, with many questions that need to be answered:

1. What should be the basis for recognizing an environmental liability?
2. How should these costs be attributed to certain accounting periods--capitalized or expensed?
3. How should future environmental outlays be measured?
4. Should offsetting of liabilities against anticipated recoveries, such as from insurance or other PRPs(those principly responsible), be permitted?

Liess, Mitchell. "Growing a Weapon Against Weeds". Oregonian. 9 July 1997: E2.

Some grass seed farmers are growing meadowfoam as a primary rotation crop in the absence of field burning.

Meehan, Brian T. "Hazy Days of Summer Are Gone". Oregonian. 27 Aug. 1997: A1.

This discusses how farmers have reduced their burning in the past few years and makes two important points. First, the regulations mandated by the Legislature leveled the playing field for growers; all farmers were forced to find alternatives. Next, field burning will not disappear entirely. Farmers believe it is still needed, as a last resort at the least, to control some weeds and disease that do not respond to alternative treatments.

Miller, Terry. "Pesticide Regulation". September 1993. Online Posting. Extension Toxicology Network (EXTOXNET): ace.orst.edu. February 1998.

This summarizes the Environmental Protection Agency regulation of pesticides in the United States under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).

Murphy, Karen. "Innovative Cropping Systems Can Replace Hazardous Pesticides". Journal of Pesticide Reform. Vol. 17, No. 4. Eugene: Northwest Coalition for Alternatives to Pesticides, 1997.

Murphy discusses how some potato farmers are growing their crops organically--without widespread pesticide use--and producing high yields and quality.

Oregon Dept. of Environmental Quality. "Preliminary Health Effects Evaluation for Pollutants Generated by Field Burning, Slash Burning, and Residential Wood Combustion". Portland: State of Oregon, Dept. of Environmental Quality, 1987.

Analyzing scientific evidence and surveys, the DEQ monetarily values the pollution from field burning due to lost work days, illness and death. This is the only study that has attempted to put a dollar figure on field burning pollution.

Oregon Seed Council. Grass Seed...The Tiny Giant. Salem, OR, 1974.

A report presenting the current efforts undertaken to minimize the effects of field burning. The report is most useful in its scientific discussion of emissions, which may help to characterize and estimate field burning effects.

Oregon State University Extension Service. "Enterprise Budget: Fine Fescue Seed Production". Corvallis: Oregon State University, Aug. 1995.

Estimates costs borne by the farmer in producing fine fescue seed in the Willamette Valley.

Oregon State University Extension Service. "Enterprise Budget: Meadowfoam Seed Production". Corvallis: Oregon State University, Oct. 1997.

Estimates costs borne by the farmer in producing meadowfoam seed in the Willamette Valley.

Oregon State University Extension Service. "Enterprise Budget: Perennial Ryegrass Seed Production". Corvallis: Oregon State University, Oct. 1995.

Estimates costs borne by the farmer in producing perennial ryegrass seed in the Willamette Valley.

Owen, Dave. Green Reporting: Accountancy and the Challenge of the Nineties.

New York: Chapman & Hall, 1992.

Accountants can most help by using their audit skills to facillitate management control of environmental practices and to assess compliance with company policies. Owen's report helps my study by suggesting that a farmer's procedures need to be evaluated on an environmental basis, and that practices need to be established that meet the environmental objectives of the farmer and society.

Pimentel, David, et al. "Environmental and Economic Costs of Pesticide Use".

Bioscience. Vol. 42, No. 10.

In the only attempt to value the indirect costs of pesticide usage, Pimentel values the impacts of pesticides on humans, domestic animals, the loss of natural enemies, pesticide resistance, honeybees, crops, fish and wildlife, birds, groundwater and the government.

Schaltegger, Stefan. Corporate Environmental Accounting. New York: Wiley, 1996.

The three monetary methods for impact assessments are:

1. Damage oriented--measures the monetary loss due to environmental damage or the replacement of environmental goods.
2. Expense oriented--answers what direct costs and opportunity costs people actually accept
3. Market price--asks what people will accept to repair or prevent environmental damage or to protect themselves against environmental interventions

There is no overall accepted technique; each approach answers different questions. Nonetheless, it is agreed that classification (e. g. ozone depletion contribution), characterization, and valuation are the steps of the procedure of impact assessment. A firm must therefore choose its approach by determining which questions are of interest to the company.

Wedin, Dick. "Externalities and Open Field Burning: A Case Study". American

Journal of Agricultural Economics. Dec. 1973: 1026-1029.

Wedin states that the only solution to the economic dilemma of field burning is a double tax-subsidy system in which the non-farm individual pays the grower not to burn. It is important to note here the reciprocal nature of the problem: the nuisance is caused both by the grower's burning and the other's living in proximity.

Young, Bill. Oregon State University Professor and Seed Production Specialist. Personal Communications, 1998.