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Title: Acreage Response of Grass Seed to Policies Concerning Field Burning: Willamette Valley, Oregon.

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This research analyzed the relationships of agricultural field burning policies, and other economic factors, with the quantity of land devoted to grass seed production in counties of the Willamette Valley, Oregon. The thesis describes the background of the grass seed industry, field burning and government policies concerning field burning in the Willamette Valley. Econometric models of acreage response to grass seed prices, prices of production alternatives, field burning limitations, and burning fees were developed for eight grass seed crops. A technique of pooling time-series and cross-sectional data was used to estimate the parameters of the models. Expost predictions of acreages were made for the purposes of model verification. The estimated parameters are discussed and some explanations are offered for the relationships.

GRASS SEED ACREAGE RESPONSE TO POLICIES CONCERNING FIELD BURNING: WILLAMETTE VALLEY, OREGON

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I. INTRODUCTION

Problem Setting

The Willamette River Basin of Oregon is an air and watershed with a total area of 12,045 square miles. The valley floor (with 3,500 square miles) is the largest contiguous agricultural region in the Northwest. Bounded on the east by the Cascade Mountains, on the west by the Coast Range, and on the south by the Calapooya Mountains, the basin has a length of approximately 150 miles from the headwaters to the mouth of the Willamette River. The basin's width averages 75 miles from crest to crest. The climate of the basin is heavily influenced by weather systems from the nearby Pacific Ocean. There is an average annual rainfall of 63 inches which varies greatly with the season. The fall, winter, and spring months characteristically have mild temperatures and abundant rainfall associated with prevailing southwest winds. The summer months, influenced by prevailing northwest winds, are usually dry with mild temperatures. The growing season is about 220 frost-free days(24). The soils of the Willamette Valley are diverse and to a great extent dictate the agricultural use of the land.

Statement of the Problem

The climate and soils of the Willamette Valley provide ideal conditions for growing several kinds of grasses for seed. The State of Oregon is the source of about 65 percent of the total grass seed grown in the United States and grows virtually all of the ryegrass (21).

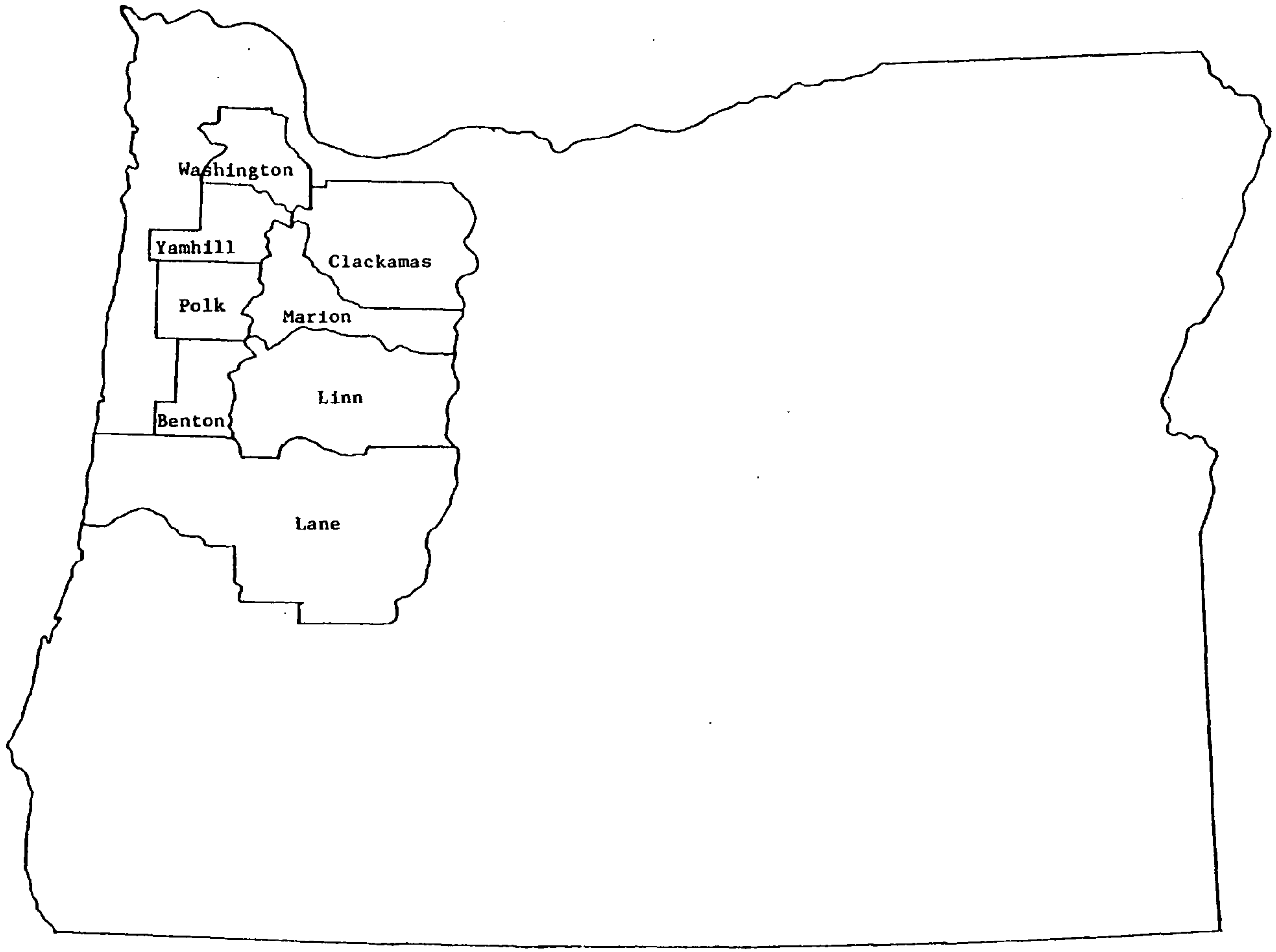
Nearly all of the grass seed grown in the state comes from the Willamette Valley, and the seed industry is an important economic influence on the region. The eight Willamette Valley counties where the bulk of the grass seed is grown are shown in Figure 1.

The mild climate and geographical attractiveness of the Valley and surrounding areas make it a desirable location for people to make their residence. These characteristics have also given rise to a tourism industry that is the third greatest revenue generating industry in the state. The grass seed industry's coexistence with the expanding population and tourism industry in the Willamette Valley has become increasingly threatened. The threat to coexistence is related to a cultivation practice of grass seed farmers who burn straw residue in the fields after the seed is harvested. The practice creates an air pollution problem that has generated increasing concern from residents of the Valley and has led to intervention by the Oregon State Legislature.

The Legislature has given the responsibility of implementing policies to control field burning to the Oregon Department of Environmental Quality (DEQ). It has not been clear what effects the various policies the DEQ has implemented have had on decisions by farmers to grow grass seed.

The effects of field burning policies on the supply of grass seed has important implications for both growers and consumers of grass seed for two reasons: 1) previous research indicates that the demand for grass seed is relatively inelastic in the price range that has existed (21) 2) Willamette Valley growers hold a dominant position in the grass seed market. Ryan, et al. estimated the elasticities of

Figure 1. Countiea of the Willamette Valley Investigated in the Analyses



demand for grass seed at the farm level, at the wholesale level in U.S. markets, and at the wholesale level in foreign markets. These elasticities are presented in Table 1. As a consequence of the inelastic demand for grass seed, policies that reduce the supply of grass seed from the Willamette Valley are likely to result in a greater percentage increase of seed prices. This result is dependent on the influence of prices on grass seed production outside the Willamette Valley.

Table 1 Grass Seed Elasticities of Demand

Grass Seed Type	Farm Demand Elasticity	U.S. Wholesale Demand Elasticity	Foreign Wholesale Demand Elasticity
Fine Fescue	-0.671	-0.299	-0.228
Bentgrass	-0.214	---	-0.368
Merion Kentucky Bluegrass	-0.678	-0.732	---
Other Kentucky Bluegrass	-0.530	-0.347	-0.319
Tall Fescue	-0.080	-0.171	-0.361
Orchard Grass	-0.784	-0.359	---
Annual Ryegrass	-0.382	-0.083	-0.764
Perennial Ryegrass	-0.765	-0.196	-0.553

Source: Ryan, James T., et al., Demand and Supply Analysis of the Oregon Grass Seed Industry.

Goals and Objectives of the Study

The goals of this research are to:

1. Discuss the nature of the conflict over field burning in the Willamette Valley, Oregon,
2. Describe the policies that have been implemented to reduce field burning,
3. Develop models of the acreage responses of grass seed crops to relevant price and policy variations,

4. Evaluate the relationships of prices and field burning policies with acreage of grass seed crops harvested in Willamette Valley counties.

II. BACKGROUND

Development of the Grass Seed Industry

The distribution of soils in the Willamette Valley is a primary factor affecting the grass seed industry. Much of the soil of the Valley floor is "whiteland" soils, so called because of the flour like dust that wagon wheels churned up on unimproved roads (16). Soils of the Amity, Dayton, and Wapato series are "whiteland" soils; these soils have a rich shallow layer of topsoil. Beneath the topsoil is a nearly impermiable hardpan layer that obstructs drainage so that "whitelands" remain saturated throughout most of the year (3). The combination of dry summers and wet soils through the winter made most early attempts to grow crops for profit unsuccessful. Alsike clover and dry edible beans were each profitable "whiteland" crops for a short time, until production in the valleys of California made these crops uneconomic. Before the tractor was widely employed, most of this wet land was used to raise hay for horses and other livestock. Native bentgrass and ryegrasses were among crops grown for livestock feed before markets developed for seed from these grasses. The recognition of annual ryegrass as a valuable pasture crop led to a limited market for seed within Oregon as early as 1915, especially in the dairy areas of Tillamook County (16).

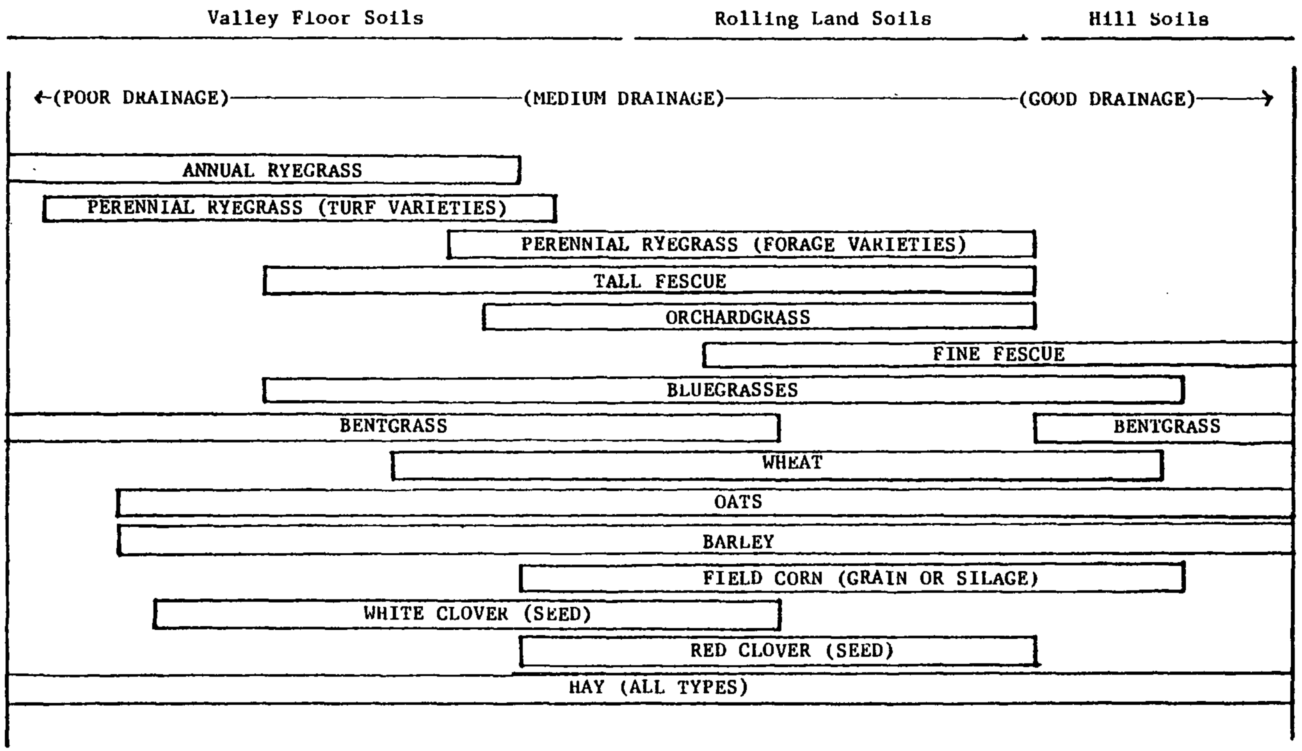
In the 1920's the first commercial shipments of ryegrass seed to the eastern United States were made. The development of this market, and a market for bentgrass as a turf grass, ended the search for "whiteland" crops. In the years since, grass seed crops have yielded net returns to the land, labor and capital far greater than alternative agricultural uses. Markets for Willamette Valley grass seed were later expanded to include eight grass seed types that make up the bulk of seed production throughout the Valley.

The rolling land of the Valley consists of medium drained soils of the Aiken, Polk, and Woodburn series. These soils are adaptable to a wider range of alternatives to grass seed production than are the "whiteland" soils. The grasses grown on these soils include turf varieties of perennial ryegrass, tall fescue, orchardgrass, and some bluegrasses.

The benchland soils or hill soils are well drained. They are frequently used for orchards and ornamental crops. These soils, which include the Chehalis, Newburg, and Willamette series, are commonly supplemented with irrigation systems. The grasses produced on this land include bentgrass, bluegrasses, and fine fescue.

To determine what crops are alternatives in production to grass seed crops, a chart was developed to summarize the physical adaptability of grass seed crops, and crops that require generally the same production inputs as grass seed, to the different soils of the Willamette Valley (Figure 2). The chart depicts a continuum of soil drainage conditions horizontally, ranging from poorly drained soils to well drained soils. The "whiteland" soils are represented on the left side of the chart, and the benchland or hill soils are represented on the right. A range of soils with intermediate drainage conditions is represented continuously between these extremes. The distribution of crop adaptability to these drainage conditions is plotted on the continuum of soil conditions.

Figure 2* Distribution of Grass Seed and Potential Alternative Crops Grown on Willamette Valley Soils



* Developed with the aid of Harold Youngberg, Extension Agronomist, Oregon State University

Table 2 was developed to determine those counties where each of the grass seed crops was primarily produced so data used in the analysis could be limited to those counties. The average annual acreage of each grass seed crop over the ten year analysis period is presented for the counties and for the Willamette Valley. The percentage of Willamette Valley acreage of each grass seed crop within the counties is also presented in the table.

The Practice of Field Burning

The quality of ryegrass seed grown in the Willamette Valley began to decline in the early 1940's. Blind seed disease, apparently imported from New Zealand, had led to decreased seed germination. The wind-born fungus that affects only the seed had spread to most Willamette Valley counties by the end of the decade. Control of the disease was imperative if the seed industry was to survive.

It was discovered that burning the field after harvesting prevented blind seed disease from occurring the following year. Growers were advised to burn the stubble and straw after harvest, as a temporary remedy for diseased fields since no chemical control measure had been found (10). It soon became apparent that burning produced beneficial effects aside from blind seed disease control. Since it was initiated in the 1940's, field burning has become an annual practice on virtually all grass seed fields, and some small grains. It is recognized as an effective control measure of ergot in perennial ryegrass, tall fescue, and Kentucky bluegrass, of grass-seed-nematode disease in chewings fescue, and of silvertop in several grasses. In addition, fall burning of grass fields has reduced the incidence of several foliar diseases

Table 2. Average Acreage of Seed Production and Percent of Willamette Valley Seed Acreage by County From 1969 to 1979

GRASS SEED CROP

COUNTY	Annual Ryegrass	Perennial Ryegrass	Bentgrass	Orchard-grass	Tall Fescue	Merion Kentucky Bluegrass	Other Kentucky Bluegrass	Fine Fescue
Benton	13,400 10.11%	3,280 7.34%	1,990 8.91%	4,430 27.62%	1,110 7.92%	15 0.64%	284 3.37%	861 3.39%
Clackamas	150 0.01%	325 0.73%	150 0.67%	338 2.11%	675 4.81%	224 9.52%	717 8.52%	7,870 31.02%
Lane	9,420 7.11%	5,430 12.16%	560 2.51%	2,610 16.27%	2,385 17.01%	107 4.55%	285 3.39%	275 1.08%
Linn	91,030 68.70%	30,370 67.99%	4,205 18.83%	4,505 28.09%	7,555 53.88%	705 29.95%	5,240 62.25%	2,030 8.00%
Marion	2,363 1.78%	4,040 9.04%	12,625 56.52%	1,122 7.00%	1,210 8.63%	1,010 42.91%	1,300 15.44%	12,470 49.15%
Polk	12,936 9.76%	820 1.84%	538 2.41%	2,680 16.71%	833 5.94%	283 12.02%	180 2.14%	1,171 4.61%
Washington	31 0.02%	17 0.04%	74 0.33%	77 0.48%	7 0.05%	0 0.00%	104 1.24%	157 0.62%
Yamhill	3,170 2.39%	387 0.87%	2,195 9.83%	275 1.71%	166 1.18%	10 0.42%	308 3.66%	535 2.11%
Willamette Valley	132,500	44,669	22,337	16,037	14,020	2,354	8,418	25,369

Source: Extension Economic Information Office, Oregon State University such as leaf rust and leaf spot (11). The disease control provided by field burning contributes to growers' incomes because seed prices are dependent on seeds being disease free and because disease-free fields produce greater seed yields.

Field burning reduces the farmer's costs of seed production, aside from its effectiveness in controlling disease. Field burning is the least cost way of removing residues which shade new growth and decrease nitrogen availability. Burning reduces the farmer's cost of weed control by destroying weeds and weed seeds and providing a clean surface for better herbicide application and activity. The absence of weed seeds is another important factor influencing grass seed prices. Perennial grasses eventually become "sod bound", a condition that diminishes seed production. Burning acts to thin growth and, therefore, prolongs the productivity of a stand of grass(1). It is evident from the extensive adoption of the cultural practice that the private benefits to Willamette Valley grass seed growers from open field burning are greater than their private costs from the practice.

The Costs of Field Burning

The natural by-product of grass seed is grass straw. Given the present level of technology, the techniques of production and consumption, much of the straw is a waste by-product. Waste can be defined as materials that no one wants, i.e., that no one will willingly either pay for or accept as a gift (5) . Therefore, someone must incur a net cost in disposing of grass straw. The method of waste disposal substantially determines the magnitude of the disposal cost and the distribution of the cost among members of society. These factors have given rise to a controversy over open-field burning as a method of disposing of the straw waste by-product.

Using terminology developed by Dales, waste disposal costs can be defined as the sum of 1) pollution prevention costs, and 2) pollution costs. Pollution prevention costs associated with grass straw disposal are expenditures aimed at reducing or eliminating pollution that would otherwise result from the disposal process. Pollution prevention costs associated with grass straw disposal include expenditures for researching the "technology of recycling" straw waste, investigations of potentials for utilizing the material in ways that give it value. Other pollution prevention costs of grass straw disposal are expenditures to reduce smoke emissions into the atmosphere when straw is burned. Included in these costs are expenditures for research of alternative burning methods and costs of implementing field burning practices and management programs with the goal of smoke reduction. Pollution prevention costs are relatively easy to measure by traditional cost accounting techniques.

The other component of waste disposal costs are pollution costs, the monetary value of damages caused by wastes after they are released into the environment. Unlike pollution prevention costs, some pollution costs are quite difficult to identify and measure. Pollution costs associated with field burning include expenditures to avoid the damage that smoke would otherwise cause. Expenditures to manage field burning for maximum smoke dispersal, or to direct smoke away from population centers or major highways where pollution damage might be greatest, are pollution costs incurred by the public sector. Private parties also make expenditures to avoid damages that they personally would otherwise suffer as a result of smoke. These costs may include increased expenditures on cleaning, painting, air conditioning, medical treatment, etc. in order to maintain the same standards attainable in the absence of smoke. Other pollution costs to private parties may include travel or moving expenses incurred to avoid smoke damage.

Another category of pollution costs is welfare damages of pollution, reductions in welfare that result from pollution damage that is not avoided. These welfare damages may or may not involve expenditures of money by the damaged party. This does not imply that there is not a monetary value of the welfare reductions. Households or firms that must accept lower incomes or profits as a result of smoke have suffered welfare damage. Reduced personal utility as a result of smoke may result from decreased visability, discomfort to the eyes or lungs, or possibly deterioration of health. The absence of market transactions makes dollar measurements of welfare damage costs difficult, but they are no less real costs of waste disposal.

It is useful to make a distinction between straw waste disposal costs that are borne by seed farmers and those that are borne by other members of society. The latter are referred to as external costs. Seed farmers have no economic incentive to consider these costs in their production decisions. Such costs are outside the market system and are not reflected in market prices of grass seed. Under these circumstances the optimal allocation of resources from the private perspective is socially inefficient. External costs of field burning have resulted from unrestricted rights to the use of air. The physical characteristics of air, its mobility, making exclusion impossible, require that it be owned in common. Consequently, uses that deteriorate the resource and disperse the costs among members of society preclude uses that do not deteriorate it, as long as the private returns exceed the private costs of those uses. This market failure has led to the property rights of air being vested in government which is responsible for establishing the rules of use. The rules and programs the government implements relating to field burning can affect both the magnitude of costs of straw waste disposal and the proportion of these costs that are external to seed farmers (the distribution of the costs).

Government Policies Regarding Field Burning

The acreage of crops burned steadily expanded following the 1940's as did the resident population of the Willamette Valley. External costs of the burning practice increased as a result of these factors, and citizen complaints about smoke became more numerous. Pressure mounted on the Oregon State Legislature to restrict the practice of field burning.

The State Legislature first acted on the field burning issue in 1967 by directing the State Sanitary Authority to advise local fire districts when to permit field burning. Prior to this time field burning was independently managed by local fire districts for safety. Under this legislative action the fire districts maintained their authority to permit burning, and they charged growers a small per-acre fee for the fire protection service that was provided (17).

In 1969, the Legislature created the Department of Environmental Quality. The DEQ was empowered to limit the amount of field burning on days that atmospheric conditions were unfavorable. The first season of this authority produced unfortunate results. Farmers grew anxious about the DEQ's authority as burning limits were invoked through early August. Unlimited field burning was permitted on August 12 on the basis of a forecast for a good burning day by the DEQ. The combination of extensive field burning and a change in atmospheric conditions led to extreme pollution levels in the Southern Willamtte Valley. That day was dubbed "Black Tuesday". Public reactions resulted in more restrictions on field burning in the next legislative session. The 1971 Legislature inacted a bill to collect a 50 cent an acre burning fee. Five cents of the fee was directed to improve the smoke management program, the rest of the fee was directed to research and development of alternatives to open field burning. There were high expectations for the development of a mobile field sanitizer from this research. Based on these expectations the Legislature set January 1, 1975, as the date open field burning would be prohibited. The burning fee was increased by the 1973 Legislature to $1 an acre, 10 cents to be used for smoke management and 90 cents to be used for research. The smoke management program had been successful at reducing the smoke in the southern valley metropolitan areas where the public outcry for burning restrictions had been greatest (7). This tempered the public demands for prohibition of field burning, and the 1975 Legislature enacted a bill that revoked the ban that was to be imposed that season. Senate Bill 311 phased down the acreage permitted burned over a four-year period. The Bill allowed the burning of 235,000 acres in 1975, 195,000 acres in 1976, 95,000 acres in 1977, and 50,000 acres in 1978. The Bill also increased fees for burning over the next four years to provide disincentives to open-field burning and to generate funds for research and for smoke management. Burning fees were to be $3 an acre in 1975, $4 an acre in 1976, $5.50 an acre in 1977 and $8 an acre in 1978.

The seed industry lobbied effectively, influencing the 1977 Legislature to ease the acreage limitations and burning fees of Senate Bill 311. House Bill 2196 was passed as a compromise bill following a veto by the Governor of a bill permitting greater acreage to be burned. The new bill permitted 195,000 acres to be burned in 1977 with a $1 an acre registration fee and a $2.50 an acre burning fee. A 180,000 acre limitation on burning with the same registration and burning fee was established for 1978 (3).

This thesis investigates policies that have been implemented regarding field burning. Table 3 summarizes the acreage limitation and burning and registration fee policies that have been implemented in Willamette Valley counties for the years 1968 to 1978. Acreage limitations on burning were implemented by the DEQ for each county on the basis of the legislative limits for the entire Valley discussed above. The burning limitation varied between counties, but the burning and registration fees were the same for all counties.

Table 3. Field Burning Policies in the Willamette Valley

	Burning Acreage Limitation*								Burning Fee
	Benton	Clackamas	Lane	Linn	Marion	Polk	Washington	Yamhill	$/acre
1969	23,099	5,669	30,364	160,828	51,944	20,392	4,323	12,919	.05
1970	23,099	5,669	30,364	160,828	51,944	20,392	4,323	12,919	.05
1971	23,099	5,669	30,364	160,828	51,944	20,392	4,323	12,919	.05
1972	23,099	5,669	30,364	160,828	51,944	20,392	4,323	12,919	.05
1973	23,099	5,669	30,364	160,828	51,944	20,392	4,323	12,919	1.00
1974	23,099	5,669	30,364	160,828	51,944	20,392	4,323	12,919	1.00
1975	16,863	4,094	20,130	122,977	36,726	17,164	3,176	10,830	3.00
1976	13,479	3,554	18,932	102,017	34,158	11,258	2,680	8,679	4.00
1977	15,640	3,320	19,205	104,540	31,495	11,815	1,226	7.089	3.50
1978	13,923	3,560	18,418	93,299	32,619	10,997	1,507	5,236	3.50

* Proxy entries for years prior to legislated limitation (1969 to 1974) are equal to maximum county acreages of grass seed grown during the study period. Actual limitation data were supplied by Oregon Department of Environmental Quality.

III. APPLICABLE ECONOMIC THEORY AND STATISTICAL TECHNIQUE

Supply Theory

The total supply of a grass seed, or of any commodity, is the sum of the quantities of the commodity produced by individual firms. A plausible assumption of economic theory is that producers are motivated to maximize their net incomes. Therefore, a supply function for a grass seed describes the relationship between the quantity of the seed produced and the factors that affect farmers' net incomes relative to their opportunity cost. Farmers' incomes can be affected by changes in their gross revenues, or by changes in their costs. Factors that affect these determinants of farmers' relative net incomes are the prices of the commodity, the price of commodities that are alternatives for production, the prices of the variable inputs in production of both the commodity and the alternatives for production, and the level of technology employed in the production process. Government policies concerning field burning may also affect farmers' gross incomes or costs, either directly or due cont to market influences on price. These factors were each considered as potential variables for inclusion in econometric models of acreage response of each of the eight major grass seed crops of the Willamette Valley.

Actual production of a grass seed is highly variable, because meteorological conditions and other factors that affect yield are beyond farmers' control. For this reason, yield and quantity of grass seed are omitted from the models. The models estimate the responsiveness of harvested acreage of grass seed to the independent variables. Harvested acreage, rather than planted acreage often used in agricultural supply models, is the best proxy for farmers' production intentions of perennial grass seeds because it accounts for acreage left in production from previous plantings. Harvested acreage is also an acceptable dependent variable for the one annual grass seed investigated.

Grass Seed Prices

The price a seed farmer expects for his product is a major consideration in his decision to grow a grass seed. The farmer doesn't have certainty of the price he will receive for seed when he makes a decision to maintain or expand his acreage of a grass seed, or to plant an alternative crop. He must base his production decision on his expectation of prices in the coming year.

Several approaches to specifying farmers' expectation of prices were considered for the models. The price of futures contracts reflect market expectations of next year's commodity prices. A market for grass seed futures contracts does not exist however, therefore, this approach could not be pursued. Since more specific information is not available, it seems reasonable to assume that the "normal" price expected for some future date depends in some way on what prices have been in the past (18). Nerlove indicates that a reasonable representation of peoples notion of long run "normal" prices is a weighted moving average of past prices, in which the weights decline back through time. In an attempt to determine the appropriate weights of past prices they were regressed on the acreage variables. This approach was abandoned because negative coefficients were consistently estimated for some prices. A simplified price expectations variable was included in the grass seed supply models. The variable specification assumes that the price seed farmers expect to receive in a given year is the price that he received in the previous year. This naive price expectations variable has been included in previous acreage response models and has displayed significant relationships with the dependent variable (2, 15). County prices for seed, lagged one year, were hypothesized to be positively related to county acreages of seeds. Thus increases in the lagged market price of a grass seed are assumed to result in increased harvested acreage of the seed, ceteris paribus.

Prices of Alternatives for Production

Farmers consider the expected prices of crops that they might grow instead of a grass seed in their production decisions. The price of an alternative for production is a key factor in the relative net income of growing grass seed. The net income from producing a crop other than the seed is a farmers' opportunity cost of producing that seed.

No previous empirical evidence was available to infer what crops might be economically viable alternatives for production of the eight grass seed crops under investigation. It was necessary to enlist the aid of an Oregon State University Extension agronomist who is knowledgeable about grass seed crops, to determine potential alternatives in production. The adaptability of grass seed and other crops to soils in the Willamette Valley is summarized by Figure 2 in the second chapter. Crops that are adaptable to the same soil conditions as a grass seed were hypothesized to be production alternatives.

The variables for the expected price of alternative crops were specified in the same manner as the grass seed price, they were lagged one year. The expected price of each potential alternative for production was tested in the models with all the other relevant variables included. Significant expected price variables were included in the models as viable production alternatives.

The expected county prices of the alternatives for production were hypothesized to be negatively related to county acreages of grass seed. When the price of an alternative commodity increases, land will be shifted from production of a grass seed to the production alternative.

Prices of Variable Production Inputs

The prices of variable inputs farmers use in producing a grass seed can greatly affect their income. These prices are considered by farmers in the production decision in relation to the input prices of production alternatives. Most inputs in agricultural production on a given land base are not crop specific; this was a criteria used to develop the potential alternatives for production. Approximately the same input prices are relevant for production alternatives to a grass seed as are relevant to grass seed production. Therefore, absolute changes in the prices of variable inputs for production of a grass seed do not represent changes relative to prices of variable inputs for the production alternative, (i.e., changes in input prices apply to the production alternative as well as to the grass seed). The opposite effects of input price variables on acreage of grass seed are offsetting. Based on these observations, variables for input prices were omitted from the models. The omission implies an assumption that any change in price of variable inputs affects the production of a grass seed and the production of the alternative crop in a similar manner.

Technology

The level of technology employed in production of a grass seed has significant implications on both the revenues and costs of seed farmers. This is due to the effects of technology on the marginal productivity of the production inputs. A common technique in specifying supply models is to include a time trend variable to account for advances in technology that result in increased production. Simple time trends are used in empirical supply analysis because of the difficulty of defining and measuring technological advances (23). Interpretation of the coefficient of a time trend is difficult because the variable may be measuring time related factors other than technology. No measure of technological change was included in the grass seed acreage response models for reasons in addition to the difficulty of interpretation. The technique of pooling time-series and cross-sectional data from the relevant seed producing counties was used in these analysis. The use of pooled data shortened the time span of the analysis to a ten year period when technological advance in grass seed production was limited, reducing the need for a time trend to account for technology. The implementation of government policies that influence the use of field burning, a technology of production, is a factor that makes a time trend an inappropriate technique to account for technology. This analysis excluded a time trend variable and incorporated variables to account for the effects of government policies.

Government Policies

The state government has intervened in the private market system to deal with the external effects of grass seed production. Effective government policies implemented for environmental purposes either directly or indirectly reallocate resources more efficiently. Grass seed farmers make their production decisions subject to public policies regarding field burning. They may allocate land between grass seed production and alternative uses as a result of the effects of public policies.

Two classes of government policies regarding field burning that have been implemented are examined in the analysis, regulation and fiscal measures. Regulation can be generally defined as any government directive controlling or limiting the actions of firms or households in the private sector (22). The Oregon Legislature has passed laws that limit the acreage in the Willamette Valley permitted burned during a season. A limitation on rights to practice field burning is essentially a restriction on the use of an input to grass seed production. The restriction reduces the value of marginal product per unit cost of grass seed production on acreage that cannot be burned. The reduction in the percentage return to grass seed production may result from decreased value of the marginal product or from increased unit costs of production. The law of comparative advantage says that to maximize profits, farmers produce those crops that yield the greatest percentage returns (12). The Department of Environmental Quality issues burning permits, which may then be bought and sold in the market (8). The transferability directs burning permits to their most productive use; efficiency in the use of these inputs is achieved via the market mechanism. The social efficiency of the regulation policy is dependent on the total acres of burning permitted. There are equity issues to consider even with an efficient regulation. Uncompensated external costs will continue to exist under regulation. In addition, the original distribution of burning permits has significant equity implications to grass seed farmers. They are presently issued in proportion to acreage registration for the permits. The distribution of grass seed permits between counties is presented in Table 3 of the second chapter. The government policy variable included in the models to describe the regulations of field burning varies over the cross-sectional units (counties). Note that no acreage burning limitations were implemented prior to 1975; the analysis spans the years 1969 to 1978. It is assumed that prior to 1975 farmers could legally burn all the acreage of grass seed that they might grow. Based on this assumption, the greatest acreage of all grass seed crops grown in each county in a year is a proxy for the pre-1975 burning acreage limitation in the analysis. The practice of field burning is part of the grass seed production function of the following years. The burning acreage limitation is lagged one year to account for this fact. It was hypothesized that as burning permits decreased, the comparative advantage shifts from grass seed production on acreage that cannot be burned. Therefore, harvested acreage of seed will decrease. A positive sign was anticipated for the burning limitation variable.

Fiscal measures are another class of government policy that have been implemented to deal with field burning. Fiscal measures are taxes or subsidies that do not directly control or prohibit private economic activities, but may add to or subtract from the benefits (costs) of conducting those activities. These fiscal tools can internalize the externalities underlying environmental problems and thus cause changes in both consumer and firm behavior to take full account of the total social costs and benefits of their activities (22). The Legislature has passed bills that tax the activity of field burning via registration and permit fees. Burning fees may act as economic deterrents to field burning, and to the related activity of grass seed production, as they are essentially costs of inputs in production. They alter the percentage returns to grass seed production and therefore may shift the comparative advantage to an alternative use of the land. The social efficiency of this fiscal policy to deal with field burning is dependent on establishing a fee that is approximately equal to the marginal external costs of field burning. The properly designed externality tax can theoretically be accepted on equity grounds; the external social benefits, tax revenues, compensate the external costs of field burning. The fees that have been charged for burning registration and permits are presented in Table 3 of the second chapter. The burning fees have varied over time but were the same for all counties in any given year. The burning fee policy variable was also lagged one year because permit fees are a cost of grass seed production in the following year. A negative sign was anticipated for the coefficient of the burning fee variable; increases in the fee were hypothesized to induce reductions in harvested acreage of grass seed.

Estimation Technique

The variables described above were included in acreage response models of eight distinct grass seed crops. The models were estimated by ordinary least squares (OLS) procedures using a technique of pooling time-series and cross-sectional observations from individual seed producing counties in the Willamette Valley. The time-series observations span ten years from 1969 to 1978. Observations from the four top producing counties are the cross-sectional units pooled for each grass seed model.

Pooling time-series and cross-sectional data was necessary because government policies concerning field burning have been implemented within the last ten years. Aggregate time-series observations for this period would not have provided sufficient degrees of freedom to estimate reliable parameters of econometric models. The pooling technique combines several potentially different populations within one sample. The inclusion of binary (dummy) variables in the models allowed for differences in the magnitude of the dependent variable, harvested acreage, due to differences in the county of the observation. The binary variables had a value of one when the observation was from the county represented by that variable and zero otherwise. One county in each model did not have a binary variable associated with it. These binary variables acted as intercept shifters to allow for inter-county differences in harvested acreage. It is also possible to allow the estimated coefficients on the independent variables to differ between cross-sections by multiplying the binary variables with other independent variables, and including these interaction variables in the regression. The counties in this analysis make up relatively homogeneous production regions with respect to grass seed crops. Therefore, interaction variables were not included in the models based on the assumption of constant elasticities throughout the production region (i.e., the production process, and therefore production decisions are the same in all counties producing the seed).

Summary and Functional Form of the Models

The eight grass seed acreage response models were estimated in double logarithmic functional form. Each model describes the relationship between the natural log of the dependent variable, harvested acreage, and the natural log of the independent variables. The double log formulation of the models was appropriate for estimating the following functional form of the equations:

$$AC_{c,t}=e^{(B_0+B_1D_1+B_2D_2+B_3D_3+E_{c,t})}B_4PR_{c,t-1}+B_5PRA_{i,c,t-1}+B_6BRNAC_{c,t-1}$$
$$+B_7BRNFE_{c,t-1}+E_{c,t}$$

where $AC_{c,t}$ = acres of grass seed harvested for county c in year t

D_1, D_2 and D_3 = binary variables for counties 1, 2, and 3;
(=1 if observation is from respective county;
=0 otherwise)

$PR_{c,t-1}$ = price of grass seed for county c in year t-1; dollars per cwt.

$PRA_{i,c,t-1}$ = price of production alternative i for county c in year t-1; dollars per unit dependent on crop

$BRNAC_{c,t-1}$ = burning acreage limitation for county c in year t-1; acres

$BRNFE_{c,t-1}$ = burning fee for county c in year t-1; dollars per acre

$E_{c,t}$ = the random error term for county c in year t

This functional form was preferred over an alternative linear functional form. The advantageous characteristic of this functional form is that all the estimated coefficients, except those for the binary variables are elasticities of acreage. This characteristic is preferable to the interpretation of the coefficients of linear models as the absolute change in acreage. Since pooled data were used, and no interaction terms were included in the models, a linear functional form would imply that a change in an independent variable will induce changes in acreage equally in all counties. Given the difference in county production of grass seed this is an unreasonable assumption. The double log formulation of the models assumes that a percentage change in an independent variable will induce an equal percentage change in harvested acreage in all counties. The assumption that elasticities of acreage are equal in each county included in a model is justifiable given the relatively homogeneous grass seed production practices in the Willamette Valley.

Autocorrelation

The classical linear regression model assumes that the disturbance occurring at one point in time is not correlated with the disturbance at previous time periods. This feature is known as non-autoregression. The eight acreage response models estimated by OLS were tested for autocorrelation in each of the four counties in the model to determine if the error terms were correlated over time.

First order autoregression coefficients were determined separately for each county. The first-order autoregressive scheme described by Kmenta (13) was estimated by OLS procedures to determine the coefficient $\hat{P}_c$:

$$e_{c,t} = \hat{P}_c e_{c,t-1} + u_{c,t}$$

where e represents the error terms, c represents the county, t represents the year, and u is the random error term. If an estimated coefficient ($\hat{P}$) was significantly different than zero, then the assumption that error terms are not correlated over time was violated. The autocorrelated OLS estimates were consistent and unbiased, but they were inefficient because they failed to utilize information on the relationship of the disturbance terms.

The data from counties where autocorrelation was determined to be present were transformed so that more efficient generalized least squares (GLS) estimates of the models could be obtained. A two stage procedure illustrated by Kmenta was followed to make the following transformations of the dependent variables and each of the independent variables (including the constant):

$$Y^*_{c,t} = Y_{c,t} - \hat{P}_c Y_{c,t-1}$$

$$X^*_{c,t} = X_{c,t} - \hat{P}_c X_{c,t-1}$$

where Y is the dependent variable and X is the independent variable. The data from counties where the autoregression coefficient wasn't significantly different from zero were not transformed. One observation was lost from each county where the transformation was necessary, decreasing the degrees of freedom of the model. The parameters of the model were then reestimated from the transformed data. The GLS estimates of the parameters using the transformed data are more efficient than the OLS estimates.

Heteroskedasticity

Homoskedasticity is another assumption of the classical regression model. This assumption implies that the variance of the disturbance term is constant across observations. After correcting the models for autocorrelation the assumption of homoskedasticity was tested. The variances of the error terms for the four counties were tested to see if they differed significantly. If the variances differ significantly, then the disturbances are cross-sectionally heteroskedastic and the assumption of the classical model is violated. To test for this condition, the following estimates were made of the variances for each county:

$$S_e^2 = \frac{1}{T-K-1} \sum_{t=1}^{T} e_{c,t}^2$$

where e represents the error terms, c is the county, t is the year, T is the number of time series observations from the cross section and K is the number of independent variables (T-K-1 is the degrees of freedom for the cross-section).

Ratios of the estimates of the variances in the counties were compared to F values to test the hypothesis of homoskedasticity. If the approximate F-test led to the rejection of the hypothesis, then the estimated models were still inefficient due to cross-sectional heteroskedasticity. Further transformations on the data were necessary so that the assumption of homoskedasticity is valid. The following procedure of dividing the dependent variable and each independent variable (including the constant) by the standard deviation of the error terms for each county was used to transform the models:

$$Y^{**}_{c,t} = \frac{Y^{*}_{c,t}}{S_c}$$

$$X^{**}_{c,t} = \frac{X^{*}_{c,t}}{S_c}$$

Where S is the standard deviation ($\sqrt{S_c^2}$, from the variance equation above), c is the county and t is the year. Weighting the variables by the standard deviations produces smaller variances of the estimated coefficients and therefore increases the efficiency of the models.

IV. EMPIRICAL RESULTS

Annual Ryegrass Acreage Response Model

The parameters acreage response model for annual varieties of ryegrass were estimated with data from Benton, Lane, Linn, and Polk Counties for the years 1969 to 1978. These counties accounted for 95.7 percent of the Willamette Valley acreage of annual ryegrass during the ten-year time series of the analysis.

The price variables for potential production alternatives to annual ryegrass were tested for significance in the model given the inclusion of the other relevant variables. The t values of the price variables tested individually in the model were:

$LPRYEPR_{c,t-1}$	$LBENTPR_{c,t-1}$	$LOATPR_{c,t-1}$	$LBARPR_{c,t-1}$
1.648	0.964	-2.199	-2.162

$LWCLVPR_{c,t-1}$	$LHAYPR_{c,t-1}$
-0.475	0.958

where $LPRYEPR_{c,t-1}$ = the natural log of the price per cwt. of perennial ryegrass seed in county c and year t-1

$LBENTPR_{c,t-1}$ = the natural log of the price per cwt. of bentgrass in county c and year t-1

$LOATPR_{c,t-1}$ = the natural log of the price per bushel of oats in county c and year t-1

$LBARPR_{c,t-1}$ = the natural log of the price per bushel of barley in county c and year t-1

$LWCLVPR_{c,t-1}$ = the natural log of the price per cwt. of white clover seed in county c and year t-1

$LHAYPR_{c,t-1}$ = the natural log of the price per ton of hay in county c and year t-1

The variable for the price of oats had the highest significance level of the production alternative prices. Therefore, it was included in the model. The remaining price variables were subsequently tested in the model that included the price of oats. The price of barley, which had been significant in the first round of tests now had a t value of 0.602. None of the other price variables were significant in the annual ryegrass acreage response model that included the price of oats.

Linn County was the base cross-sectional unit in the model; it is the base unit in each of the grass seed acreage response models in this analysis. The constant term in each of the models is the acreage intercept for Linn County. The binary variables in this model, and in each acreage response model, are the acreage intercepts of their respective counties.

The parameters of the annual ryegrass acreage response model were originally estimated following OLS procedures and were then tested for autocorrelation. Estimates of the first-order autoregression coefficients and their standard errors for each county were:

	Benton	Lane	Linn	Polk
$\hat{P}$	-0.081	0.479	0.315	0.082
$S.E._{\hat{p}}$	(0.198)	(0.332)	(0.203)	(0.367)

None of the coefficients were significant so the assumption of non-autoregression could not be rejected. The model was subsequently tested for violation of the assumption of homoskedasticity. The variances of the error terms from each county were calculated; the variances and their associated degrees of freedom were:

	Benton	Lane	Linn	Polk
S_e^2	0.057	0.055	0.036	0.041
D.F.	9	9	9	9

No significant difference between the variances could be detected; therefore, no transformations were necessary to insure cross-sectional homoskedasticity.

The final annual ryegrass acreage response model is:

$$LARYEAC_{c,t} = \underset{(2.168)}{8.287} - \underset{(2.169)}{1.211}DBENT - \underset{(0.293)}{1.930}\,DLANE - \underset{(0.358)}{1.538}DPOLK + \underset{(0.123)}{0.334}LARYEPR_{c,t-1}$$

$$-\underset{(0.175)}{0.385}LOATPR_{c,t-1} + \underset{(0.172)}{0.206}LBRNAC_{c,t-1} + \underset{(0.031)}{0.011}LBRNFE_{c,t-1} \qquad DF = 32$$

where $LARYEAC_{c,t}$ = the natural log of annual ryegrass acreage in county c and year t

DBENT = the binary variable for Benton County

DLANE = the binary variable for Lane County

DPOLK = the binary variable for Polk County

$LARYEPR_{c,t-1}$ = the natural log of the price per cwt. of annual ryegrass seed in county c and year t-1

$LOATPR_{c,t-1}$ = the natural log of the price per bushel of oats in county c and year t-1

$LBRNAC_{c,t-1}$ = the natural log of the burning acreage limitation in county c and year t-1

$LBRNFE_{c,t-1}$ = the natural log of the burning fee per acre in county c and year t-1.

The standard errors are presented in parentheses beneath their respective coefficients for each model presented in the analyses.

The signs of the estimated coefficients in the annual ryegrass models are all consistent with the hypotheses except the sign of the coefficient for the burning fee variable. That variable was not significant in the model. A level of ten percent is used for all significance tests in the analyses unless otherwise stated. The cross-sectional intercept variables, the constant term and the binary variables except the binary variable for Benton County, were the highly significant variables in the model. The high significance of these variables to a great extent account for a high R^2 and F statistic of the estimated model. An R^2 of .99 was calculated for all of the acreage response models as a result of the large percent of the variation in the dependent variables accounted for by the county of the observation.

The estimated coefficient of the price of annual ryegrass seed is 0.334. It is the elasticity of acreage with respect to seed price. It implies that when the price of seed increases one percent, the acreage of ryegrass that will be harvested the following year will increase 0.334 percent. Note that this is not the price elasticity of annual ryegrass seed supply, although it may be approximately equivalent to it. Acreage, rather than supply, is the dependent variable in the model. Acreage is a key input in the production function, but on-farm storage is an important factor relating price to supply.

The price variable for the production alternative, oats, has an estimated coefficient of -0.385; it is a significant variable in the model. The coefficient conveys the decline in harvested acreage of annual ryegrass the year following a one percent increase in the price of oats. It cannot be directly interpreted as the cross-price elasticity of supply for reasons discussed above; it is an elasticity of acreage. Both the own-price and cross-price elasticities of annual ryegrass acreage are relatively low.

Neither of the field burning policy variables were significant in the model at the levels established for testing. The burning acreage limitation variable was significant, however, at the .24 level. The burning fee variable clearly is not related to harvested acreage of annual ryegrass in the model. The standard error is nearly three times larger than its coefficient, and the sign of the coefficient is contrary to theoretical rationale.

The insignificant response of annual ryegrass acreage to field burning policies, within the range they have been implemented, and the relatively low response to prices is indicative of the limited opportunities for producing alternative crops. Few crops are adaptable to the poor drainage conditions of soils that annual ryegrass is grown on, and apparently they do not generate comparable incomes to annual ryegrass under present conditions.

Perennial Ryegrass Acreage Response Model

The perennial ryegrass acreage response model used data from Benton, Lane, Linn and Marion counties. The data account for 96.5 percent of perennial ryegrass acreage in the Valley over the ten year period of the analysis. The price variables of several crops were tested as alternatives to perennial ryegrass. The t-values of potential production alternative price variables were:

$LWCLVPR_{c,t-1}$	$LRCLVPR_{c,t-1}$	$LHAYPR_{c,t-1}$	$LARYEPR_{c,t-1}$
0.887	-0.061	-0.008	-0.698
$LORCHPR_{c,t-1}$	$LBARPR_{c,t-1}$	$LGCRNPR_{c,t-1}$	$LTFESPR_{c,t-1}$
-1.284	-0.502	-0.334	0.329
$LMERPR_{c,t-1}$	$LBLUEPR_{c,t-1}$	$LOATPR_{c,t-1}$	
0.468	0.365	0.263	

where $LWCLVPR_{c,t-1}$ = the natural log of the price per cwt. of white clover seed in county c and year t-1

$LRCLVPR_{c,t-1}$ = the natural log of the price per cwt. of red clover seed in county c and year t-1

$LHAYPR_{c,t-1}$ = the natural log of the price per ton of hay in county c and year t-1

$LARYEPR_{c,t-1}$ = the natural log of the price per cwt. of annual ryegrass seed in county c and year t-1

$LORCHPR_{c,t-1}$ = the natural log of the price per cwt. of orchardgrass seed in county c and year t-1

$LBARPR_{c,t-1}$ = the natural log of the price per bushel of barley in county c and year t-1

$LGCRNPR_{c,t-1}$ = the natural log of the price per bushel of grain corn in county c and year t-1

$LTFESPR_{c,t-1}$ = the natural log of the price per cwt. of tall fescue seed in county c and year t-1

$LMERPR_{c,t-1}$ = the natural log of the price per cwt. of merion Kentucky bluegrass seed in county c and year t-1

$LBLUEPR_{c,t-1}$ = the natural log of the price per cwt. of other Kentucky bluegrass seed in county c and year t-1

$LOATPR_{c,t-1}$ = the natural log of the price per bushel of oats in county c and year t-1

Although none of these price variables were significant at the level established for testing, the orchardgrass variable was included in the model as the price of the "best" production alternative. This variable became significant in the model after it was corrected for statistical problems.

The disturbance terms of the original OLS acreage response model were used to estimate the following first order autoregression coefficients and their standard errors:

	Benton	Lane	Linn	Marion
$\hat{p}$	-0.325	0.453	0.542	0.591
$S.E._{\hat{p}}$	(0.335)	(0.220)	(0.173)	(0.258)

The coefficients for Lane, Linn, and Marion Counties were each significant making the assumption of non-autoregressive disturbances invalid. GLS procedures were followed to reestimate the model; three degrees of freedom were lost by transforming the data. This model was then tested for cross-sectional heteroskedasticity. The calculated variances of the effor terms and their associated degrees of freedom were:

	Benton	Lane	Linn	Marion
S_e^2	0.181	0.047	0.029	0.771
D.F.	9	8	8	8

Significant differences of the variances were concluded by an F test and transformations were necessary to ensure cross-sectional homoskedasticity. The data was divided by the appropriate calculated standard deviations of the error terms, and the final perennial ryegrass acreage response parameters were estimated.

$$LPRYEAC_{c,t} = \underset{(0.238)}{10.226} - \underset{(0.126)}{2.145}DBENT - \underset{(0.111)}{1.650}DLANE - \underset{(0.302)}{1.701}DMAR + \underset{(0.115)}{0.317}LPRYEPR_{c,t-1}$$

$$-\underset{(0.215)}{0.383}LORCHPR_{c,t-1} + \underset{(0.050)}{0.036}LBRNAC_{c,t-1} + \underset{(0.020)}{0.005}LBRNFE_{c,t-1} \qquad D.F. = 29$$

where $LPRYEAC_{c,t}$ = the natural log of the acreage of perenial ryegrass seed in county c and year t

DBENT = the binary variable for Benton County

DLANE = the binary variable for Lane County

DMAR = the binary variable for Marion County

$LPRYEPR_{c,t-1}$ = the natural log of the price per cwt of perennial ryegrass seed in county c and year t-1

$LORCHPR_{c,t-1}$ = the natural log of the price per cwt of orchard-grass seed in county c and year t-1

$LBRNAC_{c,t-1}$ = the natural log of the burning acreage limitation in county c and year t-1

$LBRNFE_{c,t-1}$ = the natural log of the burning fee per acre in county c and year t-1

The estimated coefficients of the perennial ryegrass model all had the expected signs with the exception of the coefficient of burning fee per acre. The burning fee variable is insignificant just as it was in the annual ryegrass acreage response model. The binary variables and constant term in the model are very highly significant. The county of observation accounts for most of the variability in the acreage of perennial ryegrass.

The perennial ryegrass seed price variable is significant and the coefficient estimate is 0.317. The coefficient can be interpreted as the percent ryegrass acreage is expected to expand following a one percent seed price increase. This own-price elasticity of acreage is very close to that of annual ryegrass. The coefficient of the price of orchardgrass seed, the production alternative, is -0.383 and significant. This cross-price elasticity of acreage is approximately equal to that for annual ryegrass. The similar price elasticity estimates of perennial and annual varieties of ryegrass was somewhat unexpected since the flexibility of production is generally greater for annual crops than for perennials. Production flexibility is related to the time frame of the investments and affects decisions to shift production between crops. The close estimates of price elasticities may result from the aggregation of data for turf and forage varieties of perennial ryegrass. Turf varieties are generally produced on moderately drained soils that have greater adaptability to alternative crops, while forage varieties are generally produced on poorly drained soils similar to those annual ryegrass is produced on. It was also somewhat of a surprise that annual and perennial ryegrass were not production alternatives for each other since they are both extensively grown on "whiteland" soils. This may also be related to the aggregation of perennial ryegrass data. It is interesting to note that an annual crop is the production alternative for annual ryegrass, and that a perennial crop is the production alternative for perennial ryegrass. These relationships may reflect similar capital and labor intensity among the annual crops and among the perennial crops. Alternatively, the results may reflect farmer preferences for flexibility.

The field burning policy variables were not significantly related to acreage of perennial ryegrass. The burning acreage limitation variable, which displayed a positive coefficient, conforming with the theoretical model, was highly correlated with the constant term in the model. The simple correlation coefficient between the two variables was 0.98. The high correlation is the result of the Department of Environmental Quality's issuance of burning permits in counties roughly in proportion to county acreage of grass seed. Linn County has much more grass seed acreage and, consequently, a greater burning acreage limitation than the other counties. Linn County also has much more acreage of perennial ryegrass than the other counties in the model. The constant term is the intercept for Linn since it is the model's base cross-sectional unit. It is nearly forty-three times its standard error and is the most significant variable in the perennial ryegrass acreage response model. It is likely the constant is measuring the variability of acreage related to the burning limitation as well as the county due to the multicollinearity between the two variables. The lack of perennial ryegrass acreage responsiveness to the burning fee suggest that the fees that have been charged are not sufficient to alter the comparative advantage of the crop.

Bentgrass Acreage Response Model

Benton, Linn, Marion and Yamhill counties were the counties with the greatest bentgrass acreage from 1969 to 1978. They were the location of 94.1 percent of the Willamette Valley bentgrass acreage during this time period. These counties were the cross-sectional units of data used to estimate the parameters of the bentgrass acreage response model.

The following variables were investigated in the model as prices of production alternatives (t values are presented in brackets).

$LARYEPR_{c,t-1}$	$LOATPR_{c,t-1}$	$LBARPR_{c,t-1}$
-1.598	-1.598	-1.365
$LWCLVPR_{c,t-1}$	$LHAYPR_{c,t-1}$	$LFFESPR_{c,t-1}$
-2.338	-2.456	0.911

where $LARYEPR_{c,t-1}$ = the natural log of the price per cwt. of annual ryegrass seed in county c and year t

$LOATPR_{c,t-1}$ = the natural log of the price per bushel of oats in county c and year t

$LBARPR_{c,t-1}$ = the natural log of the price per bushel of barley in county c and year t

$LWCLVPR_{c,t-1}$ = the natural log of the price per cwt. of white clover seed in county c and year t

$LHAYPR_{c,t-1}$ = the natural log of the price per ton of hay in county c and year t

$LFFESPR_{c,t-1}$ = the natural log of the price per cwt. of fine fescue seed in county c and year t

The price of hay proved to be a highly significant price variable for a production alternative and was included in the model. Each of the remaining price variables were then tested in the model that included the variable for hay. The price of white clover seed had a t value of 1.925; this variable was also included in the bentgrass acreage response model.

The error terms of the initial OLS model were separated into cross-sections and used to estimate these first-order autoregression coefficients and standard errors:

	Benton	Linn	Marion	Yamhill
$\hat{P}$	0.463	0.465	-0.163	0.447
$S.E._{\hat{P}}$	(0.312)	(0.384)	(0.330)	(0.303)

The conclusion was drawn from these estimates that the disturbances of observations in Benton and Linn Counties were not correlated over time. The model was next tested for cross-sectional heteroskedasticity with F-tests of these calculated variances of the cross-sectional error terms:

	Benton	Linn	Marion	Yamhill
S_e^2	0.409	0.094	0.427	0.137
D.F.	9	9	9	9

The associated degrees of freedom necessary for the F-tests are presented beneath the variances. Significant difference between some variances was concluded and all the data were transformed to ensure cross-sectional homoskedasticity. The bentgrass acreage response model, devoid of autocorrelation and heteroskedasticity, is:

$$\begin{aligned}
LBENTAC_{c,t} = {} & \underset{(0.688)}{7.079} \underset{(0.235)}{-0.150}\ DBENT + \underset{(0.089)}{1.422}\ DMAR + \underset{(0.182)}{0.062}\ DYAM \\
& \underset{(0.063)}{-0.204}\ LBENTPR_{c,t-1} - \underset{(0.138)}{0.480}\ LHAYPR_{c,t-1} \\
& \underset{(0.085)}{-0.071}\ LWCLVPR_{c,t-1} + \underset{(0.069)}{0.298}\ LBRNAC_{c.t-1} + \underset{(0.089)}{0.056} LBRNFE_{c,t-1} \quad DF = 31
\end{aligned}$$

where $LBENTAC_{c,t}$ = the natural log of the acreage of bentgrass in county c and year t

DBENT = the binary variable for Benton County

DMAR = the binary variable for Marion County

DYAM = the binary variable for Yamhill County

$LBENTPR_{c,t-1}$ = the natural log of the price per cwt. of bentgrass seed in county c and year t-1

$LHAYPR_{c,t-1}$ = the natural log of the price per ton of hay in county c and year t-1

$LWCLVPR_{c,t-1}$ = the natural log of the price per cwt. of white clover seed in county c and year t-1

$LBRNAC_{c,t-1}$ = the natural log of the burning acreage limitation in county c and year t-1

$LBRNFE_{c,t-1}$ = the natural log of the burning fee per acre in county c and year t-1.

The above bentgrass acreage response equation has a negative estimated coefficient for the price of bentgrass seed. This aberation of economic theory was not apparent in the original OLS estimation of the model; the bentgrass seed price variable had a positive coefficient but was insignificant in that equation. The negative sign occurred and the variable became significant upon transformation and reestimation of the model to correct for heteroskedasticity. It is enlightening to note that there is a high positive simple correlation between the variables for price of bentgrass seed and bentgrass acreage (0.99), but the bentgrass seed price variable also has a strong relationship with the constant term (0.99) and the burning limitation variable (0.99). The multicolinearity between bentgrass seed price and these two variables that are highly significant in the model and have positive estimated coefficients, may have disguised a positive relationship between seed price and acreage. Another possible explanation for this aberation is the aggregation of data for two varieties of bentgrass that have distinct markets and great differences in price. Pencross bentgrass is a high-value seed sold to golf courses while highland bentgrass is a forage crop with a much lower value seed (25). The data available for this study did not distinguish between these varieties; an average bentgrass price was determined for each county (14). The varying mix between these two varieties over time and between counties makes interpretation of the price of bentgrass seed coefficient difficult.

The price variable for hay, a production alternative to bentgrass was highly significant with a coefficient of -0.480. The absolute value of the coefficient is more than three times its standard error. The expected response by farmers to a one percent increase in the price of hay is to reduce their acreage of bentgrass by 0.48 percent. Farmers who have the equipment, or can contract the work done may decide to cut hay from a stand of bentgrass during the growing season in response to increasing prices of hay. The coefficient may also reflect shifts from harvesting bentgrass for seed to using the acreage to pasture animals. The price variable for white clover became insignificant when the model was transformed to insure homoskedasticity.

The burning acreage limitation is a significant variable in the model. The coefficient was estimated as 0.298, more than four times the value of its standard error. Thus, the model suggests that as the acreage limitation is decreased by ten percent, farmers will reduce their acreage of bentgrass 2.98 percent. Field burning is not a common production practice of hay, the alternative to bentgrass production. It seems reasonable, therefore, that as acreage restrictions are placed on field burning, land will be shifted from bentgrass production to hay production and pasture. The burning fee variable was not significantly related to bentgrass acreage in the model.

Tall Fescue Acreage Response Model

Data from Benton, Lane, Linn and Marion Counties were used to estimate the parameters of the acreage response model for tall fescue. Eighty-eight percent of the tall fescue acreage in the ten years of the analysis was located in these counties. The price variables that were investigated as potential alternatives to tall fescue and their t values in the model were:

$LORCHRPR_{c,t-1}$	$LBLUEPR_{c,t-1}$	$LWHTPR_{c,t-1}$	$LOATPR_{c,t-1}$	$LBARPR_{c,t-1}$
-0.274	-4.021	-0.539	-0.665	-0.610
$LWCLVPR_{c,t-1}$	$LRCLVPR_{c,t-1}$	$LMERPR_{c,t-1}$	$LHAYPR_{c,t-1}$	
-2.690	-3.588	-5.787	-0.854	

where $LORCHPR_{c,t-1}$ = the natural log of the price per cwt. of orchardgrass seed in county c and year t-1

$LBLUEPR_{c,t-1}$ = the natural log of the price per cwt. of bluegrass seed in county c and year t-1

$LWHTPR_{c,t-1}$ = the natural log of the price per bushel of wheat in county c and year t-1

$LOATPR_{c,t-1}$ = the natural log of the price per bushel of oats in county c and year t-1

$LBARPR_{c,t-1}$ = the natural log of the price per bushel of barley in county c and year t-1

$LWCLVPR_{c,t-1}$ = the natural log of the price per cwt. of white clover seed in county c and year t-1

$LRCLVPR_{c,t-1}$ = the natural log of the price per cwt. of red clover seed in county c and year t-1

$LMERPR_{c,t-1}$ = the natural log of the price per cwt. of Merion bluegrass seed in county c and year t-1

$LHAYPR_{c,t-1}$ = the natural log of the price per ton of hay in county c and year t-1

The estimated coefficients of each of these price variables were negative when they were tested in the model, in accordance with the sign of a production alternative's price. Merion Kentucky bluegrass was chosen as the best production alternative for tall fescue on the basis of its high significance in the original OLS acreage response model. Each other price variable was then tested in the model that included the price of Merion Kentucky bluegrass seed. None of the other price variables were significant in this model.

First-order autoregression coefficients were estimated from the disturbances of the original model. The coefficients and their standard errors that were estimated were:

	Benton	Linn	Lane	Marion
$\hat{P}$	0.485	0.352	0.157	0.421
$S.E._{\hat{P}}$	(0.312)	(0.227)	(0.331)	(0.328)

None of the estimated coefficients were significant, so no transformations were necessary to satisfy the assumption of non-autoregression. The variances of the error terms were calculated to detect any cross-sectional heteroskedasticity. The variances and the associated degrees of freedom were:

	Benton	Lane	Linn	Marion
S_e^2	2.032	0.322	0.122	0.327
D.F.	9	9	9	9

Transformations of the data were necessary due to significant differences between cross-sectional variances. Following the transformations the tall fescue acreage response parameters were reestimated:

$$LTFESAC_{c,t}=9.355-2.230DBENT-1.197DLANE-1.819DMAR-0.026LTFESPR_{c,t-1}$$
$$(0.970)(0.359)\quad(0.163)\quad(0.175)\quad(0.175)$$
$$-0.056LMERPR_{c,t-1}-0.014LBRNAC_{c,t-1}-0.075LBRNFE_{c,t-1}$$
$$(0.138)\qquad(0.093)\qquad(0.033)\qquad DF = 32$$

where $LTFESAC_{c,t}$ = the natural log of the acreage of tall fescue in county c and year t

DBENT = the binary variable for Benton County

DLANE = the binary variable for Lane County

DMAR = the binary variable for Marion County

$LTFESPR_{c,t-1}$ = the natural log of the price per cwt. of tall fescue seed in county c and year t-1

$LMERPR_{c,t-1}$ = the natural log of the price per cwt. of Merion Kentucky bluegrass seed in county c and year t-1

$LBRNAC_{c,t-1}$ = the natural log of the burning acreage limitation in county c and year t-1

$LBRNFE_{c,t-1}$ = the natural log of the burning fee per acre in county c and year t-1

Only one variable with the exception of the binary variable was significant in the model following the transformation. The variables for the price of Merion Kentucky bluegrass seed and the burning acreage limitation were both significant in the original estimation, and the variable for the price of tall fescue seed had a 0.29 significance level. Each had the expected signs in the original estimation of the tall fescue acreage response parameters. After the transformation of the data these variables were insignificant at very high levels and the burning fee variable became significant.

The estimated coefficient of the burning fee variable, -0.075 was significant. This coefficient implies that an increase of ten percent in the fees farmers must pay to burn an acre of grass residue will lead to a decrease of 0.75 percent in the acreage of tall fescue (within the range of fees that have been implemented). The coefficient of the burning fee is more than twice the value of its standard error.

The Willamette Valley produces a relatively small share of the tall fescue seed in the U.S. The bulk of the seed is produced in the south east region of the country. It is likely that the added production cost of a burning fee resulting in decreased tall fescue acreage has little or no effect on seed prices. Thus the relative profitability of tall fescue production is decreased, reinforcing the decision to produce less.

Orchardgrass Acreage Response Model

The greatest acreage of orchardgrass during the ten years of the analysis was harvested in Benton, Lane, Linn and Polk Counties. This acreage accounted for 88.7 percent of the Willamette Valley orchardgrass during this time period. Thus, data from these counties were used to estimate the parameters of the orchardgrass acreage response model. Price variables of potential production alternatives to orchardgrass were investigated given the inclusion of the other variables in the model. The t values of the price variables were:

$LMERPR_{c,t-1}$	$LBLUEPR_{c,t-1}$	$LWHTPR_{c,t-1}$	$LOATPR_{c,t-1}$
-1.785	-1.022	-0.789	-1.728
$LBARPR_{c,t-1}$	$LGCRNPR_{c,t-1}$	$LHAYPR_{c,t-1}$	$LPRYEPR_{c,t-1}$
-1.784	-3.084	-1.578	0.630

where $LMERPR_{c,t-1}$ = the natural log of the price per cwt. of Merion Kentucky bluegrass seed in county c and year t-1

$LBLUEPR_{c,t-1}$ = the natural log of the price per cwt. of bluegrass seed in county c and year t-1

$LWHTPR_{c,t-1}$ = the natural log of the price per bushel of wheat in county c and year t-1

$LOATPR_{c,t-1}$ = the natural log of the price per bushel of oats in county c and year t-1

$LBARPR_{c,t-1}$ = the natural log of the price per bushel of barley in county c and year t-1

$LGCRNPR_{c,t-1}$ = the natural log of the price per bushel of grain corn in county c and year t-1

$LHAYPR_{c,t-1}$ = the natural log of the price per ton of hay in county c and year t-1

$LPRYEPR_{c,t-1}$ = the natural log of the price per cwt. of perennial ryegrass seed in county c and year t-1

The variable for the price of grain corn was the most significant production alternative and, therefore, was included in the model. This price variable is representative of price variations in corn grown for silage as well as for grain because these variations are approximately parallel. Each of the remaining price variables were tested in the model that included the price of grain corn. No other variables were significant.

The orchardgrass acreage response parameters were originally estimated following OLS procedures and the model was then tested for autocorrelation. Estimates for the first-order autoregression coefficients and their standard errors for the cross-sectional units were:

	Benton	Lane	Linn	Polk
$\hat{P}$	0.479	0.522	-0.459	0.147
$S.E._{\hat{P}}$	(0.251)	(0.337)	(0.249)	(0.406)

The coefficient for Benton County was significant so it was necessary to transform that data to ensure a non-autoregressive model. The model was subsequently tested for homoskedasticity. The variances of the error terms for each cross-section were calculated; the variances and their associated degrees of freedom were:

	Benton	Lane	Linn	Polk
S_e^2	0.077	0.449	0.098	0.125
D.F.	8	9	9	9

The variances were found to be significantly different by F-tests, so transformations were necessary to ensure cross-sectional homoskedasticity in the model. The final orchardgrass acreage response model is:

$$LORCHAC_{c,t} = \underset{(0.379)}{7.158} + \underset{(0.175)}{0.321}DBENT - \underset{(0.172)}{0.172}DLANE + \underset{(0.200)}{0.056}DPOLK - \underset{(0.227)}{0.453}LORCHPR_{c,t-1}$$

$$-\underset{(0.140)}{0.269}LGCRNPR_{c,t-1} + \underset{(0.079)}{0.250}LBRNAC_{c,t-1} + \underset{(0.028)}{0.037}LBRNFE_{c,t-1} \qquad DF = 30$$

where $LORCHAC_{c,t}$ = the natural log of the acreage of orchardgrass in county c and year t

DBENT = the binary variable for Benton County

DLANE = the binary variable for Lane County

DPOLK = the binary variable for Polk County

$LORCHPR_{c,t-1}$ = the natural log of the price per cwt. of orchardgrass seed in county c and year t-1

$LGCRNPR_{c,t-1}$ = the natural log of the price per bushel of grain corn in county c and year t-1

$LBRNAC_{c,t-1}$ = the natural log of the burning acreage limitation in county c and year t-1

$LBRNFE_{c,t-1}$ = the natural log of the burning fee per acre in county c and year t-1

The coefficient estimated for the price of orchardgrass seed is negative, contrary to theoretical expectations. This coefficient suggests that as the price of orchardgrass seed has increased one percent farmers have decreased the acreage of the crop 0.453 percent. The absolute value of this elasticity coefficient is approximately twice the value of the standard error. An explanation of the negative relationship between price and acreage may be the influence of an insect infestation during the study period. The billbug became prevalent in orchardgrass stands of the Willamette Valley during the mid 1970's. The effect of this infestation was to reduce yields (25). The infestation may have resulted in a negative price-acreage relationship in two ways: 1) decreased supply from lower yields caused the price of seed to increase, 2) infested fields were removed from production of the affected crop.

The coefficient for the price of grain corn, the proxy price variable for grain and silage corn, is significant and is estimated as -0.269. This is a relatively small cross-price elasticity. It is interesting that an annual crop had the most significant price variable of the potential production alternatives to orchardgrass. Acreage shifts from orchardgrass, a perennial, to an annual crop allows farmers flexibility in succeeding production decisions. Perhaps shifting to an annual crop was also related to the billbug infestation.

The burning acreage limitation variable is highly significant in the orchardgrass acreage response model. The estimate of the coefficient on the variable is 0.250; it is more than four times the value of the standard error. The connotation of this coefficient is that a ten percent decrease in permitted field burning will elicit a 2.5 percent reduction in orchardgrass acreage. The burning acreage limitation is significant in conjunction with a price variable of a production alternative for which field burning is not a cultural practice. The burning fee variable was not significant in the orchardgrass acreage response model. The fee policy apparently has not been a critical factor in reallocating land from orchardgrass production.

Merion Kentucky Bluegrass Acreage Response Model

Clackamas, Linn, Marion and Polk Counties have harvested 94.4 percent of the Merion Kentucky bluegrass acreage over the ten years investigated in the analysis. Data from these counties were utilized in estimating the parameters of the acreage response model of the seed crop. Eight price variables were investigated individually in the model as production alternative variables. The t values of these variables in the acreage response model were:

$LPRYEPR_{c,t-1}$	$LBLUEPR_{c,t-1}$	$LOATPR_{c,t-1}$	$LBARPR_{c,t-1}$
-1.883	-0.079	-0.942	-0.666
$LGCRNPR_{c,t-1}$	$LRCLVPR_{c,t-1}$	$LHAYPR_{c,t-1}$	$LWHTPR_{c,t-1}$
-1.499	-2.447	-2.950	-0.270

where $LPRYEPR_{c,t-1}$ = the natural log of the price per cwt. of perennial ryegrass seed in county c and year t-1

$LBLUEPR_{c,t-1}$ = the natural log of the price per cwt. of other Kentucky bluegrass seed in county c and year t-1

$LOATPR_{c,t-1}$ = the natural log of the price per bushel of oats in county c and year t-1

$LBARPR_{c,t-1}$ = the natural log of the price per bushel of barley in county c and year t-1

$LGCRNPR_{c,t-1}$ = the natural log of the price per bushel of grain corn in county c and year t-1

$LRCLVPR_{c,t-1}$ = the natural log of the price per cwt. of red clover seed in county c and year t-1

$LHAYPR_{c,t-1}$ = the natural log of the price per ton of hay in county c and year t-1

$LWHTPR_{c,t-1}$ = the natural log of the price per bushel of wheat in county c and year t-1

The price variable for hay proved to have the highest significance level among the potential production alternatives. It was included in the model and each remaining price variable was tested for significance. The price of wheat demonstrated a significant relationship in the model with a t value of 3.140 and it was added to the model. Each of the other price variables were subsequently tested in this model. The price of grain corn had a t value of -1.972 in the model, therefore it was included also. None of the remaining price variables were significantly related to the acreage of Merion Kentucky bluegrass in the equation that included the variables discussed above.

The disturbance terms of the original OLS acreage response model were used to estimate the following first-order autoregression coefficients and their standard errors so that the model could be tested for autocorrelation:

	Clackamas	Linn	Marion	Polk
$\hat{P}$	0.563	-0.086	0.493	0.272
$S.E._{\hat{P}}$	(0.308)	(0.352)	(0.299)	(0.345)

The coefficients were not significant, making the assumption of non-autoregressive disturbances valid without transforming the model. The model was then tested for cross-sectional heteroskedasticity. The calculated variances of the error term and their associated degrees of freedom were:

	Clackamas	Linn	Marion	Polk
S_e^2	2.626	0.772	2.828	0.804
D.F.	9	9	9	9

Significant differences between the variances were concluded from the F-tests. It was necessary to transform the data to correct the cross-sectional heteroskedasticity; data from each cross-sectional unit were divided by the standard deviation of its error terms. This accomplished, the parameters of the final Merion Kentucky bluegrass acreage response model were estimated:

$$LMERAC_{c,t} = \underset{(1.261)}{4.395} + \underset{(0.960)}{0.753}DCLACK + \underset{(0.380)}{0.987}DMAR + \underset{(0.586)}{0.557}DPOLK - \underset{(0.134)}{0.206}LMERPR_{c,t-1}$$

$$\underset{(0.753)}{-1.211}LHAYPR_{c,t-1} \underset{(0.527)}{+1.428}LWHTPR_{c,t-1} \underset{(1.055)}{-1.670}LGCRNPR_{c,t-1}$$

$$\underset{(0.267)}{+0.631}LBRNAC_{c,t-1} \underset{(0.122)}{+0.086}LBRNFE_{c,t-1} \qquad DF = 30$$

where $LMERAC_{c,t}$ = the natural log of the acreage of Merion Kentucky bluegrass in county c and year t

DCLACK = the binary variable for Clackamas County

DMAR = the binary variable for Marion County

DPOLK = the binary variable for Polk County

$LMERPR_{c,t-1}$ = the natural log of the price per cwt. of Merion Kentucky bluegrass seed in county c and year t-1

$LHAYPR_{c,t-1}$ = the natural log of the price per ton of hay in county c and year t-1

$LWHTPR_{c,t-1}$ = the natural log of the price per bushel of wheat in county c and year t-1

$LGCRNPR_{c,t-1}$ = the natural log of the price per bushel of grain corn in county c and year t-1

$LBRNAC_{c,t-1}$ = the natural log of the burning acreage limitation in county c and year t-1

$LBRNFE_{c,t-1}$ = the natural log of the burning fee per acre in county c and year t-1

The price of Merion Kentucky bluegrass seed was not significant at a ten percent level. A high degree of multicolinearity between the price variable and the burning acreage limitation, or the constant term may be disguising the relationship between price and acreage of Merion Kentucky bluegrass.

The coefficients for the price of hay and for the price of grain corn, cross-price elasticities of acreage, were estimated at -1.211 and -1.670 respectively. Although neither of these variables was significant at the level established for testing, each was significant at slightly higher levels. These estimates convey the percent that Merion Kentucky bluegrass acreage will decline if the price of hay and grain corn increase one percent. Since each of these coefficients is less than negative one, the acreage of Merion Kentucky bluegrass is cross-price elastic with respect to these crops. The coefficient for the price of wheat was positive and significant in the Merion Kentucky bluegrass equation. It is possible that wheat price may be reflective of some other factor not included in the model.

The burning acreage limitation was a highly significant variable in the model with an estimated coefficient of 0.631, over twice the size of its standard error. This implies that if the limitation of burning is reduced ten percent, Merion Kentucky bluegrass acreage will be reduced by 6.31 percent. The burning limitation variable is again significant when field burning is not employed in the production alternatives. The production of Merion Kentucky bluegrass has shifted recently to areas in eastern Oregon, eastern Washington and Idaho where the pollution problem from field burning is less severe, and burning limitations have not been implemented.

The burning fee variable is not significantly related to the acreage of Merion Kentucky bluegrass, given the other variables in the model.

Other Kentucky Bluegrass Acreage Response Model

The grass seed crops classified as other Kentucky bluegrass include numerous specially bred bluegrasses. The category refers to many diverse varieties; the majority of them are proprietary. Proprietary varieties are pedigreed seeds whose patents are held by seed companies (25).

The majority of the acreage of other Kentucky bluegrass, 89.9 percent, was in Clackamas, Linn, Marion and Yamhill Counties. Data from those counties were used to estimate the parameters of the acreage response model. The price variables of potential production alternatives investigated in the model and the t values of these variables were:

$LMERPR_{c,t-1}$	$LPRYEPR_{c,t-1}$	$LWHTPR_{c,t-1}$	$LOATPR_{c,t-1}$
-0.846	1.048	1.119	0.769
$LHAYPR_{c,t-1}$	$LGCRNPR_{c,t-1}$	$LBARPR_{c,t-1}$	$LRCLVPR_{c,t-1}$
-1.133	0.762	1.012	-0.448

where $LMERPR_{c,t-1}$ = the natural log of the price per cwt. of Merion Kentucky bluegrass seed in county c and year t-1

$LPRYEPR_{c,t-1}$ = the natural log of the price per cwt. of perennial ryegrass seed in county c and year t-1

$LWHTPR_{c,t-1}$ = the natural log of the price per bushel of wheat in county c and year t-1

$LOATPR_{c,t-1}$ = the natural log of the price per bushel of oats in county c and year t-1

$HAYPR_{c,t-1}$ = the natural log of the price per ton of hay in county c and year t-1

$LGCRNPR_{c,t-1}$ = the natural log of the price per bushel of grain corn in county c and year t-1

$LBARPR_{c,t-1}$ = the natural log of the price per bushel of barley in county c and year t-1

$LRCLVPR_{c,t-1}$ = the natural log of the price per cwt. of red clover seed in county c and year t-1

Although none of these price variables were significant at the level established for testing, the price variable for hay was included in the acreage response model as the "best" production alternative.

The error terms of the initial OLS estimation of the model were separated by county and used to estimate these first order auto-regression coefficients and standard errors:

	Clackamas	Linn	Marion	Yamhill
$\hat{P}$	0.413	0.576	0.472	0.693
$S.E._{\hat{P}}$	(0.390)	(0.227)	(0.419)	(0.341)

The coefficients for Linn and Yamhill Counties were significant and the appropriate transformations were made on these cross-sections. Two degrees of freedom were lost upon reestimation of the parameters of the non-autoregressive model. The once-transformed model was tested for hetero-skedastic disturbances with F-tests of the difference between these calculated variances (degrees of freedom are beneath the variables):

	Clackamas	Linn	Marion	Yamhill
S_e^2	0.040	0.213	0.233	0.377
D.F.	9	8	9	8

The variances of the error terms of Clackamas and Yamhill Counties were found to be significantly different. The data for the model was transformed by the appropriate standard deviations of the error terms. The final acreage response model for other Kentucky bluegrass is:

$$LBLUEPR_{c,t} = \underset{(2.050)}{-3.258} + \underset{(0.626)}{1.562}DCLACK - \underset{(0.268)}{0.007}DMAR - \underset{(0.569)}{0.314}DYAM + \underset{(0.081)}{0.092}LBLUEPR_{c,t-1}$$

$$+ \underset{(0.172)}{0.062}LHAYPR_{c,t-1} + \underset{(0.179)}{0.982}LBRNAC_{c,t-1} - \underset{(0.042)}{0.001}LBRNFE_{c,t-1} \qquad DF = 30$$

where $LBLUEPR_{c,t}$ = the natural log of the acreage of other Kentucky bluegrass in county c and year t

$DCLACK$ = the binary variable for Clackamas County

$DMAR$ = the binary variable for Marion County

$DYAM$ = the binary variable for Yamhill County

$LBLUEPR_{c,t-1}$ = the natural log of the price per cwt. of other Kentucky bluegrass seed in county c and year t-1

$LHAYPR_{c,t-1}$ = the natural log of the price per ton of hay in county c and year t-1

$LBRNAC_{c,t-1}$ = the natural log of the burning acreage limitation in county c and year t-1

$LBRNFE_{c,t-1}$ = the natural log of the burning fee per acre in county c and year t-1

The price of bluegrass seed, the price of hay, and the burning fee were all insignificantly related to the acreage of bluegrasses in the model. These are each factors that would normally affect farmers' relative profits from producing the crop. The production and marketing arrangements that predominate the seed varieties classified as other Kentucky bluegrass, however, preclude these factors from influencing acreage via the free market mechanism. Seed companies, who hold patents on proprietary bluegrass varieties contract with farmers to grow their seeds. The terms of these contracts vary widely; some are for a single year, some are multi-year contracts. The payment may be per cwt. of seed, per acre, or a cost plus arrangement (9). The results of the model suggest that these marketing arrangements divorce bluegrass acreage responses from factors normally affecting farmers' relative incomes in a free market.

The policy of restricting the acreage permitted burned does have a significant relationship with the acreage of bluegrass. It is a significant variable in the model with a coefficient of 0.982, more than five times the size of its standard error. The predicted response to a ten percent reduction in permitted field burning is a 9.82 percent decrease in acreage of other Kentucky bluegrass. Production of other Kentucky bluegrass has expanded in areas of eastern Oregon, eastern Washington and Idaho where restrictions on burning have not occurred.

Fine Fescue Acreage Response Model

More acreage of fine fescue was harvested in Clackamas, Linn, Marion and Polk Counties during the years of the analysis than in other Willamette Valley counties. They were the location of 92.8 percent of the Valley's fine fescue harvested acreage and data from these counties were used to estimate the crop's acreage response model. Seven price variables of potential production alternatives were investigated in the fine fescue model. The t values of these variables were:

$LBENTPR_{c,t-1}$	$LMERPR_{c,t-1}$	$LBLUEPR_{c,t-1}$	$LOATPR_{c,t-1}$
0.475	-0.828	0.713	-1.083
$LWHTPR_{c,t-1}$	$LHAYPR_{c,t-1}$	$LBARPR_{c,t-1}$	
-0.497	-1.353	-1.190	

where $LBENTPR_{c,t-1}$ = the natural log of the price per cwt. of bentgrass seed in county c and year t-1

$LMERPR_{c,t-1}$ = the natural log of the price per cwt. of Merion Kentucky bluegrass seed in county c and year t-1

$LBLUEPF_{c,t-1}$ = the natural low of the price per cwt. of other Kentucky bluegrass seed in county c and year t-1

$LOATPR_{c,t-1}$ = the natural log of the price per bushel of oats in county c and year t-1

$LWHTPR_{c,t-1}$ = the natural log of the price per bushel of wheat in county c and year t-1

$LHAYPR_{c,t-1}$ = the natural log of the price per ton of hay in county c and year t-1

$LBARPR_{c,t-1}$ = the natural log of the price per bushel of barley in county c and year t-1

The price variable for hay, although it was not significant at the level established for testing, was included in the fine fescue acreage response model as the "best" production alternative variable.

The original model was tested for correlation between the disturbance terms over time. The first order autoregression coefficients and their standard errors were estimated; they were:

	Clackamas	Linn	Marion	Polk
$\hat{P}$	0.460	0.541	0.267	0.727
$S.E._{\hat{P}}$	(0.351)	(0.303)	(0.394)	(0.324)

Autocorrelation was significant in the data for Polk County. GLS procedures were followed to transform this data to resolve the autocorrelation problem and reestimate the parameters. Then this model was tested for violation of the assumption of homoskedasticity. The cross-sectional variances of the error terms were calculated. These calculated variances and their associated degrees of freedom were:

	Clackamas	Linn	Marion	Polk
S_e^2	0.050	0.023	0.025	0.058
D.F.	9	9	9	8

The approximate F-test of significant differences between these variances was made and no cross-sectional heteroskedasticity could be detected. The final estimation of the fine fescue acreage response parameters are:

$$\underset{}{LFFESAC_{c,t}} = \underset{(0.204)}{7.538} + \underset{(0.169)}{1.384}DCLACK + \underset{(0.155)}{1.814}DMAR - \underset{(0.155)}{0.662}DPOLK$$

$$+\underset{(0.055)}{0.108}LFFESPR_{c,t-1} - \underset{(0.101)}{0.105}LHAYPR_{c,t-1} + \underset{(0.047)}{0.004}LBRNAC_{c,t-1} - \underset{(0.025)}{0.049}LBRNFE_{c,t-1} \qquad DF = 31$$

where $LFFESAC_{c,t}$ = the natural log of the acreage of fine fescue in county c and year t

DCLACK = the binary variable for Clackamas County

DMAR = the binary variable for Marion County

DPOLK = the binary variable for Polk County

$LFFESPR_{c,t-1}$ = the natural log of the price per cwt of fine fescue in county c and year t-1

$LHAYPR_{c,t-1}$ = the natural log of the price per ton of hay in county c and year t-1

$LBRNAC_{c,t-1}$ = the natural log of the burning acreage limitation in county c and year t-1

$LBRNFE_{c,t-1}$ = the natural log of the burning fee per acre in county c and year t-1

All of the coefficients in the fine fescue acreage response model were estimated with signs that are supported by economic theory. The expected price of fine fescue seed has an estimated positive coefficient nearly twice the size of its standard error. This significant price elasticity of acreage implies that farmers respond to a ten percent increase in the price of seed by increasing their acreage of fine fescue by 1.08 percent. Fine fescue is relatively unresponsive to price variation; the hill soils that this seed crop is grown on are highly susceptible to erosion. Crop alternatives are limited due to this problem. Hay, the "best" alternative for fine fescue production, is a lower value crop. The price variable for hay was insignificant in the acreage response model.

The burning acreage limitation variable was not significant in the model even though there is a high simple correlation between the variable and the acreage of fine fescue (0.96). The burning acreage limitation is multicollinear with the significant constant (intercept term for Linn County). The relationship between the limitation and acreage may be concealed by the high significance of the constant.

The burning fee variable was significantly related to the acreage of fine fescue in the model. The burning fee policy essentially alters the marginal costs of grass seed production. The coefficient of the burning fee was 0.049; implies a 0.49 percent reduction in fine fescue acreage in response to a ten percent increase in burning fees (within the established range). Apparently the fees that have been charged have shifted the comparative advantage from fine fescue production on some acreage in the four counties. Like tall fescue, the bulk of fine fescue production is in the south eastern U.S. Reduced production in the Willamette Valley will not affect the price of the seed. Therefore, burning fees increase marginal production costs without affecting marginal net revenues. Perhaps the fees have begun to approach the point that the comparative advantage shifts from fine fescue.

Acreage Forecasts and Model Verifications

The acreage response models that have been developed in this research can be used to provide forecasts of grass seed production under varying prices and field burning policies. A forecast is a quantitative estimate of the likelihood of future events based on past and current information (20). The information is embodied in the models, and extrapolations are made on the values of the models' variables to make forecasts of future events.

Each of the models was used to make point forecasts of harvested acreage in 1979. The relevant price and policy data for making these forecasts were from 1978. These are unconditional forecasts; the values of all the independent variables are known with certainty. Forecasts of harvested acreage can also be made conditional on projected values of the price and policy variables. During the course of the research, data describing the harvested acreage of grass seed crops in 1979 became available. Thus, the forecasts are ex post because the values of the dependent as well as the independent variables are known with certainty. Therefore, the forecasts are useful as verification of the models. Forecasted acreage that is far from actual acreage may indicate deficiencies in the models. A single forecast alone should not be the basis for accepting or rejecting a model; repeated observations are needed to reach such conclusions.

The forecasts of acreage were made by substituting the natural logs of the 1978 price and policy observations from each county into the models. Taking the antilog of the dependent variable produced acreage forecasts of each county. These forecasts were totaled for the four county areas represented by the respective models. The county and four county total acreage forecasts were compared to the actual 1979 acreage. Forecasting errors and their percentage of the actual acreage were calculated for each county and for the four county total.

The 1979 forecasted and actual acreage of annual ryegrass, and the forecasting errors and their percentages of actual acreage are:

	Benton	Lane	Linn	Polk	Total
Forecasted	16,714	8,379	80,414	11,115	116,622
Actual	14,500	7,000	94,000	12,500	128,000
Error	2,214	1,379	13,586	1,385	11,378
%	15.3%	19.7%	14.5%	11.0%	8.9%

The 1979 forecasted and actual acreage of perennial ryegrass, and the forecasting errors and their percentages of actual acreage are:

	Benton	Lane	Linn	Marion	Total
Forecasted	3,311	5,500	29,693	5,568	44,072
Actual	3,400	5,000	38,000	8,800	55,200
Error	89	500	8,307	3,232	11,128
%	2.6%	10.0%	21.9%	36.7%	20.2%

The 1979 forecasted and actual acreage of bentgrass, and the forecasting errors and their percentage of actual acreage are:

	Benton	Linn	Marion	Yamhill	Total
Forecasted	878	1,800	4,968	672	8,318
Actual	1,400	3,900	9,300	1,600	16,200
Error	522	2,100	4,332	973	7,882
%	37.3%	53.8%	46.6%	60.8%	48.7%

The 1979 forecasted and actual acreage tall fescue, and the forecasting errors and their percentages of actual acreage are:

	Benton	Lane	Linn	Marion	Total
Forecasted	693	1,944	6,217	1,023	9,877
Actual	800	6,000	1,800	700	9,300
Error	107	3,888	4,417	323	577
%	13.4%	64.8%	245.4%	46.1%	6.2%

The 1979 forecasted and actual acreage of orchardgrass, and the forecasting errors and their percentages of actual acreage are:

	Benton	Lane	Linn	Polk	Total
Forecasted	2,863	1,867	3,294	2,044	10,068
Actual	3,200	1,300	3,500	2,400	10,400
Error	337	567	206	356	332
%	10.5%	43.6%	5.9%	14.8%	3.2%

The source of acreage data began to aggregate data for Merion Kentucky bluegrass and other Kentucky bluegrass in 1979. Therefore, the forecasts of Merion Kentucky bluegrass and other Kentucky bluegrass were summed so they could be compared with the actual acreage of all Kentucky bluegrass. The 1979 forecasted and actual acreage of all Kentucky bluegrass, and the forecasting errors and their percentages of actual acreage are:

	Clackamas	Linn	Marion	Polk	Yamhill	Total
Forecasted	1,191	5,896	2,505	183	239	10,014
Actual	500	3,200	1,950	400	150	6,200
Error	691	2,696	555	217	89	3,814
%	138.2%	84.3%	28.5%	54.3%	59.3%	61.5%

The forecasted and actual acreage of fine fescue acreage and the forecasting errors and their percentages of actual acreage are:

	Clackamas	Linn	Marion	Polk	Total
Forecasted	7,544	1,903	11,719	974	22,140
Actual	5,480	1,700	12,800	800	20,780
Error	2,064	203	1,081	174	1,360
%	37.7%	11.9%	8.4%	21.8%	6.5%

V. SUMMARY AND CONCLUSIONS

Outcome

Models of the production responses of farmers with respect to eight major grass seed types have been developed. The models describe the relationship of prices and of policies that have been implemented to reduce field burning with the quantity of land in the Willamette Valley counties devoted to grass seed production.

Summary

Price of Grass Seed

Harvested acreage of three of the eight grass seed crops was responsive to expected prices of their seed. Expected prices of annual ryegrass seed, of perennial ryegrass seed, and of fine fescue seed were each positively related to acreage in their respective response models. The estimated own-price elasticities of acreage of these crops ranged from 0.334 for annual ryegrass to 0.108 for fine fescue; the own-price elasticity of perennial ryegrass acreage was estimated as 0.317.

The acreage of two grass seed crops, bentgrass and orchard-grass, is negatively related to the expected price of their seed in the models. The bentgrass model was actually estimated from data aggregating two distinct varieties of seed that have a wide price difference. The negative estimated elasticity probably reflects the mix of the two varieties of bentgrass. The negative elasticity of orchardgrass was likely the result of an insect infestation during the time series of the analysis. The infestation may have simultaneously led to higher prices and reduced acreage of the crop. Harvested acreage of three other grass seed crops, tall fescue, Merion Kentucky bluegrass, and other Kentucky bluegrass, were insignficantly related to the expected price of their seed in the models.

Price of Production Alternatives

Price variables of several potential production alternative crops were experimentally included in each acreage response model. Negatively related variables were found significant or very nearly significant (at the ten percent level) in the acreage response models of five of the eight grass seed crops. The acreage response model of Merion Kentucky bluegrass demonstrated the only price elastic relationships in all of the estimated models. The estimated cross-price elasticities of Merion Kentucky bluegrass acreage were -1.211 with respect to hay, 1.428 with respect to wheat and -1.670 with respect to grain corn. Wheat cannot be regarded as a legitimate production alternative to Merion Kentucky bluegrass production because of its positive estimated coefficient. The variable is probably a surrogate for some factor not specified in the model. Merion Kentucky bluegrass, bentgrass, and perennial ryegrass were each perennial grass seed crops that had perennial production alternative crops. The cross-price elasticity of perennial ryegrass acreage with respect to orchardgrass seed is -0.383. Bentgrass acreage has a cross-price elasticity with respect to hay of -0.346. Orchardgrass and Merion Kentucky bluegrass were perennial grass seeds with acreage significantly related to the price of annual crops. The estimated cross-price elasticity of orchardgrass acreage with respect to grain corn is -0.269. Perhaps the significance of an annual crop as a production alternative was related to the insect infestation in orchardgrass. Oats, an annual crop, was a significant production alternative to annual ryegrass. The estimated cross-price elasticity of acreage was -0.385. Tall fescue, fine fescue, and other Kentucky bluegrass did not have significant price variables for production alternatives.

Burning Acreage Limitation

The governmental policy of limiting the acreage permitted burned was determined to be an important factor affecting the acreage of bentgrass, orchardgrass, Merion Kentucky bluegrass, and other Kentucky bluegrass. Each of these grass seed crops, except other Kentucky bluegrass, had significant production alternatives that do not require the cultural practice of field burning. The estimated percent change in the acreage of bentgrass harvested related to a ten percent change in the burning limitation is 2.98 percent. The estimated percent change of orchardgrass acreage is 2.5 percent, of Merion Kentucky bluegrass acreage is 6.31 percent, and of other Kentucky bluegrass is 9.82 percent in response to a ten percent change in the burning acreage limitations. The bluegrass acreage has shifted to areas with no limitations of field burning. The limitation variable could not be determined significant in the acreage response model of annual ryegrass, perennial ryegrass, tall fescue, and fine fescue. The variable was strongly correlated with highly significant binary variables in each of these models. Thus it is possible that burning limitations affect the acreage of some of these crops but that the relationship was masked by multicollinearity.

Burning Fee

The government policy of charging a per acre burning registration and burning permit fee was determined to significantly reduce the acreage of only tall fescue and fine fescue. The estimated percentage acreage response of these two crops to a ten percent change in the burning fees is -0.75 and -0.49 percent, respectively. These are very small reactions to a policy that directly affects the marginal costs of production of the crops. No other acreages of grass seed crops were significantly related to the burning fee variable. Burning fees have been a very small part of the costs of producing grass seed. It appears that the range of burning fees that have been charged is not sufficient to shift the comparative advantage from grass seed production on most Willamette Valley land devoted to that use.

Limitations of the Study

The main limitation of analyzing the acreage response of grass seed to public policies concerning field burning is common to all social science research. The data available for analysis are restricted to descriptions of events that are outside the control of the researchers. Decision makers are concerned with policies that may be implemented to deal with the problem of field burning, but only data describing policies that actually have been enacted were available for this analysis.

The time distribution of the data was an important obstacle to the analysis. Burning fees have only been collected by the State since 1971 and limitations on burning have only been enacted since 1975. The obstacle was overcome by pooling time-series data from different cross-sections and by use of proxy values for some observations of the burning acreage limitation. Neither of these techniques were without adverse consequences. The pooling technique led to some multicollinearity problems between the burning limitation variable and the binary variables. When independent variables are correlated (multicollinear) their regression coefficients do not reflect any inherent relationships with the dependent variable (19). The proxy value of the burning limitation variable was constant over each county's observations prior to 1975. The coefficient on that variable therefore only reflects acreage response to the policy since that time. It would be useful to determine the effects of stricter burning limitations and higher burning fees on the acreage of grass seed. Such hypothetical policies are beyond the limitations of this empirical analysis.

Implications of the Results

Thus study provides some insight into the effects of prices and government field burning policies on the use of Willamette Valley agricultural land for grass seed production. Interpretation of the results of the analysis should be limited to the range of prices that have existed and policies that have been implemented. The relatively small estimates of most price elasticities of grass seed acreage in Willamette Valley counties implies that the comparative advantage of producing most grass seed crops in the Valley is not substantially altered by price variations that have occurred during the study period. The cross-price elasticities of Merion Kentucky bluegrass with respect to hay and grain corn are exceptions to the generally low price elasticity estimates.

Burning fees that have been implemented generally do not influence land use shifts from grass seed production. It is probable that some range of burning fees are sufficient to shift acreage from grass seed production. This hypothesis can only be tested, and the critical range of burning fees can only be discovered, when greater fees have been implemented.

The results concerning the government policy of limiting the acreage permitted open field burned are perhaps the most interesting. The 9.82 percent estimated response of other Kentucky bluegrass acreage and the 6.31 percent estimated response of Merion Kentucky bluegrass acreage were the greatest responses to a ten percent change in the burning limitation. Two other grass seed crops had significant estimated acreage response to the burning limitation policy. It is possible that acreages of grass seed crops in addition to the four with significant estimated coefficients of the burning limitation variable are affected by that policy, but these relationships may not have been observed for the reasons discussed above. It is reasonable to assume that if grass seed cannot be profitably produced unless fields are burned, limiting field burning will cause land to be shifted to other uses.

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