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An Evaluation of Expected Private Losses from Selected Public Policies for Reducing Open Field Burning, Willamette Valley, Oregon

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The authors accept full responsibility for the content of the document and any errors of omission or commission.

Preface

This document is one of a series of research reports prepared by Oregon State University during the 1970s which focuses on the field burning problem of Oregon's Willamette Valley. The purpose of such research efforts is to assist both the private and public sectors of Oregon in identifying technically feasible, economically viable, and socially acceptable solutions for reducing smoke emission levels from open field burning while maintaining economic viability of the grass seed industry which contributes to the well-being of Oregon's economy. The intent of this report is to assess initial expected economic impacts on individual grass seed producers from a selected number of public policy choices suggested for reducing open field burning.

A companion grass seed market study, soon to be published, will evaluate industry adjustments expected from market supply and demand conditions which may be influenced by public policy choices to control field burning.

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AN EVALUATION OF EXPECTED PRIVATE LOSSES FROM SELECTED PUBLIC POLICIES FOR REDUCING OPEN FIELD BURNING, WILLAMETTE VALLEY, OREGON

Frank S. Conklin and R. Carlyle Bradshaw

PROBLEM SETTING

Open field burning has been used widely by Oregon's Willamette Valley grass seed producers since the 1940s as a cultural practice to control plant diseases, insect pests, and weeds, and to dispose of large volumes of straw and stubble having low market value [17]. By 1969, nearly 310,000 acres, from a total of 500,000 acres, of grass and cereal cropland were open field burned. This practice has served as a least cost measure to producers in removing more than one million tons of post-harvest residue annually [10,11].

The field burning season, which extends from July through October, generates highly visible smoke plumes, an easily identifiable source of air pollution. With prevailing northwesterly winds and temperature inversions, there is an accentuation of smoke concentration from a number of sources, including open field burning, into the Eugene-Springfield metropolitan area of the Valley. The smoke and its contributory aggravation to respiratory health ailments, driving hazards, soiling damage, and nuisance effects are a major public concern [8].

Public concerns about environmental quality emerged in the 1960s. Initial response by Oregon's grass seed industry involved self-initiated regulation of smoke from open field burning using an aerial sky watch. The first interim public control measures were enacted in 1969. In 1971, the State Legislature implemented more permanent controls and authorized the Department of Environmental Quality (DEQ), established in 1969, to enforce and regulate a statewide environmental program, including control over field burning. The Federal Environmental Protection Agency (EPA), formed by the U.S. Congress in 1970 to establish environmental standards at the federal level, endorsed the Oregon control measures. Meteorological monitorings, daily acreage burning quotas, and the farmers sky watch were components of the initial DEQ program. Also, in 1971, the Oregon Legislature passed a bill to ban open field burning after January 1, 1975, contingent upon satisfactory development of an alternative to open field burning [31]. A $1 per acre grower fee with matching funds from the State was earmarked for private and public research to develop mobile field sanitizers, evaluate applicability of technology for straw collection and utilization, and promote marketing of straw. Daily burn quotas and meteorological monitorings continued in force.

In 1975, the Oregon Legislature passed Senate Bill 311 which established a phasedown of open field burning over a four-year period. This phasedown set 234,000 acres in 1975, 195,000 acres in 1976, 95,000 acres in 1977, and 50,000 acres in 1978 and thereafter, as maximum allowable open field burning limits [32]. Burning fees were increased incrementally from $3 per acre in 1975 to a maximum of $8 per acre in 1978. The fee was designed to serve both as an economic disincentive for open burning and to provide a stable revenue source for research as acres open burned were reduced.

In July 1977, the State Legislature passed House Bill 2196 to replace Senate Bill 311 [33]. H.B. 2196 was the outgrowth of strong grass seed industry efforts to have the acreage phasedown of S.B. 311 eased, since economically viable alternatives to open field burning had not been forthcoming. Grass seed producers argued that, under these circumstances, the phasedown would impose severe short-run economic losses, and perhaps cripple the industry. These producers also viewed the phasedown as being discriminatory in singling out the grass seed industry. At present, limited controls upon timber, industrial, and vehicular sources of air pollution are imposed which focus upon controlling emission in the South Willamette Valley for the Eugene-Springfield metropolitan area.1/ DEQ monitoring information

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1/ ORS Chapters 476 and 478 Statutes allow forest slash burning under permit pursuant to joint rules established among DEQ, the Oregon Forestry Department, and the U.S. Forest Service. The State Forestry Department has authority to determine days on which burning is allowed, its location, and magnitude on federal, state, and private forest land. Industrial sources are subject to contaminant source permits and minimal compliance schedules. Vehicular emission checks, a condition for licensing, are administered biennially only for the Portland area.

through 1977 indicated that smoke from sources other than open burning may contribute significantly to the smog problem in the Eugene area during the field burning season, as well as throughout the year [28,29]. In 1978, DEQ began placing more equipment throughout the Valley to provide a more systematic and continuous means for monitoring and evaluating air emission levels and their sources. The growers held out for 235,000 acres to be burned in 1977, with both the House and Senate passing such legislation. The bill was vetoed by the Governor. As a compromise measure, House Bill 2196 was passed by the Legislature and signed by the Governor [33]. It permits 195,000 acres to be burned in 1977, and 180,000 acres in 1978, with authority vested in DEQ to set acreage quotas after 1978 in accordance with state and federal air quality standards and development of economically feasible alternatives to open field burning. An advisory committee was established to replace the Field Sanitation Committee. A $2.50/acre annual burning fee assessment to growers, in addition to a $1/acre nonrefundable registration fee, was established to replace the incremental fee of S.B. 311. Some $400,000 of these fees are earmarked for smoke management, and the remainder is used for research on straw utilization, cropping alternatives, and public health effects. Open-endedness of the law after 1978 suggests further legislation in 1979.

Early in 1978, EPA declared jurisdictional control over air quality issues in Oregon on procedural grounds. Their federal mandate allows for such control when (1) non-point pollution, which includes air quality, exists, and (2) state implementation plans for improvement of air quality do not meet EPA procedural requirements. This occurred in the Oregon case when the DEQ implementation plan for converting from S.B. 311 to H.B. 2196 did not follow the required public hearing process. DEQ's alternatives were to (1) conduct hearings in 1978, or (2) prepare an interim plan by mutual consent of affected growers and Eugene citizenry for the 1978 burning season. The second course of action was followed since public hearings could not be conducted prior to the 1978 burning season. The agreed upon interim plan permits up to 180,000 acres maximum to be open field burned, but under stricter rules for smoke management. These new rules include (1) a 12 percent maximum moisture limitation for straw burning after August 15, and (2) open burning by backfiring rather than the traditional upwind or forward firing procedure. This compromise measure to meet federal requirements places even more pressure upon the political process for further state legislation in 1979.

Legislated controls are necessary where waste by-products, called externalities, affect the use of resources that are utilized by many or all people. These resources are referred to as common property resources. Without legislation, open field burning very likely would continue to deteriorate air quality, a common property resource, in the Valley as long as it was a least cost cultural practice to growers. The need for legislation arises because market forces, which account for grass seed purchases and sales, neither compensate for social losses from reduced air quality nor charge a use right to grass seed producers in the private sector. Problems of externalities are not unique to air, but embrace other common property resources, including water, land, and minerals [3,39].

To legislate and administer effective and flexible environmental controls, which are consistent with public desire on the one hand, while encouraging agricultural and industrial efficiency and market competition on the other, are a dilemma of no small magnitude. Tradeoffs between economic efficiency, market concentration, employment, environmental quality, income distribution, and personal freedoms become the hard choices [3,39]. While it is generally recognized that different choices will have different impacts, the magnitudes of expected tradeoffs have not been quantified. The intent of this study is to focus upon that portion of expected tradeoffs which affect grass seed producers from a selected set of actual and proposed policies intended to control air quality from open field burning.

PURPOSE OF STUDY

A variety of measures have been advanced to reduce smoke emissions from field burning. Unfortunately, none have been subjected to rigorous economic analysis to compare probable gains and losses upon grass seed producers in the private sector against probable gains and losses to the public. The purpose of this study is to focus upon the private sector by providing quantitative economic estimates of probable grower effects. The procedures to be followed in achieving the study objectives are to:

1. Outline the physical and economic environment of grass seed production in the Willamette Valley of Oregon.
2. Identify a range of choices for improving air quality and select from them a set of policy alternatives for quantitative evaluation.
3. Develop a quantitative model which characterizes the principal features of grass seed production in the Willamette Valley under (a) traditional open field burning, and (b) the selected policy alternatives.
4. Use traditional open field burning as the benchmark to compare economic effects associated with selected policy alternatives.
5. Evaluate the results in terms of probable physical and economic adjustments at the grass seed producer and industry levels.
6. Provide research recommendations for evaluation of unresolved issues in the field burning controversy.

The economic effect upon grass seed producers and corresponding air emission level reductions are expected to be different with alternative environmental control policies. Unfortunately, the magnitude of those differences is not clear because of the complexity of the issues and the only recent acquisition of monitoring equipment for measuring air quality levels. The magnitude of economic adjustments, including short-run gains and/or losses to individual grass seed producers and the industry associated with policies intended to control air emissions, is also unclear. Although the particular policy selected for implementation ultimately is resolved in the political arena, a useful input toward that resolution involves an estimation of probable or likely economic effects. That is the purpose of this study. Additional research is planned to evaluate social and health damages from reduced air quality, the relative role of field burning as a contributor to such reduced air quality, and long-run impacts of legislated policies. These issues are beyond the scope of this study. However, their evaluation will be important to a meaningful resolution of Oregon's field burning controversy.

CHARACTERISTICS OF WILLAMETTE VALLEY GRASS SEED PRODUCTION

Physical Features

Nearly all Oregon's grass seed production is concentrated in the Willamette Valley. Eight major grass seed types -- annual ryegrass, perennial ryegrass, orchardgrass, tall fescue, bentgrass, fine fescue, Merion Kentucky bluegrass, and other Kentucky bluegrass -- collectively account for more than 50 percent of the world's cool season grass seed production. The cool and moist springs favor seed pollination, while the warm and dry summers enhance seed maturation, thus providing the Willamette Valley with a natural advantage in supplying premium quality grass seeds to domestic and foreign markets for lawn and turf, cover crop, and pasture grass purposes [10].

A 1969 study of grass seed producers showed considerable farm size, cropping pattern, and income diversity within the industry [11]. This diversity is due in part to variability of topography and soil characteristics within the Valley and the ability of grass seed types to grow under well, medium, or poorly-drained land conditions.

More than 500,000 acres of the Valley floor consist of poorly-drained Dayton and Wapato (called "Whiteland") soil series. The topsoil is excellent, but has serious drainage problems caused by a nearly impermeable hardpan layer some 16 to 24 inches below the surface. Only a limited number of field crops will tolerate the high water table in the winter on these soils without extensive land reclamation. These crops include annual ryegrass, perennial ryegrass, grass pasture for livestock, spring-sown oats, alsike clover, and oats and vetch [13].

Medium drained soils of the Woodburn, Polk, and Aiken soil series form the transition between the poorly-drained Valley floor and the well drained benchlands. This soil type includes much of the rolling hill lands. Tall fescue, orchardgrass, and small grains can be produced on the medium drained lands, as well as the above listed crops that tolerate production on poorly-drained land.

Well-drained soils of the Willamette, Chehalis, and Newburg soil series comprise much of the benchland on which intensive fruit, vegetable, and ornamental cropping occurs for which the Valley is famous. These crops require supplemental irrigation, however. Without irrigation, the benchlands will produce only the crops grown on poor and medium-drained lands plus the bluegrasses and fine fescue grasses.

Production of specific grass seed types is concentrated according to the geographical distribution of Valley soils. Nearly all annual and perennial ryegrass production is confined to Linn, Benton, and Lane counties where the poorly-drained "Whiteland" soils dominate. Fine fescue is grown on the well-drained lands, principally in the hilly areas of Clackamas, Multnomah, and Marion Counties. Highland bentgrass, which can be grown both on medium and well-drained soils generally is confined to hill lands of Marion County since it is viewed as an undesirable weedy grass elsewhere [7]. Polk County combines grain production on the medium-drained hill lands with ryegrass production on the lowlands. Tall fescue and orchardgrass are dispersed throughout the Valley on medium-drained lands, as are bluegrasses on the well-drained lands.

Poor, medium, and well-drained lands often are interspersed with each other. For example, ryegrass farms on the poorly-drained "Whiteland" soils of Linn, Benton, and Lane Counties typically have some medium and well-drained soils, hence produce a number of crops in addition to the ryegrasses.

Economic Features

Forces, in addition to physical and biological ones, influence grass seed production over time. These include technical, market, and institutional changes. Technology alters the relative importance of specific production inputs and physical output. Market forces of supply and demand alter farm earnings from year to year and relative profitability among enterprise choices. Institutional forces, including environmental controls, change relative profitabilities of choices by modifying the incentive structure. In the next sections, previous research is drawn upon to outline the combined effects which physical, technical, institutional, and market forces have had upon the industry and individual growers in recent years.

Market Level

The Willamette Valley grass seed industry is comprised of an estimated 800 commercial farmers who buy and sell in essentially a perfectly competitive market. Domestically, Oregon's grass seed growers produce more than 90 percent of U.S. production of annual ryegrass, perennial ryegrass, bentgrass, and fine fescues. They produce a significant but smaller percentage of U.S.-produced bluegrass, orchardgrass, and tall fescue. Oregon competes with growers in the northern Great Plains, southern states, and Washington and Idaho regions in production of the cool season grasses. About 15 percent of the U.S.-produced cool season grasses is exported into international markets. This includes bentgrass, ryegrass, tall fescue, fine fescue, and bluegrass. Essentially all U.S.-produced bentgrass is exported. The principal export markets for grass seed are the European Economic Community (EEC), Canada, Europe, Japan, and Mexico. Some trade restrictions on U.S. grass seed exports exist which involve foreign producer subsidies and non-tariff (quality) trade barriers by the importing countries [24].

In this market setting, the grass seed growers, not unlike U.S. farmers generally, have little, if any, control over the price of the production units which they buy, or the grass seed which they sell. Market prices for grass seed and production inputs have felt the effect of considerable inflationary pressures since 1970 [10]. Since then, grass seed production costs per acre have doubled but in recent years the price of grass seed has declined with considerable year to year variation contributing to income instability. The combination of such price and cost factors contributes to "cost-price squeeze" pressures at both the industry and grower levels.

Grower Level

At the grower level, great variability exists between farms in cost and income generating characteristics. Diverse farm location, size, capital investment, and management are major contributory factors. Farmers are keenly competitive with other farmers, with the primary means involving adoption of technology which, historically, has reduced production costs per unit of output. A major form of technology has been labor substituting machinery. This machinery is a major fixed investment which requires high utilization to avoid excess capacity and to achieve size economies for reducing unit production costs. While limits to size economies may provide an upper bound for expansion, the trend of increased farm size, and fewer growers suggest considerable desire by the more economically efficient operators to buy or rent land as add-on units from those who are retiring or cannot compete because of low economic returns. The principal beneficiary of this process has been the seed consuming public, similar to the phenomena in the majority of U.S. agriculture [45].

Essentially all commercial grass seed growers in Linn, Benton, and Lane counties have from two to five grass seed types on their farms. While about two-thirds of the cropland was poorly drained, another one-fourth was medium drained, and 9 percent well drained. Nearly all those farms also had small amounts of pasture, row crops, and small grains. While soil type variation appears to explain much of this crop diversity, existence of multiple grass seed enterprises, particularly a combination of annual ryegrass with the perennial grasses, apparently also provides some flexibility against market price variation and complementarity in use of specialized farm machinery during the production and harvest seasons. Machine use complementarity is possible because field operations and managerial practices are similar across grass seed types, but do not necessarily occur at the same time for each seed type.

A large portion of the grass seed producers respond very sluggishly to changes in market prices for their crops. This is particularly true for those whose farms are located on the poorly-drained Valley floorlands which have few alternative crops, other than annual and perennial ryegrass, which will survive winter flooding. While these soils could be reclaimed by drainage and supplemental irrigation for production of intensive crops, the cost would be high. Hence, operators on these soils tend to produce grass seed with seemingly little adjustment to price fluctuations, as they have few alternatives [10].

Major technological breakthroughs in developing economically viable alternatives to open field burning without significant reduction in grass seed yields and/or farm income have not been forthcoming. A major thrust has involved development of mobile field sanitizers to provide thermal sanitation. To date, technical problems of metal fatigue, emission levels, operator safety, and field operating speed have not been overcome. Until these problems are resolved, commercial production and grower adoption of thermal sanitizers are not expected. Chemical and biological disease control measures are not yet technically feasible [26,27].

Residue removal and its market utilization have been viewed as a companion to the mobile field sanitizer to increase its field operation rate and potential for economic viability. But straw utilization has serious market limitations, even though it is technically feasible to use in manufacture of paper and fiberboard products, oil, gasoline, presto-logs, plastics, composted fertilizer, and microbial protein [9,38]. Unfortunately, the residue is expensive to compact and transport. Therefore, to date, straw is a poor competitor to alternative manufacturing raw materials [7,27]. Uncertainty of long-term straw supplies also contributes to industry hesitancy in considering straw as a potential raw material.

Agriculture has little use for the grass straw because it is low in protein and high in cellulose and lignin fiber, which confines its utility in livestock feeding to winter maintenance rations for non-pregnant mature cattle, or as a fiber source in a feedmix [34]. Improved palatability and digestibility by chemical and/or mechanical means are possible, but economically unattractive. Several thousand tons of non-treated straw have been marketed annually for livestock feed in recent years. An aggressive state-sponsored marketing program in 1976 and 1977, severe drought conditions on Eastern Oregon ranges, and high priced alfalfa hay contributed to unsubstantiated estimates of between 50,000 and 100,000 tons of straw marketed in each of those years. This is still a small fraction of the one million or so tons of grass straw produced annually, and those marketings occurred under short supply conditions for alfalfa hay. The general lack of high quality, low cost feed in the Willamette Valley appears to be an important factor explaining why large-scale livestock feeding, such as exists in the Midwest and irrigated Rocky Mountain regions, has not developed in Oregon [23].

SETTING ENVIRONMENTAL STANDARDS

Several policies have been considered by the political process for reducing smoke emissions in Oregon's Willamette Valley. In addition, a number of policy options have been used by state and federal regulatory agencies in recent years for controlling environmental degradation in the U.S. These include (1) establishment of standards which specify maximum acceptable emission levels, (2) levying of taxes or charges on emissions, and/or (3) social subsidies applied to lesser or non-polluting activities to encourage their adoption [1,3].

A well-known example of a standard is the establishment of a specified maximum emission level for the automobile. So also is a ban on open field burning. The intent of the standard is to provide a mechanism whereby emissions are controlled within some acceptable level. Auto emissions are to be limited to this level by owners of motor vehicles bearing the cost of emission control devices on their cars. These costs are passed onto the consumers of autos by the car manufacturer with an increase in the car purchase price plus any repairs required on the device over time to keep it within tolerance limits. The ban on open field burning conceptually is the same, with two major differences. First, the tolerance level is zero if it is an absolute ban, and second, individual grass seed growers operate in a perfectly competitive market with no control over market prices. Thus, they must absorb production losses and/or increased production costs, at least in the short-run. Car manufacturers, being oligopolistic in nature, can and do pass on additional costs associated with environmental standards directly to the consumer. In the long-run, however, consumers of grass seed become the recipients of increased production costs when such cost increases occur industrywide. They also become recipients of industrywide technology adoption which is cost-reducing. The extent to which such technology will come about to override cost-increasing environmental controls is unknown.

A charge or tax levy may be illustrated by controls on sewage effluent from industry and cities. There a charge is levied for the right to pollute. Examples of proposals for taxing polluters include a tax on lead additives in gasoline and/or sulphur dioxide emissions from fossil fuel combustion and taxes on industrial effluents discharged into public waterways. Several states utilize effluent charges to control water pollution [1,14]. Acreage burning fees provide an example of a charge or tax levy to grass seed producers.

Social subsidies are another choice. They are designed to enhance the economic position of low or non-polluting activities relative to high polluting ones by changing the relative internal costs for non-polluting versus polluting activities. The State of Oregon enacted legislation whereby tax credits are given to agricultural producers who acquire certain facilities which reduce air or water pollution [25]. For the grass seed producers, the mobile field sanitizer probably will qualify for a tax credit if it becomes commercially feasible. This choice has not received high marks by economists, however, because of its focus upon reduced losses which may not be adequate to reduce discharges into the environment [1].

POLICIES SELECTED FOR EVALUATION

A number of policy choices have been in effect, are in effect now, or have been proposed as plausible alternatives for reducing air emissions from open burning of grass seed fields in the Willamette Valley. The choices selected for evaluation are identified and described in this section. This information is intended to provide background for quantifying the relationships associated with such policies to be used in a model to evaluate probable grower and industry impacts.

Controlled phasedown of open field burning, discussed in the previous section, is a general policy now in force. Specific dimensions dictated by political forces have changed over time. Senate Bill 311, passed in 1975, will be evaluated. It involves a step-wise phasedown of allowable acres open burned over a four-year period from 234,000 acres in 1975 to 50,000 acres in 1978. House Bill 2196, passed in 1972 to replace S.B. 311, also will be evaluated. This bill sets 195,000 acres in 1977 and 180,000 acres in 1978 as maximum allowable acres to open burn. Jurisdictional issues arising in 1978 have added new restrictions to H.B. 2196 requirements for the 1978 burning season. This includes field backfiring and 12 percent moisture limitation requirements for field burning. This modification for 1978 also will be evaluated.

In terms of plausible alternative policy choices, development of commercial mobile field sanitizers has received the most attention. It has been advanced both by technology proponents and an urban constituency from Eugene led by Mayor Les Anderson. The concept was developed by Oregon State University agricultural engineers in the 1960s, followed by construction of the world's first experimental mechanical mobile sanitizer in 1970. Construction and experimental operation of several prototype models occurred from 1974 through 1976. Operation of the prototype models was beset with major field problems resulting in increased grass seed grower skepticism as to their potential commercial feasibility because of the problems mentioned earlier. A 1978 evaluation study, conducted under DEQ auspices, concluded that no further research monies, using grower burning fees, would be devoted to perfecting mobile field sanitizers. With subsequent endorsement of the study by DEQ, it appears that development of mobile field sanitizers is a mute issue, at least for the time being. However, the mobile sanitizer choice is evaluated to provide a preliminary assessment of its economic effects, under a current state-of-the-arts condition, relative to other policy choices.

Problems which remain with the prototype field sanitizers result in high ownership and operating costs. To lessen the cost factor, some people have recommended a policy choice which combines mobile field sanitation with controlled open burning on those acres not mobile field sanitized. This choice is predicated upon continued use and improvement of the smoke management program administered by DEQ and commercial use of field sanitizers. While smoke management is not the magic of disappearance, the premise of this approach is that smoke can be controlled adequately to keep it away from densely populated areas. Since 1969, the year of smoke management inception, results of the program have been mixed. In several years there was less than usual smoke impact on Eugene, but the incidence of complaints in the Lebanon and Sweet Home areas increased. In 1977, a year of early fall rains, the incidence of smoke complaints in the Eugene area rose again. Unfortunately, a smoke management program requires that the smoke go somewhere, and to date, there is limited controllability to push smoke to high altitudes or dilute it to negligible impact levels. Weather, an uncertain factor, is also critical to success of such a program. This study evaluates that policy option under the assumptions that it is a politically acceptable alternative, and that about one-half the total grass seed acreage is sanitized by machine with the other half open burned on a DEQ-managed basis.

Research funds aimed at reaching a satisfactory solution to the field burning problem are being directed away from sanitizer development and toward more careful and accurate smoke management programs. This is viewed by many as an interim solution until economically feasible and politically acceptable solutions of a long-run nature can be found. A plausible dimension of this type of program might involve a DEQ-controlled smoke management program which permits maximum allowable open field burning acreage not to exceed 50 percent of total acres of grass seed in production. This could be interpreted as an open burning program on an alternate year equivalent basis. This alternative also is chosen for evaluation.

An alternative policy suggested by a number of urban constituents involves no thermal sanitation with all residue removal mechanically. This alternative eliminates all thermal treatment. With annual ryegrass, the straw could be plowed under each year. However, with the perennial grasses, the straw must be removed to keep subsequent year regrowth from being smothered entirely. Any straw not sold commercially is assumed to remain in field side stacks to rot. This alternative also is evaluated.

A charge or tax levy is a policy choice employed by some states to serve as an economic disincentive for pollution and as a revenue source for research or other purposes. The tax serves as a property access right to use public resources such as air, water, and land for private pollution purposes. The present field burning fees appear to serve more generally as a revenue source for research on field burning alternatives than as an economic disincentive to pollute. Consequently, taxing as a policy choice is evaluated in this study over a range of charge levels to estimate grower adjustment sensitivity to this policy choice.

Subsidies, or tax credits, were mentioned in the previous section as a policy choice. Tax credits available include investment tax credit for use of field burning equipment, such as sanitizer and straw removal equipment, as well as other capital improvements, such as drain tiling, which encourages production of alternative crops to grass seeds. Tax credits were not chosen for analysis in this study because cost savings from those which exist appear to be ineffective in eliciting grower change from the status quo.

A summary of policy alternatives selected for evaluation of probable grass seed grower adjustments and relative economic effects include:

1. Thermal sanitation
   - by mobile field sanitizer
   - by mobile field sanitizer and controlled open field burning combination
   - by DEQ-controlled open field burning on alternate year equivalent basis
2. No thermal sanitation with crop residue removed by mechanical means.

3. Controlled phasedown of open field burning
   - Oregon S.B. 311
   - Oregon H.B. 2196
   - Oregon H.B. 2196 plus field backfiring in 1978

4. State charge on open field burning.

MODELING A GRASS SEED FARM

General Model

Quadratic programming was selected as the quantitative model for evaluating expected initial cropping adjustment and income effects to selected public policy alternatives at the grower level. QP is a conditionally normative model, generating optimum strategies for a given set of conditions, in which the objective function minimizes income variance for all levels of income generated within a feasible set.

The QP algorithm used in this study was developed at Oregon State University by Bauer [2]. It is expressed algebraically as:

$$\text{minimize } V = \sum_{j=1}^{n} \delta_j^2 x_j + \sum_{j=1}^{n} \sum_{i<j} r_{ij} \quad \delta_i \delta_j x_i x_j$$

$$\text{subject to:} \quad \sum_{j=1}^{n} P_j x_j = E°$$

$$\sum_{j=1}^{n} a_{kj} x_j \leq b_k \quad (k = 1,2,\ldots,m)$$

$$x_j \geq 0 \quad (j = ,1,2,\ldots n)$$

where: V is the variance of gross margin (return over operating cost) evaluated at E°.

δ_i^2 or δ_j^2 is the variance of gross margin per unit of x_i and x_j.

x_j is the level of the jth activity.

r_{ij} is the correlation coefficient between the gross margin of x_i and x_j.

P_j is the gross margin of the jth activity.

E° is some specified level of gross margin.

a_{kj} is the amount of the kth resource used per unit of the jth activity.

b_k is the amount of the kth resource available.

Implicit assumptions of the quadratic programming algorithm include (1) a linear production response, (2) fractional units for inputs and outputs, (3) finite number of activities and resource restrictions, (4) single valued resource levels and input coefficients, and (5) interaction effects between activities.

Data requirements include (1) specification of farm resource base, (2) input-output coefficients of the production process for each activity, (3) input prices, (4) mean yields and prices for each activity, (5) variance of prices and yields for each activity, and (6) correlation coefficients between activities for price and yield interactions.

The optimizing procedure of the algorithm is to pick, for a specified level of gross margin coming from a finite but large set of feasible activity combinations, that plan with the smallest variance. This procedure evaluates all gross margin choices using minimum variance as the "risk efficient" selection criteria. The minimum variances, corresponding to given gross margins, can be plotted as an efficiency frontier. A graphic example of an efficiency frontier plots gross margin on one axis with variance or standard deviation on the other axis. For any plan of resource use above and to the left of the efficiency frontier boundary, where gross margin is on the horizontal axis as the independent variable, there exists a plan on the boundary which gives a smaller standard deviation for a given gross margin or greater gross margin with a given standard deviation. Points below and to the right of the efficiency frontier cannot be obtained. The procedure of the algorithm derives the efficiency frontier by minimizing variance for a given gross margin. A corollary procedure used by some algorithms is to maximize gross margin for a specified level of variance. The two procedures generate identical results.

For all activities which lie on the efficiency frontier, there is a tradeoff between gross margin and its associated income variability. Solutions near the origin of the efficiency frontier represent choices with low gross margins and correspondingly low variation. While these choices do not generate much income, they also have low income risk relative to solutions further to the right on the efficiency frontier which have both higher gross margins and higher income variability. The plan on the efficiency frontier with the largest gross margin and the largest income variability coincides with the solution provided by non-risk linear programming.

The "best" or "preferred" plan on the efficiency frontier is selected by the user of the model. It is subject to a decision maker's own attitude of preference or aversion to uncertainty and the set of conditions, such as debt load, which influence or change that attitude over time. Plans selected on the lower portion of the efficiency frontier have lower income capability, but also less income variability or "riskiness" than those plans further up and to the right, or nearer the traditional non-risk linear program solution on the efficiency frontier [18]. Decision maker attitudes toward uncertain events for determining the most preferred point on the efficiency frontier may be quantified empirically by utility function analysis, direct selection by a decision maker of the most preferred plan from choices available on the efficiency frontier, or researcher selection of a plan on the efficiency frontier which comes closest to representing observed reality. The third method is used in this study.

The Grass Seed Farm Model

The procedure used to model a grass seed farm initially involves typifying the dominant or usual grass seed farm situation in the Valley, including major characteristics which reflect diversity of grass seed production. To do so, the grass seed farm model was developed to represent the most usual or typical production and economic conditions found on grass seed farms in Linn, Benton, and Lane Counties in 1977. Grass seed production in these counties is characterized by dominance of annual ryegrass with existence of other grass seed where improved soil drainage conditions exist. Specific components of the model are described in the following sections. The second step involves optimization and validation of the grass seed model to represent the open burn benchmark situation against which alternative policies are compared.

Resource Restraints

Land serves as the only direct resource limitation in the model. Farm acreages identified by soil drainage characteristics typical of grass seed farms in Linn, Benton, and Lane Counties, shown in Table 1, are used in the model. The land base involves 770 crop acres consisting of 505 acres of poorly-drained, 190 acres of medium-drained, and 75 acres of well-drained land. Non-cropland acreage was excluded in the model since the study is confined to cropland adjustment of an initial or short-run nature in which capital investment adjustments have not had time to take place.

Table 1. Average Acreage Per Farm and Grass Seed Acres by Soil Type from 67 Sample Farms in Linn, Benton, and Lane Counties, 1969

Soil type and grass seed crop	Number of acres	Percent
Poorly-drained land	(505)	66
Annual ryegrass	333	
Perennial ryegrass	107	
Pasture and spring sown oats	65	
Medium-drained land	(190)	25
Orchardgrass	72	
Tall fescue	54	
Bentgrass	48	
Small grains (excluding oats)	16	
Well-drained land	(75)	9
Bluegrass	61	
Fine fescue	14	
SUB-TOTAL	770	100
Other crops (primarily row crops on well-drained lands)	33	
Pasture, timber, farmstead roads, and rights-of-way	73	
TOTAL	876	

SOURCE: Table 6, page 27 of Conklin and Fisher [11] and direct interpretation of the 67 field questionnaires from that study.

Cropping Choices

The purpose of the study is to evaluate economic adjustments expected as open field burning is reduced or eliminated as a viable farming practice. This implies that second-best economic alternatives will be chosen by grass seed growers so as to minimize changes in income reduction and income variability. Modeling this situation requires inclusion of all crop enterprises now being grown on each of the three soil drainage types, as well as those crop and livestock enterprises which could be produced, but historically have not been because of economic reasons.

The technically feasible set of crop choices included in the model for poor, medium, and well-drained lands is listed in Table 2. A number of crop and livestock enterprises have been excluded from this list for technical and economic reasons.

Table 2. Crop Choices Included in Grass Seed Farm Model by Land Drainage Type

Poorly drained land	Medium drained land	Well drained land
Annual ryegrass	Annual ryegrass	Annual ryegrass
Annual ryegrass/ summer fallow	Annual ryegrass/ summer fallow	Annual ryegrass/ summer fallow
Perennial ryegrass	Perennial ryegrass	Perennial ryegrass
Spring oats	Spring oats	Spring oats
	Orchardgrass	Orchardgrass
	Bentgrass	Bentgrass
	Tall fescue	Tall fescue
	Fall wheat	Fall wheat
	Alfalfa a/	Alfalfa a/
	Bush beans a/	Bush beans a/
	Sweet corn a/	Sweet corn a/
		Kentucky bluegrass
		Fine fescue

a/ Investment in irrigation equipment required.

The entire class of intensive crops, including cane berries, sweet corn, and bush beans is excluded from consideration on poorly-drained soil. To grow these crops would require capital investment in drainage and summer irrigation facilities by the farmer. This is unlikely to occur for a number of reasons. First, for farm drainage to be effective, regional drainage districts would have to be formed and capital generated because simple farm drainage merely transfers winter surface water accumulation from one farm to another. Secondly, even if irrigation and drainage problems were resolved, the added costs of doing so place these farmers at a comparative economic disadvantage relative to farmers having better lands who now grow the intensive crops [10]. Thirdly, processing contracts provide the only access to market for most intensive crops, and current market conditions suggest extremely limited opportunities for expansion. In years when carryover stocks are high, some farmers cannot obtain contracts so are forced to produce less intensive, lower income crops. Adequate acreage for expansion of intensive crops on well drained lands exists in the foreseeable future. Historically, the only evidence of intensive crop expansion onto poorly drained soils has occurred where the dominant farm soil type involved medium and well drained lands, a historical contract existed, and expansion onto poor lands had a reasonable chance for economic payoff in conjunction with the total farm operation.

Historically, beef and sheep operations have not been economically attractive alternatives in the Valley except on a supplemental basis. High price risk, high capital investment, and lack of high quality-low cost feed sources in the Valley and the Pacific Northwest generally have discouraged livestock feeding [23]. This in turn eliminates any real demand for pasture, except that which the grass seed fields provide. There is no evidence to suggest these economic conditions have changed. Consequently, pasture and livestock enterprises were excluded from the model.

Oats and vetch, as a hay crop, while technically feasible for production on any of the soil types, were eliminated from consideration on economic grounds. Historical cost and return information indicate negative returns for those crops [30].

As indicated earlier, some bentgrasses will tolerate "wet feet" in the winter, as do the ryegrasses. Bentgrass was excluded as a crop choice on poorly-drained land, however. This native of Western Oregon, once established, is very hardy and difficult to get rid of because of its rhizomous propagation characteristics. Consequently, bentgrass has consistently been viewed as a noxious weed by most ryegrass growers, and great care has been exercised to see that it does not become established on the poorly drained lands [5]. This situation is not expected to change unless market prospects for bentgrass expand drastically relative to ryegrasses, an unlikely prospect.

Bush beans, sweet corn, and alfalfa are considered technically feasible crop choices on medium and well-drained soils with supplemental summer irrigation. Capital investment in such facilities is required and those costs are included in the analysis.

Data Sources and Estimating Procedures

Gross margin per acre was calculated for each crop activity representing estimated conditions for 1977. Gross margin is gross returns minus operating costs per acre. Gross return is calculated as price times yield per acre. Gross margins and associated income dispersion characteristics for each crop choice included in the analysis are presented in Table 3.

The 1977 farmgate price used for each crop activity is a calculated historical mean annual farm price reported in Oregon for the 10-year period from 1967 through 1976. Variance of the farmgate price was calculated from the same data base.

The 1977 farm yield for each grass seed crop activity was estimated from a linear trend equation using historical Willamette Valley yields for the 10-year period from 1967 through 1976. This procedure was used in lieu of a simple average because of technology effects affecting yields. This situation is reported in another study [12]. The estimated 1977 yield per acre from the trend line was used in this study. Yield variance also was calculated from the same data base. It was assumed, and supported by agronomic evidence, that the yield of a given grass seed crop is the same whether grown on poor, medium, or well drained lands [4].

Operating cost components per acre for 1977 were obtained from the 1969 Conklin-Fisher study and adjusted for price increases to 1977 using a USDA price index for "all production inputs" [11,42]. The average input cost increase of 86 percent that occurred from 1969 through 1976 is reflected in the costs used in the study. Per acre operating costs include machine operating costs, materials, and amortized stand establishment costs for "average cost farms" specified in the Conklin-Fisher study. Annual operating costs for the grass seed crops include a $1 per acre permit fee for the controlled smoke management program established by the 1973 Oregon

Table 3. 1977 Yield, Cost, Income, and Income Dispersion Components Per Acre for Crops Included in Grass Seed Farm Model, Open Field Burning Conditions Assumed

Crop	Suitability by land drainage type: Poorly-drained	Suitability by land drainage type: Medium-drained	Suitability by land drainage type: Well-drained	Yield[a]	Variance of yield[b]	Farm price[c]	Variance farm price[d]	Gross returns[e]	Annual operating cost[f]	Gross margin[g]	Variance gross margin[h]	Coefficient of variation[i]
Annual Ryegrass....................	X	X	X	1394 lbs.	16,302	$ .089	$ .00166	$124.07	$ 55.01	$ 69.06	$ 3,382	.84
2 years Annual Ryegrass/ Summer Fallow..................	X	X	X	967 lbs.[j]	7,845	.089	.00166	86.05	46.17	39.88	1,627	1.01
Perennial Ryegrass................	X	X	X	757 lbs.	10,790	.176	.00845	133.23	60.30	72.93	5,268	1.00
Spring Oats.......................	X	X	X	63 bu.	40	1.13	.23165	71.19	32.36	38.83	981	.81
Orchardgrass......................		X	X	728 lbs.	1,563	.274	.00228	199.47	79.10	120.37	1,324	.30
Bentgrass.........................		X	X	346 lbs.	315	.445	.01016	153.97	68.52	85.45	1,282	.42
Tall Fescue.......................		X	X	715 lbs.	8,094	.159	.0026	113.69	78.02	35.67	1,555	1.11
Fall Wheat........................		X	X	73 bu.	26	2.45	1.8889	178.85	70.61	108.24	10,273	.94
Alfalfa...........................		X	X	3.6 tons	.029	46.88	326.63	168.77	109.24	59.53	4,306	1.10
Bush Beans[k].....................		X		7600 lbs.	662,107	.062	.00027	471.20	382.12	89.08	18,319	1.52
Bush Beans........................			X	7600 lbs.	662,107	.062	.00027	471.20	337.48	133.72	18,319	1.01
Sweet Corn[k].....................		X		14200 lbs.	1,133,479	40.57	.00008	284.00	203.39	80.61	16,675	1.60
Sweet Corn........................			X	14200 lbs.	1,133,479	40.57	.00008	284.00	158.75	125.25	16,675	1.03
Kentucky Bluegrass................			X	633 lbs.	15,254	.362	.02068	229.15	95.19	133.96	10,600	.77
Fine Fescue.......................			X	530 lbs.	3,096	.309	.0116	163.77	83.55	80.22	3,587	.75

a/ Estimated from a linear trend equation using yields for the 10-year period 1967-76 in the Willamette Valley, reported by Statistical Reporting Service, USDA, and OSU Extension Service cooperating.

b/ Variance of the 10-year yield data base.

c/ Mean annual farm price in Oregon for the 10-year period 1967-76, reported by Statistical Reporting Service, USDA, and OSU Extension Service cooperating.

d/ Variance of the 10-year price data base.

e/ Yield times price.

f/ Grass seed costs obtained from Conklin-Fisher study [11] and updated to 1977 using USDA price index of all production items, December 1976. Other crop costs obtained from Enterprise Data Sheets prepared by Extension Economists, Oregon State University.

g/ Gross returns minus annual operating costs.

h/ Variance of gross margin = $(Y)^2V(P) + (P)^2V(Y) + V(P)V(Y)$

i/ $\sqrt{V(GM)}$ /gross margin.

j/ Represents an average yield per year from a production cycle involving two years production, followed by one year fallow.

k/ Annual operating costs include amortized drainage costs on medium-drained soils.

Legislature. A machine intensive capital technology geared for grass seed and grain crop production is reflected in cost components of the grass seed crop budgets.

Farm overhead costs, including depreciation, interest, repairs, taxes, and insurance on machinery and land, were not included in the cost calculations. Such costs will exist regardless of short-run production adjustment and are important for inclusion only when long-run adjustments are being considered. Consequently, the reader must be cautioned not to interpret gross margin calculations by crop as a measure of profit, either short or long-run in nature. They are not.

Correlation coefficients on gross margins were calculated for each crop activity to reflect interdependency characteristics which exist between crops because of price and yields effects. The correlation coefficient matrix is presented in Appendix Table 1.

The quadratic program algorithm has a 10-activity capacity. Consequently, separate interactions of the model were required to generate optimizing solutions for each of the three land types in the grass seed farm model. Since 11 crop choices were available for medium-drained land, and 13 for well drained land, crop choice deletions were required to accommodate the 10-activity computer capacity limitations. In such cases, the crops activities having the lowest, including negative, gross margins were deleted. In the benchmark model, this involved deletion of annual ryegrass/summerfallow on medium and well drained lands, and annual ryegrass and spring oats on well drained lands. The same procedure was applied in evaluation of alternative policy choices in which the 10-activity limit is exceeded.

Optimizing the Grass Seed Farm Under Open Field Burning Conditions

Optimum solutions for the grass seed farm model are generated first under conditions of open field burning. The purpose of doing so is to select model results which are a good representation of the existing situation of grass seed farms in the Linn, Benton, and Lane County area. These results then will be used as a benchmark for comparing model results which evaluate alternative public policy choices.

Optimizing the model under open field burning conditions generated four "risk efficient" crop mixes on poorly-drained land, one crop on medium-drained land, and four crop mixes on well-drained land. The results are summarized in Table 4. These results represent solutions on the efficiency frontier, i.e., solutions representing minimum variance for each, and all levels of gross margins from the combination of crops available.

Table 4. Summary of Cropping Patterns and Gross Margin Characteristics of Risk Efficient Plans Generated from Programming Solutions Under Open Field Burning

Item	Unit	Plan 1	2	3	4
Poorly-drained land					
Annual ryegrass	acres	218	415	427	0
Annual ryegrass/summer fallow a/	acres	287	90	0	0
Perennial ryegrass	acres	0	0	78	505
Spring oats	acres	0	0	0	0
Gross Margin	$	26,505	32,287	35,175	36,831
Standard Deviation	$	14,034	23,174	29,982	36,652
Medium-drained land					
Annual ryegrass	acres	0			
Perennial ryegrass	acres	0			
Spring oats	acres	0			
Orchardgrass	acres	190			
Bentgrass	acres	0			
Tall fescue	acres	0			
Fall wheat	acres	0			
Alfalfa	acres	0			
Bush beans	acres	0			
Sweet corn	acres	0			
Gross Margin	$	22,871			
Standard Deviation	$	6,913			
Well-drained land					
Perennial ryegrass	acres	0	0	0	0
Orchardgrass	acres	75	72	0	0
Bentgrass	acres	0	0	0	0
Tall fescue	acres	0	0	0	0
Fall wheat	acres	0	0	0	0
Alfalfa	acres	0	0	0	0
Bush beans	acres	0	3	30	0
Sweet corn	acres	0	0	0	0
Kentucky bluegrass	acres	0	0	45	75
Fine fescue	acres	0	0	0	0
Gross Margin	$	9,028	9,064	10,040	10,047
Standard Deviation	$	2,729	2,789	5,209	7,724

a/ Rotation of two years annual ryegrass and one year summer fallow.

Validating the Open Field Burning Conditions - A Benchmark for Policy Comparisons

The criteria used to select the "best" or most appropriate crop mix for each soil type from the "risk efficient" solution plans in Table 4 were that which most closely represented observed reality of grass seed farms in Linn, Benton, and Lane counties in 1976. The task of doing so is accomplished indirectly since no farm survey information for 1976 is available upon which to make a direct comparison. The most recent survey of Willamette Valley grass seed farms was conducted in 1969 by the Conklin-Fisher study which included 67 sample farms in the Linn, Benton, and Lane county area. The extent to which this information can be used must be judged by whether the crop mixes by soil type existing in 1969 are reasonably good reflections of those which prevailed in 1976. To make this evaluation, the proportion of each grass seed type grown, relative to total grass seed produced, is compared for 1969 and 1976 for the Linn, Benton, and Lane county area, as reported by the Statistical Reporting Service and the OSU Extension Service. Results are presented in Table 5.

Table 5. Total Grass Seed Acres and Proportion By Seed Type for Linn, Benton, and Lane Counties, 1969 and 1976

	1969		1976	
Grass type	Total acres	% total acres	Total acres	% total acres
Annual ryegrass............	98,500	53.0	106,800	61.5
Perennial ryegrass..........	42,200	22.7	37,000	21.3
Orchardgrass................	11,500	6.2	9,100	5.2
Bentgrass...................	9,250	3.9	5,750	3.3
Tall fescue.................	11,850	6.4	7,980	4.6
Fine fescue.................	3,750	2.0	2,550	1.5
Merion Kentucky bluegrass...	900	.5	450	.3
Other bluegrass.............	9,950	5.3	4,000	2.3
TOTAL.................	187,900	100.0	173.630	100.0

SOURCE: Reported by Statistical Reporting Service, USDA, and OSU Extension Service cooperating.

These data indicate that proportional shifts between grass seed types have been small with total grass seed acreage declining slightly. The major proportional shift involved an increased acreage of annual ryegrass from 75 to 85 percent of total crop acreage. The relatively small proportional shifts among other grass seed types, from 1969 to 1976, suggest that the crop mix patterns obtained from the 1969 study provide an acceptable basis to match against the risk efficient crop mix results presented in Table 4.

Plan 3 on poorly-drained soils, plan 1 on medium-drained soils, and plan 3 on well-drained soils were selected as being the most realistic representation of observed reality as a basis for validating the model. This crop combination by land type is summarized in Table 6.

Table 6. Cropping Pattern, Income, and Income Dispersion Characteristics of Grass Seed Farm Model Solution Under Assumed Open Field Burning in 1977, A Benchmark for Policy Comparisons

Item	Unit	Quantity	Percent of total cropland acres
Poorly-drained land	acres	(505)	(66)
Annual ryegrass/open burn	acres	427	55
Perennial ryegrass/open burn	acres	78	11
Gross Margin	$	35,200	--
Standard Deviation	$	30,000	--
Medium-drained land	acres	(190)	(25)
Orchardgrass/open burn	acres	190	25
Gross Margin	$	22,900	--
Standard Deviation	$	6,900	--
Well-drained land	acres	(75)	(9)
Kentucky bluegrass/open burn	acres	45	6
Bush beans	acres	30	3
Gross Margin	$	10,000	--
Standard Deviation	$	5,200	--
Gross Margin (total farm)	$	68,100	--

The grass seed farm model, under traditional open burn, has both annual and perennial ryegrass grown on poorly-drained soils with annual ryegrass utilizing 85 percent of the poorly-drained acreage. Comparison with Table 5 indicates this crop mix is reasonably close to observed grower behavior. While annual ryegrass historically has a slightly lower gross margin than perennial ryegrass, it appears to dominate because of greater cropping flexibility as an annual grass, and its slightly lower variability of gross margin. A gradual decline in acreage of perennial ryegrass has occurred in the Valley over the last 15 years. The data here suggest that lower cropping flexibility, declining yields, smaller profit margins, and increased riskiness, relative to annual ryegrass, attribute to this situation.

Orchardgrass is the only viable crop on medium-drained land because of its distinctly higher returns and lower income variability relative to other crop choices. While this does not appear unreasonable, no direct means for comparison with observed reality is available for validation purposes. Table 3 indicates that fall wheat is the second best choice. Fall wheat does not enter the solution, however, because of slightly lower returns and markedly greater variability of income. While evidence exists to indicate that some conversion from orchardgrass to fall wheat occurred from 1974 to 1976, because of a very high world price on wheat in those years, the current price situation suggests a shift back to orchardgrass, consistent with model results.

Kentucky bluegrass and bush beans emerge as the crop mix on well-drained lands. They share nearly identical income characteristics, as shown in Table 3, but bush beans have a much higher income variability. Access to a market contract and grower attitude toward uncertainty appear to be major factors in deciding the proportion of well-drained land acres devoted to bush beans.

EVALUATING POLICY ALTERNATIVES

Implicit in the evaluation of policy alternatives is the assumption that, from an economic point of view, grass seed growers are expected to respond so as to minimize their income disruption. That is, in adjusting from open field burning, a current least cost choice for farmers, the ranking of alternative choices, involves (1) minimizing income reduction, and (2) minimum change in income variability (riskiness). These assumptions are contained implicitly in the quadratic program and in the selection of "best plans" from the Q.P. solutions.

Thermal Sanitation

By Mobile Field Sanitizers

As specified earlier, mobile field sanitizer units are not available on a commercial basis because of technical problems on pre-commercial test units which have not yet been overcome. Consequently, a number of assumptions are required to model this alternative. The assumptions used are based on best estimates of 1977 conditions for mobile field sanitizers [22]. The assumptions are:

1. Custom operators own the field sanitizer units and charge a rate which covers operating and overhead costs for the sanitizer, a tractor as the power unit, and a fire control unit to contain afterburn for the system which is operated continuously throughout the burning season.

2. The sanitizer is capable of burning up to two tons of straw per acre as it passes over a field.

3. All straw and stubble in excess of two tons per acre are removed at a cost of $10 per ton using a stack former and mover as a minimum cost choice.1/ The removal charge includes transportation to a straw center within 10 miles of the field. Since markets for straw are weak, no value for the straw is assumed. Per acre removal costs by seed type are as follows:

1/ Personal communication with Thomas R. Miles, consulting engineer, Portland, Oregon, October 22, 1974.

Grass seed type	Total straw yield in tons[2/]	Tons removed	Straw removal cost
	----------------per acre----------------		
Kentucky bluegrass	3.15	1.15	11.50
Fine fescue	3.15	1.15	11.50
Tall fescue	3.75	1.75	17.50
Orchardgrass	4.15	2.15	21.50
Highland bentgrass	3.07	1.07	10.70
Annual ryegrass	4.25	2.25	22.50
Perennial ryegrass	3.65	1.65	16.50

4. The sanitizer is custom hired at a rate of $33.61 per acre, based upon the following ownership and operating cost estimates generated for 1977 conditions:

Annual ownership costs[3/]	
Sanitizer:	
Depreciation[4/]	$ 5,000.00
Interest on average investment @ 9%	1,125.00
Insurance @ .35% of average investment	43.75
Repairs @ 15% of average investment	1,250.00
Tractor[5/]	4,819.64
Fire control unit[6/]	256.76
TOTAL	$12,495.15
Average ownership cost per acre	$20.83
Operating cost per acre[7/]	7.20
Total cost per acre	28.03
Overhead costs per acre[8/]	5.58
Custom charge per acre	33.61

5. The total cost per acre for the combined operations of thermal sanitation and straw removal by seed type is:

[2/] Average annual straw production was obtained from research conducted by Harold Youngberg and D. C. Chilcote, Crop Science Department, Oregon State University, Corvallis [46].

[3/] Assumes machine investment of $25,000, a five-year useful life, and a burn rate of two acres per hour, or 600 acres per season. Cost calculation procedures are the same as used in the Conklin-Bradshaw study [10].

[4/] Straight line method with a five-year useful life and no salvage value.

[5/] Depreciation, interest, insurance, and repairs charged at the same rates as for the sanitizer. A ten-year life is assumed. For details, see Conklin and Bradshaw [8].

[6/] Estimated for 1977 from Conklin and Bradshaw [10].

[7/] The 1969 rates were adjusted to 1977 by USDA index on all production items, December 1976 [10,12,42].

[8/] Estimated allowance for office, management, transportation of machines, and fuel for tractor and fire control unit.

Bentgrass..................	$44.31
Kentucky bluegrass.........	45.11
Fine fescue................	45.11
Perennial ryegrass.........	50.11
Tall fescue................	51.11
Orchardgrass...............	55.11
Annual ryegrass............	56.11

6. Mobile field sanitation is an effective direct substitute for open field burning with no change in grass seed yields.

7. The sanitizer meets DEQ emission standards.

The field sanitizer policy alternative alters the gross margin and income dispersion characteristics on the grass seed crops from those presented in Table 3 under open field burning. Those revised input coefficients for affected crops are presented in Appendix Table 2. Input coefficients for non-grass seed crops were not affected by this strategy, so cost and return calculations shown in Table 3 continue to be used for those crops. Gross margins and income dispersion characteristics for each crop alternative used in the model are shown in Table 7. Because gross margins of the grass seed crops were reduced from that in the open burn case by the mobile sanitizer strategy, due to cost increases, the relative riskiness of each grass seed crop is greater than under open field burning. Increases in production costs, other things being equal, increase the relative riskiness of the remaining income, not by any change in variance, but by a reduction in gross margin.

The thermal sanitizer alternative is optimized and "best" cropping patterns selected for each soil type using a judgment criteria which minimizes income reduction and increases in income variability relative to the open burn alternative. The results and comparison with the open burn alternative are presented in Table 8 to facilitate comparison of effects of each policy alternative against the open burn benchmark.

The results show a marked reduction in total farm income, nearly 40 percent from the open burn case, with little net change in income dispersion effects. Although income reductions occurred with all three soil types, they were most pronounced on the poor and medium-drained lands. Cropping pattern shift on the poorly-drained land was pronounced. Perennial ryegrass production was terminated. Spring oats became the dominant crop, followed by annual ryegrass/summer fallow. No cropping pattern shift occurred on the

Table 7. Cross Margin and Income Dispersion Characteristics Per Acre by Crop and Policy Alternative

	1979 Open burn benchmark		1977 Thermal Sanitation: Field sanitizer only		1977 Thermal Sanitation: Controlled open burn		1977 Thermal Sanitation: Sanitizer controlled open burn		1977 No sanitation with residue removal		S.B. 311 1975		S.B. 311 1976	S.B. 311 1977	S.B. 311 1978	H.B. 2196 1977	H.B. 2196 1978	Revised H.B.2196 1978
	GM	VAR	GM	VAR	GM	VAR	GM	VAR	GM	VAR	GM	VAR	GM	GM	GM			
POORLY-DRAINED LAND:																		
Annual ryegrasa/open burn........................	69.06	3,382	-	-	44.31	3,382	-	-	-	-	64.56	3,382	63.56	62.06	59.56	64.06	64.06	60.59
Annual ryegrass/summer fallow....................	39.88	1,627	39.88	1,627	39.88	1,627	39.88	1,627	39.88	1,627	39.88	1,627	39.88	39.88	39.88	39.88	39.88	39.88
Perennial ryegrass/open burn.....................	72.93	5,268	-	-	51.18	5,268	-	-	-	-	68.43	5,268	67.43	65.93	63.43	67.93	67.93	64.21
Spring oats......................................	38.83	981	38.83	981	38.83	981	38.83	981	38.83	981	38.83	981	38.83	38.83	38.83	38.83	38.83	38.83
Annual ryegrass/sanitizer........................	-	-	16.42	3,382	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Perennial ryegrass/sanitizer.....................	-	-	26.54	5,268	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Annual ryegrass/no sanit. or straw removal.......	-	---	-	-	-	-	-	-	-7.89	-	-	-	-	-	-	-	-	-
Perennial ryegrasa/no sanit. or straw removal....	-	-	-	-	-	-	-	-	-7.72	-	-	-	-	-	-	-	-	-
Annual ryegrass/open burn-ssnitizer..............	-	-	-	-	-	-	37.51	3,382	-	-	-	-	-	-	-	-	-	-
Perennial ryegrass/open burn-sanitizer...........	-	-	-	-	-	-	44.37	5,268	-	-	-	-	-	-	-	-	-	-
MEDIUM-ORAINED LAND:																		
Annual ryegrass/open burn........................	69.06	3,382	-	-	44.31	3,382	-	-	-	-	64.56	3,382	63.56	62.06	59.56	64.06	64.06	60.59
Annual ryegrass/summer fallow....................	39.88	1,627	39.88	1,627	39.38	1,627	39.88	1,627	39.88	1,627	39.88	1,627	39.88	39.88	39.88	39.88	39.88	39.88
Perennial ryegrass/open burn.....................	72.93	5,268	-	-	51.18	5,268	-	-	-	-	68.43	5,268	67.43	65.93	63.43	67.93	67.93	64.21
Spring oats......................................	38.83	981	38.83	981	38.83	981	38.83	981	38.83	981	38.83	981	38.83	38.83	38.83	38.83	38.83	38.83
Orchardgrass/open burn...........................	120.37	1,324	-	-	96.12	1,324	-	-	-	-	115.87	1,324	114.87	113.37	110.87	115.37	115.37	109.90
Bentgrass/open burn..............................	85.45	1,282	-	-	67.60	1,282	-	-	-	-	80.95	1,282	79.95	78.45	75.95	80.45	80.45	76.51
Tall fescue/open burn............................	35.67	1,555	-	-	13.42	1,555	-	-	-	-	31.17	1,555	30.17	28.67	26.17	30.67	30.67	27.33
Fall wheat.......................................	108.24	10,273	108.24	10,273	108.24	10,273	108.24	10,273	108.24	102.73	108.24	10,273	108.24	108.24	108.24	108.24	108.24	108.24
Alfalfa..	59.53	4,306	59.53	4,306	59.53	4,306	59.53	4,306	59.53	4,306	59.53	43.06	59.53	59.53	59.53	59.53	59.53	59.53
Bush beans.......................................	89.08	18,319	89.08	18,319	89.08	18,319	89.08	18,319	89.08	18.319	89.08	18,,319	89.08	89.08	89.08	89.08	89.08	89.08
Sweet corn.......................................	80.61	16,675	80.61	16,675	80.61	16,675	80.61	16,675	80.61	16,675	80.61	16,675	80.61	80.61	80.61	80.61	80.61	80.61
Annual ryegrass/sanitizer........................	-	-	16.42	3,382	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Perennial ryegrass/sanitizer.....................	-	-	26.54	5,268	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orchardgraas/sanitizer...........................	-	-	70.73	1,324	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bentgraas/sanitizer..............................	-	-	45.08	1,282	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tall fescue/sanitizer............................	-	-	-12.30	1,555		-	-	-	-	-	-	-	-	-	-	-	-	-
Annual ryegrass/no sanit. or straw removal.......	-	-	-	-	-	-	-	-	-7.78	3,382	-	-	-	-	-	-	-	-
Pereonial ryegrass/no sanit. or straw removal....	-	-	-	-	-	-	-	-	-7.72	5,268	-	-	-	-	-	-	-	-
Orchardgrass/no sanit. or straw removal..........	-	-	-	-	-	-	-	-	4.33	1,324	-	-	-	-	-	-	-	-
Bentgraas/no aanit. or straw removal.............	-	-	-	-	-	-	-	-	-33.04	1,282	-	-	-	-	-	-	-	-
Tall fescue/no sanit. or atrsw removal...........	-	-	-	-	-	-	-	-	-45.92	1,555	-	-	-	-	-	-	-	-
Annual ryegrasa/open-burn-aanitizer..............	-	-	-	-	-	-	37.51	3,382	-	-	-	-	-	-	-	-	-	-
Perennial ryegrass/open burn-ssnitizer...........	-	-	-	-	-	-	44.37	5,268	-	-	-	-	-	-	-	-	-	-
Orchardgraas/open burn-sanitizer.................	-	-	-	-	-	-	89.31	1,324	-	-	-	-	-	-	-	-	-	-
Bentgrass/open burn-eanitizer....................	-	-	-	-	-	-	59.79	1,282	-	-	-	-	-	-	-	-	-	-
Tall fescue/open burn-sanitizer..................	-	-	-	-	-	-	6.61	1,555	-	-	-	-	-	-	-	-	-	-
WELL-DRAINED LAND:																		
Perennial ryegrass/open burn.....................	69.06	5,268	-	-	51.18	5,268	-	-	-	-	68.43	5,268	67.43	65.93	63.43	67.93	67.93	64.21
Orchardgrass/open burn...........................	120.37	1,324	-	-	96.12	1,328	-	-	-	-	115.87	1,324	114.87	113.37	110.87	115.37	115.37	109.90
Bentgrass/open burn..............................	85.45	1,282	-	-	67.60	1,282	-	-	-	-	80.95	1,282	79.95	78.45	75.95	80.45	80.45	76.51
Tall fescue/open burn............................	35.67	1,555	-	-	13.42	1,555	-	-	-	-	31.17	1,555	30.17	28.67	26.17	30.67	30.67	27.53
Fall wheat.......................................	108.24	10,273	108.24	10,273	108.24	10,273	108.24	10,273	108.24	10,273	108.24	10,273	108.24	108.24	108.24	108.24	108.24	108.24
Alfalfa..	59.53	4,306	59.53	4,306	59.53	4,306	59.53	4,306	59.53	4,306	59.53	4,306	59.53	59.53	59.53	59.53	59.53	59.53
Buah beans.......................................	133.72	18,319	133.72	18,319	133.72	18,319	133.72	18,319	133.72	18,319	133.72	18,319	133.72	133.72	133.72	133.72	133.72	133.72
Sweet corn.......................................	125.25	16,675	125.25	16,675	125.25	16,675	125.25	16,675	125.25	16,675	125.25	16,675	125.25	125.25	125.25	125.25	125.25	125.25
Kentucky bluegraaa/open burn.....................	133.72	10,600	-	-	114.71	10,600	-	-	-	-	129.46	10,600	128.46	126.96	124.46	124.96	124.96	125.24
Fine fescue/open burn............................	80.22	3,587	-	-	60.97	3,587	-	-	-	-	75.42	3,587	74.72	73.22	70.72	75.22	75.22	70.81
Perennial ryegraas/sanitizer.....................	-	-	26.54	5,268	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orchardgrass/aanitizer...........................	-	-	70.73	1,324	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bentgrass/sanitizer..............................	-	-	45.08	1,282	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tall fescue/aanitizer............................	-	-	-12.30	1,555	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kentucky bluegrasa/sanitizer.....................	-	-	92.57	10,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fine fescue/aanitizer............................	-	-	39.52	3,587	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Perennial ryegrass/no sanit. or straw removal....	-	-	-	-	-	-	-	-	-7.72	5,268	-	-	-	-	-	-	-	-
Orchardgrass/no sanit. or straw removal..........	-	-	-	-	-	-	-	-	4.33	1,324	-	-	-	-	-	-	-	-
Bentgrass/no sanit. or straw removal.............	-	-	-	-	-	-	-	-	-33.04	1,282	-	-	-	-	-	-	-	-
Tall fescue/no sanit. or straw removal...........	-	-	-	-	-	-	-	-	-45.92	1,555	-	-	-	-	-	-	-	-
Kentucky bluegraaa/no sanit. or straw removal....	-	-	-	-	-	-	-	-	10.97	10,600	-	-	-	-	-	-	-	-
Fine fescue/no sanit. or straw removal...........	-	-	-	-	-	-	-	-	-50.69	3,587	-	-	-	-	-	-	-	-
Perennial ryegraas/open burn-sanitizer...........	-	-	-	-	-	-	55.37	5,268	-	-	-	-	-	-	-	-	-	-
Orchardgrass/open burn-sanitizer.................	-	-	-	-	-	-	89.31	1,324	-	-	-	-	-	-	-	-	-	-
Bentgrsaa/open burn-sanitizer....................	-	-	-	-	-	-	59.79	1,282	-	-	-	-	-	-	-	-	-	-
Tall feacue/open burn-sanitizer..................	-	-	-	-	-	-	6.61	1,555	-	-	-	-	-	-	-	-	-	-
Kentucky bluegraas/open burn-aanitizer...........	-	-	-	-	-	-	107.91	10,600	-	-	-	-	-	-	-	-	-	-
Fine feacue/open burn-sanitizer..................	-	-	-	-	-	-	54.16	3,587	-	-	-	-	-	-	-	-	-	-

Table 8. Grass Seed Farm Model Results Comparing the Open Burn Benchmark With Selected Policy Alternatives

Item	Unit	Open field burn benchmark	Thermal sanitation (1)[a]	Thermal sanitation (2)[b]	Thermal sanitation (3)[c]	No sanitation with residue removal	Controlled phasedown of open field burning: S.B. 311 1975	S.B. 311 1976	S.B. 311 1977	S.B. 311 1978	H.B. 2196 1977	H.B. 2196 1978	H.B. 2196 plus backfiring 1978
Open burn acres allowable	acres	770	0	385	385	0	640	531	262	138	531	493	493
Poorly-drained land - 505 acres:													
Annual ryegrass/open burn	acres	427	0	0	0	-	331	222	0	0	222	184	184
Perennial ryegrass/ open burn	acres	78	0	505	505	-	78	78	31	0	78	78	78
Spring oats	acres	0	0	0	0	-	0	0	0	0	0	0	0
Annual ryegrass/ summer fallow	acres	0	505	0	0	505	96	205	474	505	205	243	243
Gross margin	$	35,200	20,100	25,800	22,400	20,100	30,500	27,500	20,900	20,100	27,700	26,800	21,800
Standard deviation of gross margin	$	30,000	20,400	36,600	36,600	20,400	28,800	26,800	21,400	20,400	26,800	26,200	26,200
Coefficient of variation d/	-	.85	1.01	1.42	1.63	1.01	.94	.97	1.02	1.01	.97	.98	1.20
Decrease in gross margin from open burn	%	-	43	27	36	43	14	22	40	43	22	24	38
Change in risk from open burn e/	%	-	19	67	92	19	11	14	20	19	14	15	41
Medium-drained land - 190 acres:													
Orchardgrass/open burn	acres	190	0	190	190	0	190	190	190	97	190	190	190
Orchardgrass/sanitizer	acres	0	190	0	0	0	0	0	0	0	0	0	0
Fall wheat	acres	-	-	-	-	190	-	-	-	93	-	-	-
Gross margin	$	22,900	13,400	18,300	16,970	20,500	22,000	22,000	22,000	20,800	22,100	22,100	18,300
Standard deviation of gross margin	$	6,900	6,900	6,900	6,900	19,300	6,900	6,900	6,900	13,000	6,900	6,900	6,900
Coefficient of variation	-	.30	.51	.38	.41	.94	.31	.31	.31	.63	.31	.31	.38
Decrease in gross margin from open burn	%	-	41	20	26	10	4	4	4	9	4	4	20
Change in risk from open burn	%	-	70	27	32	213	3	3	3	110	3	3	27
Well-drained land - 75 acres:													
Kentucky bluegrass/ open burn	acres	45	0	39	41	-	41	41	41	41	41	41	41
Bush beans	acres	30	35	36	34	30	34	34	34	34	34	34	34
Kentucky bluegrass/ sanitizer	acres	0	40	0	0	-	0	0	-	-	0	0	-
Fall wheat	acres	-	-	-	-	45	-	-	-	-	-	-	-
Gross margin	$	10,000	8,300	9,000	9,000	7,300	9,800	9,800	9,700	9,700	9,700	9,700	9,200
Standard deviation of gross margin	$	5,200	5,300	5,300	5,300	8,600	5,300	5,300	5,300	5,300	5,300	5,300	5,300
Coefficient of variation	-	.52	.64	.59	.59	1.18	.54	.54	.55	.55	.55	.55	.58
Decrease in gross margin from open burn	%	-	17	10	10	27	2	2	3	3	3	3	8
Change in risk from open burn	%	-	23	13	13	127	8	8	6	6	6	6	12
Total Farm:													
Gross margin	$	68,100	41,500	53,100	48,370	47,900	62,300	59,300	52,600	50,600	59,500	58,600	49,300
Standard deviation of gross margin	$	42,100	32,600	48,800	48,800	48,300	41,000	39,000	33,600	38,700	39,000	38,400	38,400
Coefficient of variation	-	.62	.79	.92	1.01	1.01	.66	.66	.64	.76	.66	.66	.78
Decrease in gross margin from open burn	%	-	39	22	29	30	9	13	23	26	13	14	18
Change in risk from open burn	%	-	27	48	63	63	6	6	3	23	6	6	26

a/ By mobile field sanitizer.

b/ By controlled open field burning on alternate year equivalent basis.

c/ By mobile field sanitizers and controlled open field burning combination.

d/ $\sqrt{V(GM)}/GM$.

e/ Percent change in coefficient of variation.

medium and well-drained lands, but thermal sanitation was converted from open burn to mobile sanitizer. Continuance of grass seed production with conversion to mobile sanitizers did not occur on the poorly-drained lands because its high cost made crop conversion a more attractive, or less economically painful, choice. While orchardgrass was retained on the medium-drained soils, model results indicate some conversion to wheat could be expected under modest market price increases for wheat relative to orchardgrass. This would be expected primarily by farmers who are willing to "gamble" on wheat because of its much higher "riskiness" or income dispersion relative to grass seed production.

By DEQ-Controlled Open Field Burn On Alternate Year Equivalent Basis

This policy choice limits DEQ controlled open field burning in which one-half of total grass seed acres for a grower are burned in any one year. The decision of which grass seed crop to open burn logically should be left to growers to permit consideration of seed quality, disease, and other economic factors. Assumptions used to evaluate this choice are:

1. All grass seed types respond similarly to the benefits of thermal sanitation so that, on the average, and over time, the thermal rotation for any grass seed involves burn and no-burn strategies in equal proportions. The result is an alternate year burn equivalency on a cost-return basis.

2. Grass seed yields are comparable to those from open burning as long as an alternate year controlled open burning equivalency is realized and the straw is removed in the non-burn years.

3. Mobile field sanitizers are not available.

4. The DEQ-controlled open burn program includes the following fire control costs:

    a. Farmer fire control costs as under traditional open burning.

    b. An additional $5.50/acre permit fee for 1977 in accordance with S.B. 311 requirements.

    c. An additional estimated farmer fire control cost of $1.50 per acre for fire crew labor to maintain on-call status.

Annual operating costs by seed type from Table 3 were adjusted to reflect the assumptions of this policy with revised input coefficients presented in Appendix Table 3. Resulting gross margin and income dispersion characteristics for each crop alternative used in the model are shown in Table 7.

Optimization of the controlled open field burning alternative, including selection of the "best" cropping patterns by soil type using a similar risk strategy to the open burn benchmark case, produced the results shown in Table 8.

The results indicate a reduction in total farm income of slightly more than 20 percent from the open burn case with considerable increase in income dispersion effects. The income reductions were relatively uniform across all three soil types. The cropping pattern shift on poorly drained land involved conversion from an annual-perennial ryegrass crop mix to perennial ryegrass only which is open burned on a controlled alternate year basis. No cropping pattern shift occurred on the medium-drained land, although modest price increases for wheat could see conversion from orchard-grass to wheat by those grass seed producers willing to "gamble" on high risk wheat production. Only minor acreage shifting between Kentucky blue-grass and bush beans occurred on the well-drained land.

Equal Combination of Mobile Field Sanitation and Controlled Open Field Burning

The choice evaluated here combines the sanitizer program with a controlled open burn in which all grass seed fields are sanitized - one-half by DEQ-controlled open field burning and one-half by mobile-field sanitization. While the mix of grass seed crops to produce likely would be left to grower choice, sanitation porportion for a given crop is set on an equal basis between open burn and mobile field sanitation. The model used is not sufficiently flexible to permit choice of specific fields to be open field burned based on seed type, disease problems, seed quality, and income effects to farmers. Rather, it assumes that, on the average, over time, the proportion is equal between open burn and mobile sanitation. Assumptions are:

1. Grass seed yields are comparable to those under open field burning.

2. Straw removal and sanitizer operation costs are the same as with the field sanitizer alternative.

3. Fire control costs with controlled open burning are the same as with the controlled open field burn on alternate year equivalent basis.

4. Straw removal is not required with controlled open field burning.

Annual operating costs by seed type from Table 3 were adjusted to reflect these assumptions with revised input coefficients presented in Appendix Table 4. Resulting gross margin and income dispersion characteristics for each crop alternative used in the model are shown in Table 7. Cost and return data for the non-grass seed crops were not changed.

Optimization of the combined sanitizer-smoke management alternative and selection of "best" cropping patterns by soil type using a similar risk strategy to the open burn benchmark case produced the results shown in Table 8.

Model results indicate approximately a 30 percent reduction in total farm income from traditional open burning is expected initially with this policy alternative. Income reduction is uneven with expected gross margins reduced by 36, 26, and 10 percent respectively for poor, medium, and well-drained lands as total farm income reductions are minimized by more pronounced adjustments on the poorly-drained lands. Income riskiness increased substantially because of lowered gross income from increased sanitizer costs and burning fee charges. Very little cropping pattern shifts occurred except on poorly-drained land where some shifting from perennial to annual ryegrass took place.

No Thermal Sanitation With Residue Removal

The practice of harvesting grass seed and leaving the residue on the ground to decompose has been available to grass seed growers during the years of open field burning. This was the practice followed by growers before introduction of open field burning in the 1940s. Up to that time, acreage of grass seed production was very low because non-removal of straw generated relatively low yields after stand establishment and a second year's accumulation of straw tended to smother out the crop completely. Consequently, neither thermal sanitation nor residue removal (where the straw is left in the field to rot) is viewed as a technically viable alternative. A choice perceived as being technically feasible involves no thermal sanitation with residue removal. Research over several years, by the OSU Department of Crop Science, provides yield decline information with such an alternative [47]. No information is available, however, on possible long-run yield effects from disease incidence increases, if thermal sanitation were not practiced at all for several continuous years for the entire Willamette Valley.

Assumptions used with this alternative are:

1. Grass seed yields under no thermal sanitation with residue removal are:

Grass type	Yield under no sanitation with straw removal	Yield as a percent of open burn
Kentucky bluegrass	370	62
Fine fescue	194	40
Tall fescue	418	60
Orchardgrass	436	64
Highland bentgrass	140	47
Annual ryegrass	968	67
Perennial ryegrass	485	60

2. Grass seed yields reflect initial changes with no attempt to estimate long-run effects from general disease buildup in the Valley.

Grass seed yields, operating costs, and expected gross margins of the benchmark model were adjusted to those shown in Appendix Table 5 to model this alternative. Resulting gross income and income dispersion characteristics for each crop alternative used in the model are shown in Table 7.

Optimization of the no-thermal sanitation -- with residue removal alternative and selection of "best" cropping patterns by the same risk criteria used in the open-burn case generated the results shown in Table 8.

Model results show about a 30 percent decline in farm income from open field burning income levels with a marked increase in income dispersion as production on medium and well-drained lands converts to "risky" wheat production. On poorly-drained land, a shift from annual and perennial ryegrass to an annual ryegrass/summerfallow rotation took place with only a slight increase in income dispersion but more than a 40 percent decline in income.

Income declines 10 to 30 percent in the medium and well-drained lands, and income dispersion showed a one to two-fold increase.

Controlled Phasedown of Open Field Burning

Oregon S.B. 311. Oregon Senate Bill 311, passed in 1975, gave the State authority to phaseout open field burning on grass seed and small grain crops over a four-year period [32]. The schedule for maximum allowable acres burned and permit fee schedule are:

Year	Maximum acres to be burned	Burning fee per acre
1975	234,000	$3.00
1976	195,000	4.00
1977	95,000	5.50
1978	50,000	8.00

The DEQ is charged with issuing annual burning permits, regulating the smoke management program, and adjusting the maximum acreage downward if circumstances warrant it. Assumptions are:

1. For the 770-acre farm model, the acreage reduction translates to 640 acres allowable to be open burned in 1975, 531 acres in 1976, 262 acres in 1977, and 138 acres in 1978 and thereafter.

2. To meet S.B. 311 requirements, the following fire control costs are involved:

   a. Farmer fire control costs as under traditional field burning.

   b. Burning permit fee per acre of $3 for 1975, $4 for 1976, $5.50 for 1977, and $8 for 1978.

   c. Additional farmer fire control cost of $1.50 per acre is estimated to maintain fire crews on on-call status.

To reflect the costs of a controlled phaseout of open field burn policy, the per acre annual operating costs for grass seeds used in the open burn model were modified to those listed in Appendix Table 5 for each of the four years from 1975 to 1978. Resulting gross income and income dispersion characteristics for each crop alternative used in the model are shown in

Table 7. The permit fee is a cost component only if grass seed land is open burned. If the land is not open burned, the fee is not charged. The annual permit fee started at $3 per acre in 1975 and increased to $8 by 1978. A $1.50 per acre fire control cost above that required under open burning is charged to account for on-call status of fire crews.

Optimization of the Senate Bill 311 alternative and selection of "best" cropping patterns by the same risk criteria used in the open-burn case generated results shown in Table 8. The procedure employed was an iterative one since the computer algorithm had a capacity of only ten activities. This required that solution for each land type be generated separately creating a minor problem since the acreage phaseout is on a total farm basis. To overcome this, the total farm open burn acreage constraint was specified external to the model by picking from the set of crop choices that cropping pattern which minimizes reduction of expected gross margin and income dispersion on a per acre basis for the farm.

Model results in Table 8 show farm income to be reduced from open burn levels by 9, 13, 23, and 26 percent respectively, for each of the years during the phasedown. The effect upon income dispersion is limited. The primary cropping pattern adjustments and income reductions occurred on the poorly-drained soils because of (1) limited cropping alternatives, (2) low profit margins on alternative crop choices, and (3) smaller income losses by continuing to open burn the higher income grass seed crops grown on the medium and well-drained soils. Income reduction on poorly-drained land increased 14 to 43 percent as the acreage phasedown became more severe over the four-year period. On the poorly-drained soils, the rate of conversion from ryegrasses to annual ryegrass/summer fallow increased throughout the four-year period. On the medium and well-drained soils, very little cropping pattern shifts occurred.

A major implication of S.B. 311 is that it is not expected to be felt equally across all seed types grown in the Willamette Valley. Producers with proportionately higher percentages of poorly-drained land to total cropland are expected to suffer greater economic losses relative to producers having higher percentage of total farm land in medium and well-drained soils. This is expected to be true for any alternative to open field burning, in large part because any policy choices will affect the economic gain from poorly-drained lands more than on other lands because the profit margins on those lands is lower.

House Bill 2196. H.B. 2196, passed in 1977 to replace S.B. 311, sets open burn acreage limits of 195,000 acres in 1977, and 180,000 acres in 1978. Assumptions used to evaluate this choice are:

1. Grass seed yields are maintained when DEQ-controlled open burning is conducted.

2. Mobile field sanitizers are not available.

3. The following fire control costs for DEQ-controlled open burn are borne by the producer:

    a. Farmer fire control costs, as under traditional open burning.

    b. An additional $5/acre, of which $3.50 is a permit fee, and $1.50 is for additional fire crew labor to maintain on-call status.

Annual operating costs, by seed type from Table 3, were adjusted to reflect the assumptions of this policy with revised input coefficients presented in Appendix Table 7. Resulting gross margin and income dispersion characteristics are shown in Table 7. Optimization with this policy, and selection of cropping patterns, produced the results in Table 8.

The results indicate a reduction in total farm income of somewhat more than 10 percent in both 1977 and 1978, with the bulk of adjustment occurring on the poorly-drained lands. Annual ryegrass converted to annual ryegrass/summer fallow. No cropping pattern adjustments occurred on medium or well-drained soils. However, shifts to wheat are expected to occur with modest price increases in wheat by farmers willing to absorb the risks of doing so. The 1977 and 1978 year results are quite similar because of the very small percentage reduction of open burn acres allowable. They are comparable to the 1976 results with S.B. 311. Again, the cropping change occurred only on the poorly-drained land with annual ryegrass open burned shifting to annual ryegrass/summer fallow and perennial ryegrass open burn to spring oats. Total farm income was reduced about 15 percent from traditional open burning.

House Bill 2196 Plus Backfiring in 1978

The revised requirements for open field burning in 1978 involve the 180,000-acre open burn limitation plus (1) a 12 percent maximum moisture limitation for open burning, and (2) a backfiring practice to replace the traditional forward fire burn which used backfiring only as a fire spread control measure. To evaluate this additional requirement, it is assumed that traditional open burn fire control costs will be doubled because of the much longer burn time associated with such a procedure. The modified cost structure associated with this procedure is shown in Appendix Table 6. Resulting gross income and income dispersion characteristics for each crop alternative used in the model are shown in Table 7.

The direction of adjustment is the same as with H.B. 2196, but more pronounced because of the increased costs on fire control. Overall farm income reduction for open burn is near 20 percent with most of the adjustment occurring on poorly-drained lands. Slightly more than half the annual ryegrass converted to annual ryegrass/summer fallow with nearly a 40 percent reduction in income. No crop shifts occurred on medium or well-drained lands, but the increased burning costs reduced income by 20 and 8 percent, respectively.

State Charge on Open Field Burning

A grower charge or tax on field burning was treated only partially in the legislated phasedown of open field burning through use of the increasing permit fee. This alternative explicitly evaluates a state tax on open field burning as a separate policy instrument. Treatment of a charge on a per acre basis with a per ton of residue burned equivalency is modeled.

Evaluation of the charge does not require use of the optimizing algorithm of the quadratic program. All that is necessary is to determine what charge level is required to cause a shift from the existing open burn pattern to the next best economic alternative which also significantly reduces smoke emissions. This is done by ranking the gross margins for each crop by soil type, as shown in Table 9.

Table 9. Ranking of Gross Margins Per Acre by Crop Used in Evaluating A Charge or Taxing Policy on Grass Seed Production

	Gross margin (rounded to nearest 25¢)
Poorly-drained land:	
Perennial ryegrass	$ 73.00
Annual ryegrass	69.00
Annual ryegrass/summer fallow	39.75
Spring oats	38.75
Medium-drained land:	
Orchardgrass	120.25
Fall wheat	108.25
Bush beans	89.00
Bentgrass	85.50
Sweet corn	80.50
Perennial ryegrass	73.00
Annual ryegrass	69.00
Alfalfa	59.50
Annual ryegrass/summer fallow	40.00
Spring oats	38.75
Tall fescue	35.75
Well-drained land:	
Kentucky bluegrass	134.00
Bush beans	133.75
Sweet corn	125.25
Orchardgrass	120.25
Fall wheat	108.25
Bentgrass	85.50
Fine fescue	80.25
Perennial ryegrass	69.00
Alfalfa	59.50
Annual ryegrass/summer fallow	40.00
Spring oats	38.75
Tall fescue	35.75

Table 9 shows that on poorly-drained land, perennial ryegrass open burned is the most profitable crop with a gross margin of about $73 per acre. The second-best economic choice is annual ryegrass open burned at $69 per acre. But this choice does not reduce smoke emissions so the next best alternative is looked at. This is annual ryegrass/summer fallow which meets both criteria and provides a gross margin of $39.75/acre. The difference between the choices of perennial ryegrass and annual ryegrass/summer fallow is approximately $33/acre. This translates to requiring a charge of about $33/acre to get this type of shift to occur. The income loss to do so would be severe, more than 50 percent, for ryegrass production. If the charge were on a per ton of straw basis, a \$9/ton charge (\$33 ÷ 3.65 tons straw/acre = \$9) would be necessary to achieve the same result.

In applying the procedure to annual ryegrass, a charge/acre of about \$29 per acre (\$69.00 - \$39.75 = \$29.25) would be required to affect a shift to the second best alternative of annual ryegrass/summer fallow. This charge per acre translates to \$7/ton (\$29.25 ÷ \$4.25 tons straw/acre ≈ \$7).

The same procedure is used to generate results for medium and well-drained soils. On medium drained soils, a charge of more than \$12 per acre is necessary to force a shift from orchardgrass open burned to the second best alternative of wheat. How much more than \$12 is not clear, but some additional increment is expected to compensate for the greater riskiness of wheat. On the well-drained land, a charge in excess of perhaps \$10 to \$20 per acre may be necessary to affect a shift from bluegrass open burn to sweet corn production to account for its high level of price riskiness.

Validity of Results Conditioned by Price, Yield, and Cost Changes

Results of this study are conditioned by crop price, yield, and operating costs estimates used as parameters in the analysis. Yet, these parameters, in reality, are variables which can and do change over time in the marketplace. These forces in turn affect farm income and cropping patterns. Of great importance to farmers are prices, yields, and costs expected to occur in the future. Because this study has strong normative or "what if" implications, it is important to evaluate not only what has occurred historically, but also what may occur in the future.

The historical data base of this study utilizes the following set of relationships:

1. The 1977 expected farm price is calculated using historical mean annual farm price for the 10-year period from 1967-76 for the Willamette Valley.

2. The 1977 expected yield is estimated for 1977 from a linear trend equation using historical yields for the 10-year period from 1967-76 in the Willamette Valley.

3. The 1977 operating costs are estimated by adjusting known 1969 production costs using USDA input price indexes for input price increases through 1976.

The implicit assumptions of using this data base are that (1) the immediate future farm prices for crops used in this study will be the same as the mean historical farm price in the 10-year period from 1967-76, (2) immediate future operating costs will be the same as the estimated 1976 operating costs and (3) immediate future yields will follow the historical yield trends estimated.

Using expected or future estimates for price, yield, and cost changes is an alternative to using historical time series averages as used in this study. This approach would be particularly useful if researchers could obtain such estimates from individual grass seed producers in the Willamette Valley and aggregate such information to represent a meaningful set of expected values for the industry. Unfortunately, using expected prices, yield and costs is not yet a workable option because (1) research costs of doing so are high, (2) aggregation problems have not been overcome, (3) dynamic decision models have not yet been perfected to the degree that they are reliable, and (4) no one has yet developed a crystal ball which predicts prices, yields, and costs for the future with any degree of accuracy, especially if projections are made beyond one or two years. Until these problems are overcome, one is forced to use estimates, although of some questionable validity, based upon current or immediate past information to project into the near future. Consequently, the implications of this study in estimating grower and seed industry effects of alternative policy choices are confined to an initial (one to two year) grower adjustment, and are based heavily upon immediate past performances of grass seed producers.

Furthermore, the direction of projected changes suggested from this study must be viewed as being considerably more accurate than the magnitude of those changes. The reason for this is that "averaged" Willamette Valley conditions for Linn, Benton, and Lane Counties were used which generalize from the many cropping patterns actually found on individual farms. The "averaging" of production costs and returns masks the likely slower rate of adjustment for high return farms and more rapid adjustment on low return farms as referred to in an earlier study [11]. While the long-run yield trend, historical average prices, and historical operating costs used in the study reflect historical effects, whether those trends will occur very long into the future is problemmatical. In the long-run, development of cost-reducing technologies, domestic and foreign market forces influencing demand for grass seed and production capabilities elsewhere, and changes in comparative advantage between regions in the production of cool season grasses all will influence the relative profitabilities among crops assumed in this study. Changes in political and institutional forces over time will do likewise. Certain technical issues, such as uncertainty of grass seed yields if no thermal sanitation were permitted at all in the Willamette Valley, also are not accounted for in the study.

ADJUSTMENT IMPLICATIONS OF ALTERNATIVE POLICIES FOR REDUCING OPEN FIELD BURNING

The primary function of this study is to estimate probable, or most likely initial, on-farm adjustments by grass seed growers in response to alternative policy choices for improving air quality in the Willamette Valley by directly reducing acres open field burned or modifying the economic incentive to discourage open field burning.

A quadratic programming model was used to evaluate seven policy alternatives in terms of expected cropping pattern changes and initial income reductions at the producer level relative to that found with traditional open field burning. A summary comparison of the model results is presented in Table 10.

Percent reduction in grower income, percent increase in dispersion of grower income, and percent reduction in acres burned relative to the open burning benchmark level are presented in the first five columns. The total farm income reductions in column one are based on the assumptions that the grass seed farm has 65, 25, and 10 percent of its land in poorly-drained, medium-drained, and well drained land, respectively, and that the model used is a good first approximation of reality. Column two shows a range in income losses based upon proportion of grass seed types grown on individual farms. The low end of the range generally reflects expected adjustments on grass seed farms which have little if any poorly-drained soil. The high end generally reflects expected adjustments on farms which have nearly <u>all</u> poorly-drained lands producing annual and perennial ryegrass with the more pronounced income losses being a consequence of limited crop alternatives relative to other grass seed types. Columns four and five provide an index of change in income dispersion associated with conversion from the open burn benchmark case to an alternative policy. The purpose of such an index is to provide, in addition to income effects, a measure of increased riskiness from a price and yield perspective as farm adjustments are made. Column five of Table 10 represents an estimate of the percent reduction of acres open field burned associated with each policy choice to represent a crude proxy of social gains in air quality improvement. A later section treats

Table 10. A Ranked Summary of Estimated Initial Reductions in Grower Income, Associated Reduction of Acres Open Field Burned and Cropping Pattern Shifts Obtained From Using a Conditionally Normative Quadratic Program Model to Evaluate Selected Policy Choices for reducing open field burning

Policy choice	Percent reduction in grower income from open burning benchmark level: Total farm	Percent reduction in grower income from open burning benchmark level: Range by land type	Percent increase in range of income dispersion as a measure of production risk a/: Total farm	Percent increase in range of income dispersion as a measure of production risk a/: Range by land type	Percent reduction in acres burned from open burning benchmark level	Initial cropping pattern adjustment: Poorly-drained land	Initial cropping pattern adjustment: Medium-drained land	Initial cropping pattern adjustment: Well-drained land	Initial farm adjustment
S.B. 311:						Shift from annual ryegrass to annual ryegrass/summer fallow.	Continuation of orchardgrass open burn with limited shifts to fall wheat for risk taking growers.	No major crop shifts.	Cropping shifts primarily on poorly-drained lands; cost increases absorbed internally.
- 1975	9	2-16	6	3-11	17				
- 1976	13	2-22	6	3-14	31				
H.B. 2196:						Shift from annual ryegrass to annual ryegrass/summer fallow	Continuation of orchardgrass open burn with limited shifts to fall wheat for risk-taking growers.	No major crop shifts.	Cropping shifts primarily on poorly-drained lands; cost increases absorbed internally.
- 1977	13	3-22	6	3-14	31				
- 1978	14	3-24	6	3-15	36				
Charge/acre on grass seed production of $10-$20 ($2-$5/ton of straw)	16	10-30	56	-	26	No cropping shift.	Shift from orchardgrass to fall wheat.	Shift from bluegrass and orchardgrass to sweet corn and bush beans if contracts available.	Cropping shifts primarily on poorly-drained lands; cost increases absorbed internally.
H.B. 2196 - Revised:						Shift from annual ryegrass to annual ryegrass/summer fallow.	Continuation of orchardgrass open burn with limited shifts to fall wheat for risk taking growers.	No major crop shifts.	Cropping shifts primarily on poorly-drained lands; cost increases absorbed internally but with greater economic stress.
- 1978	18	8-38	26	12-38	36				
Controlled burn on alternate year basis	22	10-27	48	13-67	50	Shift from AR to PR/open burn.	Continuation of OG open burn.	No major crop shift.	Some reduction of AR but otherwise no major movement out of grass seed production.
S.B. 311:						Major shift of all AR and PR to AR/summer fallow.	Continuation of orchardgrass open burn with limited shifts to fall wheat for risk taking growers plus major shift to fall wheat in 1978.	No major crop shifts.	Cropping shifts primarily on poorly-drained lands; cost increases absorbed internally, plus probable reduction in number of seed growers located on predominantly poorly-drained land as economic pressure counts and limited crop alternatives exist.
- 1977	23	3-40	3	3-20	66				
- 1978	26	3-43	23	6-110	88				
Charge/acre on grass seed production of $20-$35 ($5-$9/ton of straw)	30	10-40	63	20-210	100	Major shift of all AR and PR to AR/summer fallow.	Shift from orchardgrass to fall wheat.	Shift to fall wheat if vegetable contracts not available.	Same as above.
No burn with straw removal	30	10-43	63	20-210	100	Major shift of all AR and PR to AR/summer fallow.	Shift from orchardgrass to fall wheat.	Shift from bluegrass to fall wheat.	Cropping shifts primarily on poorly-drained lands; cost increases absorbed internally, plus probable reduction in number of seed growers located on predominantly poorly-drained land as economic pressure mounts and limited crop alternatives exist.
Sanitizer only	39	17-43	27	20-70	100	Major shift of all AR and PR to AR/summer fallow.	Shift from OG/open burn to OG/sanitizer.	Shift from KB/open burn to KB/sanitizer.	Cropping pattern change primarily on poorly-drained lands. Cost increases absorbed internally plus probable reduction in number of seed growers located on predominantly poorly-drained land with limited cropping alternatives.

a/ A relative measure of income dispersion change using the percent increase in coefficient of variation ($\sqrt{V(GM)}/GM$) from open field burning.

limitations of measuring social gains by reduction in acres burned. Initial cropping patterns and initial farm adjustments are presented in the last four columns.

House Bill 2196 and Senate Bill 311 for 1975 and 1976 appear to be the least disruptive in terms of minimizing grower income losses and income dispersion effects while achieving up to 36 percent reduction in acres open field burned. Both bills result in a 9 to 13 percent income reduction for the grass seed farm as a whole with as low as 2 percent income reduction on well-drained lands and as high as 24 percent reduction on poorly-drained lands.

The second best choice for growers appears to be a charge or tax on production of grass seed of $10 to $20 per acre or $2 to $5/ton of straw burned. This choice indicates a reduction in whole farm income of some 16 percent with a maximum reduction of 30 percent on poorly-drained lands and a minimum of 10 percent on well-drained lands. Income dispersion effects are more severe with this choice than the one discussed in the previous paragraph. Up to 26 percent reduction in acres open field burned is estimated with essentially all of it coming from the medium and well-drained lands in which cropping shifts from grass seed to fall wheat and more intensive vegetable production is expected. The degree of this shift is somewhat uncertain, however, since it is predicted upon the ability to obtain vegetable contracts and the relative price relationship between fall wheat and grass seed crops grown on medium and well-drained lands. A further limitation, from the point of view of urban constituency in the south Valley, is that the bulk of open burn acreage reduction is expected in the north and mid-Valley areas in which medium and well-drained lands predominate.

The third best choice for growers appears to be Revised H.B. 2196 which results in whole farm income reduction of some 18 percent with a low of 8 percent on well-drained lands and a high of 38 percent on poorly-drained lands. Income dispersion is greater than with choice one, because of the increased cost effects.

The fourth level choice for growers appears to be DEQ-controlled open burning on an alternate year equivalency basis. Farm income would be reduced by 22 percent with a low of 10 percent reduction on well-drained land and a high of 27 percent on poorly-drained land. Income dispersion at the farm level increases by nearly 50 percent with a range of from 13 to 67 percent. A 50 percent reduction in acres open burned is expected. No major crop shifts are involved. This alternative would appear to be more attractive, relatively speaking, if it were not for the high cost of roadsiding straw, and straw's inability to compete in markets for which it could be used as a raw material.

The fifth level choice for growers appears to be S.B. 311 for 1977 and 1978 which erodes farmer incomes by about 25 percent, with a range of 3 to 45 percent depending upon land type. Sizeable increases in income dispersion, ranging from 3 to 110 percent, are expected. Some 66 to 88 percent reduction in acres open burned are indicated with this choice.

The sixth level choice for growers appears to be a charge or tax on production of grass seed of \$20 to \$35 per acre, or \$5 to \$9/ton of straw burned. This choice reduces whole farm income some 30 percent while ranging from 10 to 40 percent, depending upon land type. Essentially all acres open field burned would be eliminated due to cropping pattern shifts to annual ryegrass/summer fallow on poorly-drained lands and fall wheat and vegetable crops on medium and well-drained lands. Income dispersion increases would be severe, 20 to 210 percent, primarily because of cropping shifts on the medium and well-drained lands.

A seventh level choice for growers involves no thermal sanitation with straw removal. A 30 percent whole farm income reduction is expected while ranging from 10 to 43 percent, depending upon land type. Acres thermally sanitized would, of course, not be open burned. Income dispersion increases, as with the previous choice, are expected to be severe, ranging from 20 to 210 percent with the greatest increases on medium and well-drained lands. This choice underscores the importance of straw removal and existence of economically viable markets for straw when no sanitation is used. Finally, potential hazards exist for resurgence of yield-reducing disease pathogens if no thermal sanitation is conducted. The degree to which this may occur is not known, nor easily validated by research without total cessation of field sanitation in the entire Valley.

The eighth and least desirable choice for growers involves thermal sanitation by mobile field sanitizers only. Grass seed incomes would be reduced by nearly 40 percent. While this choice would cut acres open burned entirely and emission levels perhaps equivalent to reduction of open burning by 70 to 90 percent, reliance upon experimentally unproven, commercially unavailable and economically costly sanitizer makes this choice economically unattractive and a high risk as well.

The policies evaluated in this study are intended to reduce air emissions by reducing the number of acres open field burned. While each policy affects farm income and acreage burn levels somewhat differently, their general results, as summarized in Table 10, are similar. These general results, expressed as individual crop and whole farm adjustments, are summarized in the next two sections. Issues related to industry adjustment are discussed briefly in a third section.

Crop Adjustment

Study results suggest that adjustment to public policies for reducing open field burning will be met initially by grower shifts away from open burning of annual and perennial ryegrasses on the poorly-drained lands, orchardgrass and bentgrass on the medium-drained lands, and orchardgrass and bluegrass on the well-drained lands.

The potential for wholesale shifting to non-grass seed crops on the poorly-drained lands is severely limited, leaving changes in cultural practices, such as annual ryegrass/summer fallow rotation, plowdown of annual ryegrass, and roadsiding of straw on perennial ryegrass, as the best choices. These choices imply considerable expected income reductions, depending upon the policy choices. As a means for offsetting declining incomes, continued conversion of perennial ryegrass from public to proprietary varieties is expected, with the rate dictated by market conditions.

The relatively high historical profit margins for orchardgrass suggest considerable reluctance to reduce its production on medium-drained lands unless substantial economic penalties are imposed, such as with policy choices (1) grass seed production charge above $15/acre, (2) S.B. 311 for 1978, (3) no burn with straw removal, and (4) sanitizer only. Expansion of orchardgrass on well-drained soils may occur if a large-scale shift of bluegrass production to other producing areas were to occur.

The extent of cropping pattern shifts on medium-drained land also is closely linked to the relative market price relationship between wheat and grass seed crops. This study indicates, and is supported by wheat acreage shifts from 1974 to 1976, that fall wheat price in excess of $3 a bushel is necessary for voluntary conversion from grass seed to wheat. Involuntary conversion to wheat, as this study indicates, can be expected to occur with some policy alternatives. Reluctance to shift is linked to the high price and yield risk for wheat relative to grass seeds. For example, 1978 wheat yields are expected to be only 55 percent of normal because of high disease levels from the wet and mild spring [15].

A substantial decline in acres of tall fescue grown on medium-drained land is expected to occur with policies designed to reduce open field burning. Profitability of tall fescue, relative to other grass seed types grown in Oregon, has eroded severely in recent years with reduced open burning further aggravating an already unfavorable position. In addition, Oregon produces a very small volume of total U.S. production of tall fescue. If other producing regions of tall fescue are not subjected to the same air standard requirements as Oregon, they would tend to gain an economic advantage and hence increase their production of tall fescue.

Bentgrass production is confined primarily to the well-drained lands of the Silverton hills area north of Salem. Historically, the world markets for bentgrass and wheat appear to have been major factors influencing bentgrass acreage. Large shifts from bentgrass to other seed types have not occurred because of difficulty in its eradication as a weed in other seed types. The results of this study do not give a clear picture for bentgrass, because orchardgrass consistently appears in the model as a superior choice. This model was not robust enough to evaluate bentgrass as a special case. The authors' intuitive feeling is that adjustment away from bentgrass largely will be a function of (1) degree of economic stress imposed by policy choice, and (2) extent of offsetting market price increases which result as bentgrass acreage is reduced.

For bluegrass, fine fescues and orchardgrasses grown on well-drained lands, shifts away from their production by public policy choices are not expected to occur nearly as rapidly as with grass seed production on poor and medium-drained lands because of relatively high historical income levels. Some form of thermal sanitation, even with strong policy disincentives, is more apt to prevail than on the poor and medium-drained lands, because greater capacity exists for absorbing increased production costs before a shift to less economically attractive crops becomes necessary. However, the high historical profit margin of these grasses make them a good target for increasing production in other producing regions. Whether policies to reduce open field burning in the Valley will precipitate large-scale shifting of bluegrass, fescues, and orchardgrasses to other regions will be determined not only by the type of public policy chosen for the Valley, but also by the profitability of grass seed production relative to other enterprise choices in those regions. The extent to which field burning controls will be imposed in those regions in the future will also be an important economic factor. This is the case with bluegrass acreage which is seeing some shift into Eastern Oregon, Washington, and Idaho where open field burning to maintain seed yields and seed quality is still permitted. While this study does not focus upon probable or possible regional production shifts with grass seed from alternative field burning policies in Oregon's Willamette Valley, it is clearly an important economic issue in need of research.

Farm Adjustment

Farm adjustments to changing economic conditions over time throughout the U.S. and in Oregon historically have taken the form of (1) farm size expansion and adoption of unit cost-reducing technology, (2) transfer of farmland by high unit cost farmers to lower unit cost farmers by rental or sale, and (3) transfer of farmland near urban centers to non-farm uses [45]. The extent to which grass seed farm adjustments will continue these historic trends and/or be accelerated by field burning policy choices is an important but unanswered question. This study should be viewed as being more accurate in estimating probable direction of future change rather than the precise magnitude of such change, since the changes are linked to policy choice selected and future market and technology forces beyond the control of grass seed farmers.

In central Willamette Valley counties, where poorly-drained soils are prevalent, the primary farming choice is to continue ryegrass production and adopt cost-reducing cultural practices and output-stimulating machine technology, as they become available, i.e., to stay competitive or leave the industry. Farm size expansion is an integral part of this adjustment process. Conversion of poorly-drained grass seed land for urban use is not expected to be rapid unless joint action for costly large-scale drainage efforts is conducted.

The pressure to acquire land for agricultural purposes will keep land values high in spite of varying market prices for grass seed as long as a relatively large number of growers can withstand increased costs from environmental controls. The number of commercial growers is expected to decline from the current estimated level of 800. The normal decline rate is expected to be accelerated by the magnitude or degree of economic pressure from environmental controls and their political uncertainty until such time as mutually determined policies are established which are acceptable to (1) the grass seed industry, (2) the urban constituency of the Valley, and (3) state and federal air control agencies.

Industry Adjustment

Total acres of grass seed produced in the Valley declined from a high of 285,000 acres in 1973 to a low of 236,000 acres in 1976. A principal factor appears to have been very high market prices in excess of $4 a bushel for fall wheat as a substitute crop for grass seed from 1973 to 1976. Then, in 1977, fall wheat prices declined to about $2.65 per bushel with a corresponding increase in grass seed to 244,200 acres. Other contributing factors to such industry adjustment appear to include (1) immediate uncertainties of field sanitation for disease and weed control and their effect upon increased production costs, and (2) uncertainties surrounding future public policies for field burning.

Whether declining grass seed acres are a permanent trend is not known. Countervailing market prices, future technology developments, future air quality policies, and relative production cost increases between competing regions are important factors. Historically, the grass seed industry has been able to adopt unit cost-reducing technology, at the expense of farm numbers, which has more than offset market price decreases from increased production volume. Consequently, volume of grass seed production in Oregon generally has increased quite steadily over the last 20 years in spite of low and sometimes declining farm prices. Whether this will continue in the future because of added economic pressure from environmental controls, is an unanswered question influenced by the relative magnitude of changing physical, biological, economic, social, and institutional forces. A companion grass seed market study, being prepared by Rayn and Conklin, will be published soon [33]. It will evaluate industry adjustment of supply and demand to conditions which are felt in the marketplace.

AN INQUIRY INTO MEANS FOR EVALUATING GAINS AND LOSSES FROM REDUCED FIELD BURNING

As stated in the Problem Setting section of this report, establishment and implementation of environmental standards involve a departure from the status quo. Consequently, tradeoffs or changes can be expected for both the private and public sectors which are felt as gains and/or losses when measured against the existing or status quo condition. While some of the tradeoffs can be measured directly in the marketplace, others are more subtle, requiring utilization of a social value system to measure the desirability of alternative courses of action.

This study has focused on evaluating probable and initial private losses to grass seed growers as they adjust operations to reduce air pollution from open field burning. Unfortunately, this provides only a partial answer for the assessment or evaluation process. Measurement of social gains and losses, as well as additional private gains and losses beyond the grass seed grower level, need also to be made to provide a complete picture of who gains and who loses from alternative air quality policies and by how much. Until such efforts are conducted, we have a very incomplete perspective of total effects. The next section is written to provide a conceptual framework for development of a more complete picture, followed by recommendations for research to quantify those relationships.

Existence of Private and Social Gains/Losses Beyond the Farm Gate

Private Losses

To the extent that total volume of cool season grass seed production declines in the U.S., as a consequence of Willamette Valley field burning policy, the consumers of such grass seeds for lawn and turf, cover crop, and pasture mix purposes will pay higher prices in the market place for grass seed. A reduced property tax base in the Willamette Valley, while unlikely, also would be a loss if it occurred, particularly in terms of reduced services to the public sector for schools and other local services. Reduced grass seed quality would generate a similar loss but in a more indirect way by resorting to cost-increasing alternatives to combat the lower quality. This might include purchases of larger volumes of seed, more rapid stand re-establishment practices, and conversion to less desirable grasses and legumes in stand establishment. Reduced seed volume might adversely affect employment at the processor level initially with possible transfer of the processor function to other geographic areas. Other agri-business adjustments from change in fertilizers, chemicals, machinery, etc., sales might also occur with the magnitude of change, either gains or losses, influenced by the level of offsetting changes in agri-business demands from alternative cropping patterns.

A subtle private loss involves increases in taxes at state and federal levels to build and maintain a public sector component to manage and enforce public rules for environmental quality.

Private Gains

Some economic activity is generated as a consequence of seeking viable alternatives to open field burning. This includes research and consulting efforts which focus upon new technology options as well as marketing and other research studies conducted by both the private and public sectors.

Social Losses

Loss of the Willamette Valley green belt by urban sprawl, to the extent that it is socially undesirable, is an example of a social loss. An additional but difficult social loss to assess involves loss of personal freedoms of choice. Greater controls over individual actions in the market-place and in social action of how we may or may not be allowed to utilize our natural resources constrains individual actions. This may involve deferred resource use to benefit future generations or more shared access to the use of air and water resources.

Social Gains

A number of social benefits exist from improving air quality in the Willamette Valley. The most frequently suggested ones include enhanced tourist trade, alleviation of respiratory health ailments, reduction of highway driving hazards, and reduced soiling and nuisance effects. Measurement of these social gains, in an economic sense, is fragmentary and incomplete, and has been limited to a preliminary study of tourism, Oregon's number three industry. The study indicates that tourism appears to be affected relatively little by field burning, since most recreation activities are outside the Willamette Valley, in the mountains, and along the ocean [44]. Those people with respiratory ailments who live in the Valley during the burning season appear to be the principal sufferers. No health study has yet been conducted in the Willamette Valley to evaluate the effects of air emissions from all sources, including field burning, upon its citizenry. Plans to conduct such a study, which may require several years, are being developed.

Only a handful of health studies have been conducted in the U.S. to evaluate effects of air pollution [21, 22]. Federal and state funds only recently have become available to conduct such efforts, and they face difficult measurement problems. The few studies conducted to date provide limited evidence. A 1977 study in Allegheny County, Pennsylvania, an area with heavy industrial concentration, found positive correlation between industrial air pollution and mortality [16]. Two 1976 studies in metropolitan areas of Washington, D.C., and Portland, Oregon, found some association between air pollution levels and health effects, using health costs as a proxy [4,20,40,41]. Only recently have studies been initiated to evaluate economic gains and losses associated with driving hazards and soiling and nuisance effects from air pollution with none of them focusing upon the Willamette Valley case [19].

The value of visibility, as an aesthetic commodity, is becoming recognized by the consuming public as an important area for evaluation of social benefits from environmental control. Studies in the Southwest, by Randall, Crocker, and others, relative to point sources of air pollution from power plants, indicate that valuation of visibility using consumer bidding games holds promise for providing consistent and meaningful measurements of aesthetic values [5,6,35,36].

A Framework for Measuring Private and Social Gains and Losses

Cost-benefit analysis has been employed in the public sector for quite some time, particularly in evaluating potential gains and losses from public investment for natural resource policy, especially those involving reclamation projects for power generation, recreation, irrigation, and other multiple uses. While not perfect, considerable advances have been made in recent years in accounting, not only for expected monetary gains and losses, but also the more difficult non-monetary components as well. As quantitative measurements improve, greater account will be taken in the future of such issues as social time preference in resource use, regional and national income distribution effects, national security, and future uncertainties. Quantifiable portions of these issues will become a part of the formal benefit-cost framework while the remaining qualitative components will be identified and weighted subjectively through the political decision process. The process of adapting such a benefit and cost framework for assessing environmental impacts has just begun at the federal level.

Social losses associated with air quality degradation have been the subject of careful empirical research for less than a decade, spawned by public awareness of environmental issues in the late 1960s [Barkeley and Seckler]. Nearly all the technology for physical measurement of chemical and other toxic components of air emissions has been developed in the 1970s. But such monitoring equipment is expensive to set up and use with most of it concentrated in areas of high urban concentration. In addition, very limited effort has focused upon using such equipment to (1) identify and separate the relative effects of each type of air pollutant upon human and non-human activity, including crop losses. In the Willamette Valley case, monitoring equipment has been expanded only recently to investigate air pollutant levels and durations from field burning, slash burning, industrial, and vehicular sources. Even then, separating air pollutant effects from other variables which also affect human health, such as personal habits in smoking, drinking, and nutrition, urban housing density, etc., will require considerable effort.

Air pollution and its relationship to human health, in a social gain or loss setting, requires going beyond even the difficult task of measuring physical relationships between air pollution and health. It requires coming to grips with the economic question of "is it worth it?", which necessitates placing values upon human health and human life and its tradeoff with other human activity. Economic gains and/or losses are being developed as a first approximation of social gains/losses by measuring changes in in-patient and out-patient health care activity and human mortality. While less than ideal, and costly to develop and quantify because of complex statistical relationships, they are essential first steps to any realistic assessment of expected private and social gains and losses associated with alternative courses of social action for changing air quality. Environmental economics research is focusing upon household production function studies, wage differentials between geographical regions, property value changes over time within a region, and property value differentials between regions as measures of willingness to pay for environmental improvements [16].

Recommendations for Research

The requirements for measuring private and social gains and losses from alternative air quality control policies in Oregon's Willamette Valley call for much more than the initial step attempted by this study which assesses private losses at the grass seed grower level. Ultimately, it will necessitate evaluation of the entire spectrum of private and social gains and losses. As a step in that direction, the authors of this document recommend that a number of research efforts be initiated utilizing state and federal funds. The following topics should be given high priority:

1. Measurement of existing sources of air emissions. This should embody all sources, including agricultural field burning, forest slash burning, vehicular emissions, industrial emissions, and urban household emissions.

2. Determination of the physical properties of air emissions. This requires measurement of the geographic source, emission levels, dispersion characteristics, and physical (toxicity) components of the mix of emissions at specific points in time and over time.

3. Determination of the physical health and other effects which the various physical properties of air emissions have upon various segments of society. This requires quantification of the current level of economic activity and the negative and/or positive effects which air emissions are having upon it. Evaluation of tourist activity, visibility hazards for transportation, soiling effects, general health effects, and the aesthetic value of improved visibility would be necessary. Health studies should include health risks, probability of

exposure, and avoiding costs of health risks. Linkage between the various types and levels of air pollution and their contribution to social effects also must be clearly established.

4. Determine the degree to which management factors influence or modify the adverse effects which air emissions have upon segments of society. This requires modeling expected changes in air emission characteristics (including their source, level, timing, duration, toxicity, etc.) associated with a number of management options (change in air quality standards, smoke management programs, etc.) and the expected effects of these changes upon tourism, driving hazards, health effects, industrial expansion, changing land use practices, etc. This issue is of particular significance since state and federal air emissions standards involve upper limits on ambient airshed pollution levels. For airsheds already at upper limits, any desired change in its economic base involves economic tradeoffs in choice of requiring existing industries to reduce emissions, have new industries install costly air pollution control equipment, or require new plants to limit plant size in meeting emission levels. Thus, management of airsheds involves multiple-industry and consumer tradeoffs.

5. Compare current economic activities with those expected from alternative management policies. The intent is to quantify, to the extent possible, the relative changes expected to occur in both the private and public sectors so as to identify who gains and who loses and by how much, a necessary condition in selecting most desired strategies for social action.

SUMMARY AND CONCLUSIONS

This study was conducted to assess initial expected adjustment and resulting economic losses to producers of grass seed from selected public policy choices for reducing open field burning in Oregon's Willamette Valley.

A quadratic programming algorithm was used to model a commercial grass seed farm on which poorly-drained soils predominate with limited acreage of medium and well-drained lands. The grass seed farm model was optimized and validated to represent a comparison of economic conditions under open field burning against selected alternative public policy choices.

Quantitative comparisons showed considerable differences in expected or probable economic impacts to growers among the public policy choices. A summary, ranked from least to most economically disruptive, is shown as follows:

Policy Choice	Percent reduction from open burn: in Grower income — Total farm average	in Grower income — Range by land type	of Acres burned
S.B. 311 - 1975	9	2-14	17
- 1976	13	2-22	31
H.B. 2196 - 1977	13	3-22	31
- 1978	14	3-24	36
Charge of $10-$20/acre to open field burn	16	10-30	26
H.B. 2196 - 1978, Revised	18	8-38	36
DEQ-controlled burn on alternate years	22	10-27	50
S.B. 311 - 1977	23	3-40	66
- 1978	26	3-43	88
Charge of $20-$35/acre to open field burn	30	10-40	100
No burn with straw removal	30	10-43	100
Mobile sanitizer only	39	17-43	100

The first four choices are expected to reduce acres open burned from 17 to 36 percent while confining total farm income reductions to less than 20 percent. No major crop pattern shifts away from grass seed production are expected, and increased income dispersion effects are low due primarily to internalized cost increases. The next two choices are expected to reduce acres open burned from 50 to 88 percent while reducing total farm income by 22 to 26 percent. Major crop pattern shifts from annual and perennial ryegrass to annual ryegrass/summer fallow rotation take place on the poorly-drained lands with considerable income reduction and increased income variability. Some crop shifts to wheat on medium-drained lands, but no major crop shifts on well-drained lands, are expected. The final three choices, while eliminating acres open burned entirely, would have severe farm income effects, reducing income some 30 to 40 percent on the average. Major crop pattern shifts occur on all soil types with income dispersion (riskiness) increasing markedly.

Policy effects would not be felt uniformly across growers in the Willamette Valley. Income reductions for essentially all policy choices are expected to be more severe for grass seed farms having a high percentage of poorly-drained lands relative to those having higher proportion of medium and well-drained lands. This is due to low income margins and severely limited crop alternatives on poorly-drained lands.

This study evaluates only expected private losses to growers. A companion study nearing completion evaluates expected industry effects [33]. In it, evidence exists that market price increases associated with reduced production of grass seed will provide some dampening effect upon farm income reductions. Hence, results of this study, to a limited extent, may overstate farm income reductions.

Social impacts from reduced open field burning are limited in this study to estimated percent reductions in acres open field burned. Unfortunately, this is an exceedingly poor proxy for measuring the socio-economic impacts which air emissions from all sources have upon human health, tourist trade, etc., in the Willamette Valley. Consequently, it is urged that a major research effort be implemented to assess the full spectrum of private and social gains and losses from reduction of open field burning with special attention given to (1) identification of major sources of air emissions in the Valley, including field burning, forest slash burning, industry and motor vehicles; (2) measurement of the impacts such sources have upon health and other economic activity; (3) evaluation of alternative policy choices, including changes in air quality standards, smoke management programs, etc., and their impact upon the various activities in the State; (4) comparison of such policy choices to assess their net effects upon the private and public sectors of Oregon; and (5) assessment of change in economic advantage for Willamette Valley agriculture and industry relative to other competing regions.

BIBLIOGRAPHY

1. Anderson, F. R., Allen Kneese, Phillip Reed, Serge Taylor, and Russell Stevenson. Environmental Improvement Through Economic Incentives. Resources for the Future, 1977.

2. Bauer, Leonard. "A Quadratic Programming Algorithm for Deriving Efficient Farm Plans in a Risk Setting." Unpublished Ph.D. thesis, Oregon State University, Corvallis, 1971.

3. Baumol, William J., and Wallace E. Oates. The Theory of Environmental Policy. Prentice Hall, 1975.

4. Bhagia, Gobind S., and Herbert H. Stoevener. "Impact of Air Pollution on the Consumption of Medical Services by Hospital Patients in the Portland Metropolitan Area." Socioeconomic Environmental Studies Series EPA-600/5-78-002. Office of Research and Development, U.S. Environmental Protection Agency, Corvallis, Oregon, August 1977.

5. Blank, F. "Evaluation of Aesthetic Preferences: A Case Study of the Economic Value of Visibility." Research Report to the Electric Power Research Institute, REEL, University of Wyoming, 1977. (Draft).

6. Brookshire, David, Berry C. Ives, and William D. Schulz. "Evaluation of Aesthetic Preferences." Journal of Environmental Economics and Management, 3:325-346 (1976).

7. Carnes, James L. Personal communication, January 1977.

8. Conklin, Frank S. "Environmental Quality Problems: A Case Study of Field Burning in the Willamette Valley." Oregon Agricultural Experiment Station Technical Paper 2921. Oregon State University, Corvallis, July 1970.

9. Conklin, Frank S. "Some Economic Consequences of Densifying, Handling, and Storing of Willamette Valley Grass Straw." Oregon Agricultural Experiment Station Technical Paper 4043. Presented at World Straw Conference, Eugene, Oregon, May 1975.

10. Conklin, Frank S., and R. Carlyle Bradshaw. "Farmer Alternatives to Open Field Burning: An Economic Appraisal." Oregon Agricultural Experiment Station Special Report 336, Oregon State University, Corvallis, 1971.

11. Conklin, Frank S., and Douglas E. Fisher. "Economic Characteristics of Farms Producing Grass Seed in Oregon's Willamette Valley." Oregon Agricultural Experiment Station Circular of Information 643, Corvallis, November 1973.

12. Conklin, Frank S., and Jon Dean. "Costs and Returns of Grass Seed Production in Oregon's Willamette Valley, 1959 to 1975." Oregon Agricultural Experiment Station Special Report 464, Corvallis, October 1976.

13. Foote, W. H., and H. J. Mack. "Alternative Crops to Grass Seed Production on Poorly Drained Soils." In: Agricultural Field Burning in the Willamette Valley. Oregon Agricultural Experiment Station and Air Resources Center, Corvallis, 1969.

14. Freeman, A. Myrick III, and Robert A. Haveman. "Residuals Charges for Pollution Control: A Policy Evaluation." In: Science, Vol. 177, July 28, 1972.

15. Goetze, Norman. Personal Communication, August 1978.

16. Gregor, John J. "Intra-Urban Mortality and Air Quality: An Economic Analysis of the Costs of Pollution Induced Mortality." Socioeconomic Environmental Studies Series EPA-600/5-77-009. Office of Research and Development, U.S. Environmental Protection Agency, Corvallis, Oregon, July 1977.

17. Hardison, John R. "Justification for Burning Grass Fields." In: Proceedings, 24th Annual Oregon Seed Growers Conference, Corvallis, Oregon, 1964.

18. Heady, Earl O., and Wilfred Candler. Linear Programming Methods, Iowa State University Press, Ames, 1964.

19. Jaksch, John A. Personal communication, August 1978.

20. Jaksch, John A., and Herbert H. Stoevener. "Outpatient Medical Costs Related to Air Pollution in the Portland, Oregon Area." Socioeconomic Environmental Studies Series 600/5-74-017. Office of Research and Development, U.S. Environmental Protection Agency, Corvallis, Oregon, July 1974.

21. Lave, Lester B., and Eugene P. Seskin. Air Pollution and Human Health. Resources for the Future, 1978.

22. Lave, Lester B., and Eugene P. Seskin. "Does Air Pollution Cause Mortality?". Resources for the Future Reprint 141, 1977.

23. Middlemiss, Willis E. "The Economic Feasibility of Utilizing Irrigable Willamette Valley Floor Land for Beef Production." Unpublished M.S. Thesis, Oregon State University, Corvallis, 1970.

24. Miles, Thomas. "Consulting Engineers' Report to the Oregon Field Sanitation Committee Covering 1975 and 1976 Activities." December 1976.

25. Nelson, A. Gene. "Evaluating Oregon's Tax Options on Pollution Control Facilities." Cooperative Extension Service Special Report 361, Oregon State University, Corvallis, 1972.

26. Oregon Agricultural Experiment Station. "Field Burning in Oregon." Special Report 476, Oregon State University, Corvallis, February 1977.

27. Oregon Agricultural Experiment Station. "Oregon State University Research on Field Burning." Circular of Information 647, Oregon State University, Corvallis, December 1974.

28. Oregon Department of Environmental Quality. "Field Burning in the Willamette Valley 1975." DEQ Air Quality Control Division, Portland, April 1, 1976.

29. Oregon Department of Environmental Quality. "Field Burning in the Willamette Valley 1976." DEQ Air Quality Control Division, Portland, January 31, 1977.

30. Oregon Enterprise Data Sheets. Department of Agricultural and Resource Economics, Oregon State University, Corvallis, January 1975.

31. Oregon Laws 1971, Chapter 563. Filed in Office of Secretary of State, Salem, Oregon, June 29, 1971.

32. Oregon Laws 1975, C-Eng. "Senate Bill 311." Filed in Office of Secretary of State, Salem, Oregon, June 1975.

33. Oregon Legislative Assembly. "House Bill 2196." June 1977.

34. Porfily, Lenard, and Frank S. Conklin. "Technical and Economic Considerations in Shipping Grass Seed Residue to Japan." Oregon Agricultural Experiment Station Circular of Information 638, Corvallis, March 1973.

35. Randall, Alan, Berry C. Ives, Clyde Eastman. "Abating Aesthetic Environmental Damage from the Four Corners Power Plant, Fruitland New Mexico." Agricultural Experiment Station Bulletin 618, Las Cruces, New Mexico, 1974.

36. Randall, Alan, Berry C. Ives, Clyde Eastman. "Bidding Game Evaluation of Aesthetic Environmental Improvements." Journal of Environmental Economics and Management, Vol. 1, 1974.

37. Ryan, James T., Frank S. Conklin, John A. Edwards, and Gobind Bhagia. "Demand and Supply Analysis of the Oregon Grass Seed Industry." To be published as an Agricultural Experiment Station Technical Bulletin, Oregon State University, Corvallis, 1979.

38. Sandwell International. "Ryegrass Straw Utilization in Paper and Fiberboard Products: An Exploratory Investigation." Oregon Agricultural Experiment Station Circular of Information 648, Corvallis, January 1975.

39. Seckler, David W., and Paul W. Barkley. Economic Growth and Environmental Decay, the Solution Becomes the Problem. Harbrace Press, New York, 1972.

40. Seskin, Eugene P. "An Analysis of Air Pollution and Its Health Effects in the Washington Metropolitan Area." Paper presented at 69th Annual Meeting of the Air Pollution Control Association, Portland, Oregon, June 1976.

41. Seskin, Eugene P. "Air Pollution and Health in Washington, D.C.: Some Acute Health Effects of Air Pollution in the Washington Metropolitan Area." Socioeconomic Environmental Studies Series EPA-600/5-77-010. Office of Research and Development, U.S. Environmental Protection Agency, Corvallis, Oregon, July 1977.

42. U.S. Department of Agriculture. Agricultural Prices, Annual Summaries, and Monthly Summaries, 1959-1977. Crop Reporting Board, Statistical Reporting Service, Washington, D.C., and Oregon State University Cooperative Extension Service, Corvallis.

43. U.S. Department of Agriculture. Agricultural Statistics, 1974. U.S. Government Printing Office, Washington, D.C., 1975.

44. Vars, Charles R., and Gary W. Sorenson. "Study of the Economic Effects of Changes in Air Quality." Air Resources Center, Oregon State University, June 1972.

45. Wilcox, Walter H., Willard W. Cochrane, and Robert W. Herdt. Economics of American Agriculture. Prentice-Hall, 1974.

46. Youngberg, Harold, and D. O. Chilcote. "Grass Seed Straw Residue and Stubble in the Willamette Valley." Unpublished Research, Department of Agronomic Crop Science, Oregon State University, Corvallis, 1974.

47. Youngberg, Harold. Personal communication, August 1976.

APPENDIX

Appendix Table 1. Correlation Coefficients on Gross Margins by Crop Type

	Perennial ryegrass	Annual ryegrass	Bent-grass	Fine fescue	Tall fescue	Blue-grass	Orchard-grass	Bush beans	Sweet corn	Fall wheat	Spring oats	Annual ryegrass/ summer fallow	Alfalfa
Perennial ryegrass	1	.8904	.68465	.80937	.68740	.76931	.94390	.36928	.65478	.93610	.87614	.89040	.84118
Annual ryegrass/summer fallow		1	.57588	.60444	.64071	.49500	.89351	.63994	.84773	.90028	.93486	.99990	.92394
Bentgrass			1	.78566	.67440	.74843	.75370	.03801	.31831	.48757	.55416	.57588	.63738
Fine fescue				1	.79976	.96284	.77231	.16391	.21320	.70457	.54225	.60444	.61893
Tall fescue					1	.72996	.74969	.06328	.31940	.62031	.53515	.64271	.66219
Bluegrass						1	.72247	.28737	.12938	.63118	.47632	.49500	.54759
Orchardgrass							1	.37631	.73507	.88659	.91261	.89357	.91758
Bush beans								1	.82333	.45326	.64409	.63994	.50968
Sweet corn									1	.75266	.42968	.84773	.51648
Fall wheat										1	.91339	.90025	.87675
Spring oats											1	.93486	.96545
Annual ryegrass/summer fallow												1	.42394
Alfalfa													1

Appendix Table 2. Calculation of Gross Margin and Income Dispersion Estimates Per Acre for Grass Seed Crops to Represent the Mobile Field Sanitizer Alternative a/

	Expected gross returns b/	Annual operating costs under open burning b/	Cost of open field burning c/	Cost of mobile sanitizer	Annual operating costs using mobile field sanitizer d/	Gross margin using mobile sanitizer	Variance of gross margin with mobile sanitizer	Coefficient of variation e/
Annual ryegrass................	$124.07	$55.01	$3.47	$56.11	$107.65	$16.42	3,382	3.54
Perennial ryegrass..............	133.23	60.30	3.72	50.11	106.69	26.54	5,268	2.74
Orchardgrass....................	199.47	79.10	5.47	55.11	128.74	70.73	1,324	.51
Highland bentgrass..............	'153.97	68.52	3.94	44.31	108.89	45.08	1,282	.79
Tall fescue.....................	113.69	78.02	3.14	51.11	125.99	-12.30	1,555	.76
Kentucky bluegrass..............	229.15	95.19	3.72	45.11	136.58	92.57	10,600	1.11
Fine fescue.....................	163.77	83.55	4.41	45.11	124.25	39.52	3,587	1.52

a/ Income and income dispersion characteristics not affected for non-grass seed crops.

b/ Obtained from Table 3.

c/ Estimated from 1969 open field burning costs which include firebreak requirements adjusted to 1977 by USDA index of all production items, December 1976 [10,42,43].

d/ Calculated as annual operating costs under open burning - cost of open burning + mobile sanitizer cost.

e/ $\sqrt{V(GM)}$ / gross margin.

Appendix Table 3. Calculation of Gross Margin and Income Dispersion Estimates Per Acre for Grass Seed Crops to Represent Conditions Under DEQ-Controlled Open Field Burning on Alternate Year Equivalent Basis a/

Crop	Expected gross returns	Annual operating cost under open burning b/	Annual DEQ-controlled open burn costs c/	Annual straw removal costs	Total annual operating costs d/	Gross margin	Variance of gross margin	Coefficient of variation e/
Annual ryegrass.................	$124.07	$55.01	$7.00	$42.50	$ 79.76	$ 44.31	3,382	1.31
Perennial ryegrass..............	133.23	60.30	7.00	36.50	82.05	51.18	5,286	1.42
Orchardgrass....................	199.47	79.10	7.00	41.50	103.35	96.12	1,324	.38
Highland bentgrass..............	153.97	68.52	7.00	30.70	87.37	67.60	1,282	.53
Tall fescue.....................	113.69	78.02	7.00	37.50	100.27	13.42	1,555	2.94
Kentucky bluegrass..............	229.15	95.19	7.00	31.50	114.44	114.71	10,600	.90
Fine fescue.....................	163.77	83.55	7.00	31.50	102.80	60.97	3,587	.98

a/ Income and income dispersion characteristics not affected on non-grass seed crops.

b/ Obtained from Table 3.

c/ Additional fire control per acre costs under DEQ smoke management burn in 1977.

d/ Annual operating cost under open field burning plus $\frac{\text{[annual DEQ-controlled open burn costs + annual straw removal costs]}}{2}$.

e/ $\frac{\sqrt{V(GM)}}{\text{gross margin}}$.

Appendix Table 4. Calculation of Gross Margin and Income Dispersion Estimates Per Acre for Grass Seed Crops to Represent Conditions Where Field Sanitation is Achieved by an Equal Combination of Controlled Open Field Burning and Mobile Field Sanitation. a/

	Expected gross returns b/	Annual operating costs under open burning	Annual DEQ-controlled open burn costs	Mobile sanitizer cost	Total annual operating costs c/	Gross margin	Variance of gross margin
Annual ryegrass	$124.07	$55.01	$7.00	$56.11	$ 86.56	39.51	3,382
Perennial ryegrass	133.23	60.30	7.00	50.11	88.86	44.37	5,286
Orchardgrass	199.47	79.10	7.00	55.11	110.16	89.31	1,324
Highland bentgrass	153.97	68.52	7.00	44.31	94.18	59.79	1,282
Tall fescue	113.69	78.02	7.00	51.11	107.08	6.61	1,555
Kentucky bluegrass	229.15	95.19	7.00	45.11	121.24	107.91	10,600
Fine fescue	163.77	83.55	7.00	45.11	109.61	54.16	3,587

a/ Income and income dispersion characteristics not affected on non-grass seed crops. Input coefficients for such crops are same as those shown in Table 3.

b/ From Table 3.

c/ Annual operating costs under open field burning plus $\left[\frac{\text{Annual DEQ-controlled open burn costs + annual mobile sanitizer costs}}{2}\right]$.

Appendix Table 5. Revision of Gross Margin and Income Dispersion Estimates Per Acre for Grass Seed Crops to Represent <u>No Thermal Sanitation With Residue Removal</u> Alternative a/

	Expected gross return b/	Annual operating costs under open burning c/	Cost of open field burning d/	Straw removal costs	Annual operating costs with straw removal e/	Gross margin	Variance gross margin
Annual ryegrass................	$ 86.15	$55.01	$3.47	$42.50	$ 94.04	- 7.89	3,382
Perennial ryegrass.............	85.36	60.30	3.72	36.50	93.08	- 7.72	5,286
Orchardgrass...................	119.46	79.10	5.47	41.50	115.13	4.33	1,324
Highland bentgrass.............	62.30	68.52	3.94	30.70	95.28	-33.04	1,282
Tall fescue....................	66.46	78.02	3.14	37.50	112.38	-45.92	1,555
Kentucky bluegrass.............	133.94	95.19	3.72	31.50	122.97	10.97	10,600
Fine fescue....................	59.95	83.55	4.41	31.50	110.64	-50.69	3,587

a/ Income and income dispersion characteristics not affected for non-grass seed crops. Input coefficients for such crops are same as those shown in Table 3.

b/ Calculated from yields shown on p. 38 and price listed in Column 3 of Table 3.

c/ Obtained from Table 3.

d/ Obtained from Table 7.

e/ Obtained from total straw yield on p. 28 times $10/ton straw removal cost.

f/ Calculated as annual operating costs under open burning - cost of open burning + cost of straw removal.

Appendix Table 6. Revision of Gross Margin and Income Dispersion Estimates Per Acre for Grass Seed Crops to Represent Legislated Acreage Phaseout by S.B. 311 of Open Field Burning Alternative

Year	Crop	Expected gross returns[a/]	Annual operating costs under open burning plus DEQ fire control	Annual permit fee	Annual operating cost with DEQ smoke management and permit fee	Expected gross margin	Coefficient of variation[d/]
1975	Annual ryegrass	$124.07	$56.51	$3.00	$ 59.51	$ 64.56	.90
	Perennial ryegrass	133.23	61.80	3.00	64.80	68.43	1.06
	Orchardgrass	199.47	80.60	3.00	83.60	115.87	.31
	Highland bentgrass	153.97	70.02	3.00	73.02	80.95	.44
	Tall fescue	113.69	79.52	3.00	82.52	31.17	1.27
	Kentucky bluegrass	229.15	96.69	3.00	99.69	129.46	.80
	Fine fescue	163.77	85.05	3.00	88.05	75.72	.79
1976	Annual ryegrass	124.07	56.51	4.00	60.51	63.56	.91
	Perennial ryegrass	133.23	61.80	4.00	65.80	67.43	1.08
	Orchardgrass	199.47	80.60	4.00	84.60	114.87	.32
	Highland bentgrass	153.97	70.02	4.00	74.02	79.95	.45
	Tall fescue	113.69	79.52	4.00	83.52	30.17	1.31
	Kentucky bluegrass	229.15	96.69	4.00	100.69	128.46	.80
	Fine fescue	163.77	85.05	4.00	89.05	74.72	.80
1977	Annual ryegrass	124.07	56.51	5.50	62.01	62.06	.94
	Perennial ryegrass	133.23	61.80	5.50	67.30	65.93	1.10
	Orchardgrass	199.47	80.60	5.50	86.10	113.32	.32
	Highland bentgrass	153.97	70.02	5.50	75.52	78.45	.46
	Tall fescue	113.69	79.52	5.50	85.02	28.67	1.38
	Kentucky bluegrass	229.15	96.69	5.50	102.19	126.96	.81
	Fine fescue	163.77	85.05	5.50	90.55	73.22	.82
1978	Annual ryegrass	124.07	56.51	8.00	64.51	59.56	.98
	Perennial ryegrass	133.23	61.80	8.00	69.80	63.43	1.14
	Orchardgrass	199.47	80.60	8.00	88.60	110.87	.33
	Highland bentgrass	153.97	70.02	8.00	78.02	75.95	.47
	Tall fescue	113.69	79.52	8.00	87.52	26.17	1.51
	Kentucky bluegrass	229.15	96.69	8.00	104.69	124.46	.83
	Fine fescue	163.72	85.05	8.00	93.05	70.72	.85

[a/] Obtained from Table 3.

[b/] Annual operating cost from Table 3 plus $1.50/acre for additional fire crew costs.

[c/] Column 2 plus fire control cost of $2.15 per acre.

[d/] Coefficient of variation = standard deviation ÷ expected gross margin with the standard deviation of gross margin for each crop being the same as shown in Table 3.

Appendix Table 7. Revision of Gross Margin and Income Dispersion Estimates Per Acre for Grass Seed Crops To Represent Conditions Under H.B. 2196 for 1977 and 1978 a/

	Expected gross returns b/	Annual operating costs under open burn b/	DEQ permit fee and fire control cost c/	Total operating costs d/	Gross margin	Variance	Coefficient of variation
Annual ryegrass..................	$124.07	$55.01	$5.00	$ 60.01	$ 64.06	3.382	.91
Perennial ryegrass...............	133.23	60.30	5.00	65.30	67.93	5,268	1.07
Orchardgrass.....................	199.47	79.10	5.00	84.10	115.37	1,324	.32
Highland bentgrass...............	153.97	68.52	5.00	73.52	80.45	1,282	.45
Tall fescue......................	113.69	78.02	5.00	83.02	30.67	1,555	1.29
Kentucky bluegrass...............	229.15	95.19	5.00	104.19	124.96	10,600	.82
Fine fescue......................	163.77	83.55	5.00	88.55	75.22	3,587	.80

a/ Income and income dispersion characteristics not affected for non-grass seed crops. Input coefficients for such crops are same as those shown in Table 3.

b/ Obtained from Table 3.

c/ Permit fee of $3.50 per acre plus $1.50/acre for additional fire crew labor to maintain on-call status.

d/ Annual operating costs under open field burning plus DEQ permit fee and additional fire control costs.

Appendix Table 8. Revision of Gross Margin and Income Dispersion Estimates Per Acre for Grass Seed Crops to Represent Conditions Under House Bill 2196 Plus Backfiring for 1978 a/

	Expected gross returns b/	Annual operating costs under open burn b/	Additional cost of backfiring c/	DEQ permit fee and fire control cost d/	Total operating costs e/	Gross margin	Variance	Coefficient of variation
Annual ryegrass..............	$124.07	$55.01	$3.47	$5.00	$ 63.48	$ 60.59	3,382	.96
Perennial ryegrass...........	133.23	60.30	3.72	5.00	69.02	64.21	5,268	1.13
Orchardgrass.................	199.47	79.10	5.47	5.00	89.57	109.90	1,324	.33
Highland bentgrass...........	153.97	68.52	3.94	5.00	77.46	76.51	1,282	.47
Tall fescue..................	113.69	78.02	3.14	5.00	86.16	27.53	1,555	1.43
Kentucky bluegrass...........	229.15	95.19	3.72	5.00	108.91	125.24	10,600	.82
Fine fescue..................	163.77	83.55	4.41	5.00	92.96	70.81	3,587	.85

a/ Income and income dispersion characteristics not affected for non-grass seed crops. Input coefficients for such crops are same as those shown in Table 3.

b/ Obtained from Table 3.

c/ Backfiring requirement assumed to double fire control costs under traditional open field burning.

d/ 1978 permit fee of $3.50 per acre plus $1.50/acre for additional fire crew labor to maintain on-call status.

e/ Annual operating costs under open field burning plus additional backfiring costs plus DEQ permit fee and fire control costs.