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Title: COSTS OF ALTERNATIVE POLLUTION CONTROL POLICIES AFFECTING OPEN FIELD BURNING IN THE WILLAMETTE VALLEY OF OREGON: A STUDY IN MEASUREMENT

Abstract approved: R. Charles Vars, Jr.

Open field burning is the lowest-cost method of harvest residue disposal used extensively by grass seed producers in the Willamette Valley of Oregon. The beneficial effects of open field burning include effective disease control and increased seed yields. However, smoke produced by open burning in the late summer pollutes valley air, reduces visibility, and possibly poses traffic and health hazards.

The growing concern among Oregon citizenry coupled with increased national interest in environmental quality has led Oregon authorities to legislate controls on open field burning. However, such controls by changing resource allocation in Oregon's seed industry would impose costs upon society.

The major objective of this study was to estimate costs of three alternative field burning control policies in terms of the changes in

consumers' surplus and producers' rents associated with each policy. To accomplish this objective an econometric model of demand and supply relationships for the six grass seeds raised in the Willamette Valley was developed. To establish a reasonable range for policy-induced changes in consumers' surplus and producers' rents, three alternative supply situations were postulated, and costs of grass seed production under each policy were assumed to increase by $5.00, $9.00, and $13.00 per acre, respectively. Supply situation I assumed positvely-sloped Oregon and non-Oregon supply curves whereas situation II assumed a perfectly inelastic Oregon supply curve and a positively-sloped non-Oregon supply curve. Supply situation III postulated a perfectly elastic non-Oregon and a positively-sloped Oregon supply curve.

In supply situation I, depending upon policy and assumed increase in costs of seed production, the relative decrease in consumers' surplus varied from 3 to 15 percent at national level when aggregated over all six grass seeds. Oregon producers' rents were predicted to decline by 4 to 20 percent. The increases in non-Oregon rents under each policy and assumed cost increase were only about 20 percent of the losses in Oregon rents. Consequently, the relative decreases in the sum of consumers' surplus and producers' rents (Oregon and non-Oregon) were approximately equal to the decreases in consumers' surplus.

Since under supply situation II and III seed prices remained unchanged, only changes in Oregon producers' rents needed estimation. Decreases in Oregon rents in situation II were 6 to 12 percent smaller than in situation I. In contrast, the results for supply situation III suggested that, other things equal, the greater the responsiveness of non-Oregon supplies to price, the greater the losses in Oregon producers' rents.

To provide additional perspective on the possible economic impacts of regulating open field burning, changes in earnings in grass seed production were translated into changes in the value of agricultural land now in seed production in the Willamette Valley. To accomplish this objective, the relative decreases in seed production earnings were estimated for supply situations I and II, and a model of the determinants of Willamette Valley grass seed land values was developed. The model predicted that land values in the Willamette Valley would typically decline by approximately two to nine percent depending upon the type of controls imposed on open field burning and the associated cost increase.

Although the methodological approach followed in this study is traditional, new measurement techniques are employed to estimate changes in the economic well-being of grass seed producers in Oregon.

Furthermore, the extension of partial welfare analysis to predict the effects of Oregon's regulatory policies on the well-being of non-Oregon producers also distinguishes the findings of this study from those of other studies with similar methodological approaches.

Costs of Alternative Pollution Control Policies Affecting Open Field Burning in the Willamette Valley of Oregon: A Study in Measurement

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I. INTRODUCTION

Oregon is the major grass seed producing state in the United States. More than half of all the U. S. certified grass seed is raised in Oregon. In 1968, Oregon's total seed crop sales at farm level were about 31 million dollars (Middlemiss and Coppedge, 1970), or approximately 12 percent of all the crop sales in the state.

Oregon's production of grass seeds is mostly concentrated in the Willamette Valley. In 1968 and 1969, the Valley accounted for nearly 81 and 85 percent, respectively, of Oregon's total seed crop value (Cooperative Extension Service, Oregon State University, 1971).

The Willamette Valley produces seven major grass seed types: ryegrass (annual and perennial), tall fescue, orchardgrass, red fescue, chewings fescue, Merion-Kentucky bluegrass, and bentgrass.[1] Table 1 shows that during 1966-68 all Oregon and U. S. grown ryegrass was raised in the Willamette Valley. Similarly, during the same period, except for tall fescue and Merion-Kentucky bluegrass,

[1] These seven seed types can, however, be classified into two broad categories: forage and turf. Forage grasses include ryegrass, tall fescue, and orchardgrass, whereas turf grasses include red fescue, chewings fescue, Merion-Kentucky bluegrass and bentgrass.

Table 1. Grass seed production by major seed types for Willamette Valley, Oregon and United States, 1966-68.

Seed	1966			1967			1968			Willamette Valley production as percent of					
										Oregon production			U. S. production		
	W. V. [1]	Oregon	U. S.	W. V.	Oregon	U. S.	W. V.	Oregon	U. S.						
Type	thousand pounds									1966	1967	1968	1966	1967	1968
Ryegrass	151,925	151,940	151,940	136,945	136,960	136,960	163,465	163,480	163,480	100	100	100	100	100	100
Tall Fescue	10,530	10,560	79,070	10,692	10,720	49,899	9,117	9,145	56,217	99.7	99.7	99.7	13.3	21.4	16.2
Red Fescue	5,765	6,670	6,918	7,370	8,480	8,893	5,840	6,450	6,578	86.4	86.9	90.5	83.3	82.9	88.8
Chewings Fescue	7,000	7,175	7,175	7,030	7,350	7,350	5,535	5,760	5,760	97.6	95.6	96.1	97.6	95.6	96.1
Merion-Kentucky Bluegrass	1,383	2,296	5,143	1,615	2,340	6,496	1,029	1,575	4,531	60.2	69.0	65.3	26.9	24.9	22.7
Bentgrass	7,615	8,160	8,253	7,515	7,840	7,868	5,780	6,160	6,176	93.3	95.9	93.8	92.3	95.5	93.6

[1] Willamette Valley

Source: Middlemiss, W. E., and R. O. Coppedge, "Oregon's Grass and Legume Seed Industry in Economic Perspective." Special Report 284, Cooperative Extension Service, Oregon State University, 1970 and

Seed Crops, Annual Summary, Statistical Reporting Service, USDA, 1969.

the Valley accounted for a very large percentage of total U. S. production of red- and chewings fescue and bentgrass. In case of tall fescue and Merion-Kentucky bluegrass more than 99 and 60 percent, respectively, of Oregon's production was raised in the Valley.

Statement of the Problem

The Willamette Valley accounts for a major share of U. S. grass seed production because of (1) ideal climatic conditions for seed development, and (2) lower unit costs of production. The Valley seed[2] producers, in order to minimize their production costs, have adopted open field burning as a method of harvest residue disposal. Open field burning also controls certain seed diseases, stimulates plant growth, and helps control weeds, thereby increasing the output and quality of Willamette Valley seed.[3] Burning takes place between mid-July and late September. In 1970, an estimated 260, 000 acres of grass straw and stubbles were burned in the Willamette Valley. Assuming an average residue yield of 3.8 tons per acre, approximately one million tons of residue are burned annually (Fisher, 1972).

Thus, although open field burning provides an effective and low-cost method of harvest residue disposal and seed disease control, the

[2]The words "seed" and "grass seed" are used synonymously, in this dissertation.

[3]For a detailed discussion on historical background and economic basis of open field burning, see Air Resources Center (1970, appendix).

substantial quantities of straw and stubbles burned produce smoke and pollute Willamette Valley air. The smoke produced by open field burning consists of carbon particles of varying sizes, ash and certain gases. A study under controlled burning conditions has revealed that carbon particulate emissions from straw vary from 10 to 20 pounds per ton of material burned (Air Resources Center, 1970). Assuming an average figure of 15 pounds of carbon particulate emissions per ton of straw with 1,000,000 tons burned, the total particulate material released into the ambient air of the Valley each year from field burning would total 7,500 tons.[4]

The problem of air pollution and environmental quality deterioration is further aggravated due to the unique physical and climatic features of the Valley. The Valley extends southward 130 miles from the Columbia River to a range of foothills. It is about 40 miles wide near the metropolitan city of Portland; however, this width decreases to less than ten miles at its southern end near Eugene. On the east the Valley is bounded by the Cascade mountain range, while on the west it is bounded by the Coastal range. Meteorologists have described the Willamette Valley as a box with a movable lid and a set of ventilating windows. In summer, when open burning takes place, meteorological conditions in the Valley favor development of

[4]This estimate does not include the ash particles, including those that remain on the ground, which may later be picked up by the wind to become air borne.

temperature inversion layers characterized by stratified air currents with very little mixing of upper and lower levels. (Olson and Tuft, 1970). These peculiar physical and meteorological features combine to retain air currents and the pollutants they carry within the Valley during the burning season.

Thus, the substantial smoke emissions resulting from open burning of grass straw and stubbles pose a major seasonal environmental pollution problem in the Willamette Valley where the majority of Oregon's population resides.[5] The major metropolitan areas of the state are located in the Valley, and smoke from open field burning affects all of them at least occasionally.

Although concern has been expressed about harmful health, soiling and materials damage affects of the smoke, most concern has arisen from visibility reduction.[6] This loss of visibility occurs at the height of Oregon's tourist and resident-vacation season, obscuring scenic views and possibly posing traffic hazards, especially when

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[5]The Willamette Valley has only 14 percent of Oregon's land area, but houses 70 percent of Oregon's 2.1 million residents (Conklin, 1970).

[6]In a study dealing with the estimation of pollution production function, visibility at Salem and Eugene airports has been shown to be inversely related to acres burned under particular meteorological conditions (Vars and Sorenson, 1972, Appendix D).

fields adjacent to the highways are burned.[7] In 1970, the Department of Environmental Quality (DEQ) reported that the smoke produced by open burning and the resulting visibility reduction were major sources of citizen complaint (DEQ, 1971).

The growing concern among Oregon citizenry coupled with increased national interest in environmental quality has led Oregon authorities to legislate controls on open field burning. At present, the acreage quotas are defined for each fire district, and burning in different geographical regions is allowed depending upon the prevailing meteorological conditions. However, effective January 1, 1975, Oregon's legislature has declared a total ban on open field burning.[8]

Since open field burning is the lowest-cost method, substitute cultural practices to dispose of harvest residues and control certain seed diseases would increase unit costs of production (see Table 2). Other things equal, in the short-run, earnings in grass seed production in Oregon would decline. However, in the long-run, some resources would leave the industry, total quantity of various grass seeds produced in Oregon would decline and (assuming a less than

[7]In an effort to minimize potential hazards from open burning, effective 1970, the DEQ has established priority areas around major highways, airports, and cities with a population of 10,000 or more. Within these priority areas no burning on the upwind side of any highway, airport, and city is permitted (DEQ, 1970).

[8]For discussion of regulations affecting open field burning, see Fisher (1972).

Table 2. A summary of increases in total costs per acre over open field burning with alternative residue removal techniques on selected grass seed crops.

	Alternative Residue Removal Techniques	Annual Ryegrass $/A	Perennial Ryegrass $/A	Highland Bentgrass $/A	Fine Fescue $/A	Merion Bluegrass $/A
A.	Incorporation of residues into the soil	21-26	---	---	---	---
B.	Mobile field incinerator	5-10	5-10	5-10	5-10	5-10
C.	Mechanical removal of residues followed by field sanitation a/					
	1. Bunching and Field Bucking	12-16	11-14	10-12	10-12	9-11
	2. Stack Former and Mover	15-25	13-21	11-17	11-17	11-15
	3. Chopper-Blower and Hauling b/	43	34	25	25	22
	4. Baling and Hauling c/	24-39	18-28	18-28	18-28	16-24
	5. Field Cubing and Hauling d/	34-68	34-52	25-37	25-37	22-31

a/ Costs include an $8/acre charge for use of a mobile field incinerator but exclude any expenses which may be required for residue utilization or disposal.

b/ Due to a lack of data, no range in costs were calculated. Only a custom rate of $10/ton for chopping, blowing, and hauling, and $8/acre for field sanitation were used.

c/ Projecting a range in baling and hauling costs of $6 to $12/ton with no swathing required.

d/ Projecting a range in cubing and hauling costs of $10 to $17/ton.

Source: Conklin, Frank S. and R. Carlyle Bradshaw, "Farmer Alternatives to Open Field Burning: An Economic Appraisal," Special Report 336. Agricultural Experiment Station, Oregon State University, Corvallis, October 1971. 15 p.

perfectly elastic non-Oregon supply) seed prices would rise. Consequently, regulatory policies to control air pollution from open burning would impose costs upon the society in terms of higher prices paid by seed consumers as well as changes in returns to owners of specialized resources in the seed industry.

Land is one of the most important specialized resources[9] in grass seed production. Much land employed in grass seed production, especially the land under ryegrass production, is of relatively poor quality and has very limited and economically unattractive alternative uses. Since controls on open field burning would decrease earnings in grass seed production and, as a consequence the current returns to grass seed land, such controls would be expected to lower the market values of grass seed lands below what they would be otherwise.

The Objectives

The principal objective of this research effort is to study the economic effects of alternative pollution control policies affecting open field burning on grass seed consumers, Oregon, and non-Oregon producers. The purpose is to provide useful information for public policy makers in ascertaining the economic and social desirability of alternative pollution control measures. Specifically, the objectives

[9] The terms "factor of production," "resource," and "input," are used interchangeably in this dissertation.

are as follows:

1. to develop an econometric model of demand and supply relationships for grass seeds raised in the Willamette Valley;
2. to estimate determinants of grass seed land values in the Willamette Valley;
3. to estimate losses resulting from the implementation of alternative open field burning control policies to seed consumers and Oregon producers, as well as gains to non-Oregon producers; and
4. to estimate decline in grass seed land values in the Willamette Valley consequent to controls on open field burning.

II. THEORETICAL FRAMEWORK

Chapter II presents the conceptual framework to estimate costs of an institutional control on open field burning.

The first section presents a discussion on the existence of externality and imposition of controls on open field burning. The second section discusses the application of partial welfare analysis in measuring costs of such controls. Some of the conceptual and definitional issues underlying the application of this type of analysis are also highlighted and relevant literature cited. Following this discussion, the particular model employed in this study to measure costs of an institutional control on open field burning is specified. The chapter concludes by presenting a conceptual model to study impacts of such a control on grass seed land values in Oregon.

Externality and Imposition of Controls

A representative grass seed producer is assumed to have a production function of the following form:

$$Q_i = Q_i\ (X_1,\ X_2,\ \ldots,\ X_n)\quad i = 1,\ 2,\ \ldots,\ y$$

where Q refers to output and X's represent production activities undertaken by the i^{th} producer. For convenience, production activity X_1 is defined as open field burning.

Assume that a representative Willamette Valley resident or a tourist has a well defined preference function which can formally be stated as:

$$U_j = U_j\ (C_1,\ C_2,\ \ldots,\ C_m;\ E)\quad j = 1,\ 2,\ \ldots,\ Z$$

where C's represent consumption activities undertaken by the j^{th} individual, and E refers to the "state of the environment." Consumption activities are regarded to be under the control of an individual, whereas, the state of the environment (E) is viewed to be unaffected by individual action alone. Deterioration of E shifts the utility function such that

$$\frac{d\left(\frac{\partial Ui}{\partial Ci}\right)}{dE} \leq 0$$

i.e., deterioration of the environment has negative or zero effects on the marginal utilities of consumption activities.[10]

To the extent the deterioration of the state of the environment adversely affects the marginal utilities of consumptions activities, an individual experiences a decline in the level of utility derived from a given activity mix. Therefore, as the environment deteriorates, the Valley residents and tourists experience a loss in their well-being. However, the deterioration of the state of the environment is imposed upon the Valley residents and tourists by a member group which produces grass seed, and in the process engages in the production activity

[10] This specification of the utility function and the hypotheses regarding the changes in marginal utilities of consumption activities with respect to changes in the state of environment are based on Sorenson (1970).

of open field burning.[11] Since the utility of the Valley residents and tourists is dependent not only upon the consumption activities under their control but also upon a production activity X_1 under the control of grass seed producers, an externality exists (Castle, 1965; Buchanan and Stubblebine, 1962).

The externality in this instance arises because the grass seed producers in the Willamette Valley open burn harvest residues in the fields and release smoke into the ambient air. Since air in the Valley is a publicly-owned natural resource, the seed producers' right to pollute air and cause imbalances in the natural environment has been challenged. However, the only way to eliminate or reduce air pollution and restore balances in the natural environment is to impose restrictions or controls on the usage of ambient air by producers. Imposition of controls on open field burning, therefore, involves restructuring of "property rights" with respect to air usage. Since the investigation of property rights _per se_ is not within the scope of this study, two

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[11] The Willamette Valley residents who grow grass seed are perceived to be members of two different groups: producers of seed and consumers who experience the Valley environment.

alternative "property right structures" are postulated:[12] (1) seed producers have <u>no</u> right to pollute air, and (2) seed producers have <u>some</u> right to pollute air. Both these property right structures imply that certain institutional controls need to be imposed upon production activity X_1, thereby changing the "access" of seed producers to production function Q although technically it is still available. Depending upon the nature of controls, the "accessible" production function can be defined as:

$$Q_1' = Q_1' (X_2, X_3, \ldots, X_n)$$

if a total restraint or ban on X_1 is imposed, <u>or</u>

$$Q_1'' = Q_1'' (X_1^o, X_2, \ldots, X_n)$$

if a certain specified level X_1^o of open burning is permitted.

For illustration refer to Figure 1. With the imposition of an institutional control, either total or partial, on the production activity X_1, production function Q shifts downward.[13] This shift, although

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[12]These two property right structures are assumed only for analytical convenience. One could conceivably think of alternative property right structures involving various types of compensatory arrangements. However, in the case of controls on open field burning a compensatory arrangement does not appear feasible because (1) a very large population is involved, (2) certain harmful effects of air pollution are not well established, and (3) some of the aesthetic benefits of improved environmental quality are not easily measured.

[13]Throughout this investigation imposition of a control is assumed to be permanent.

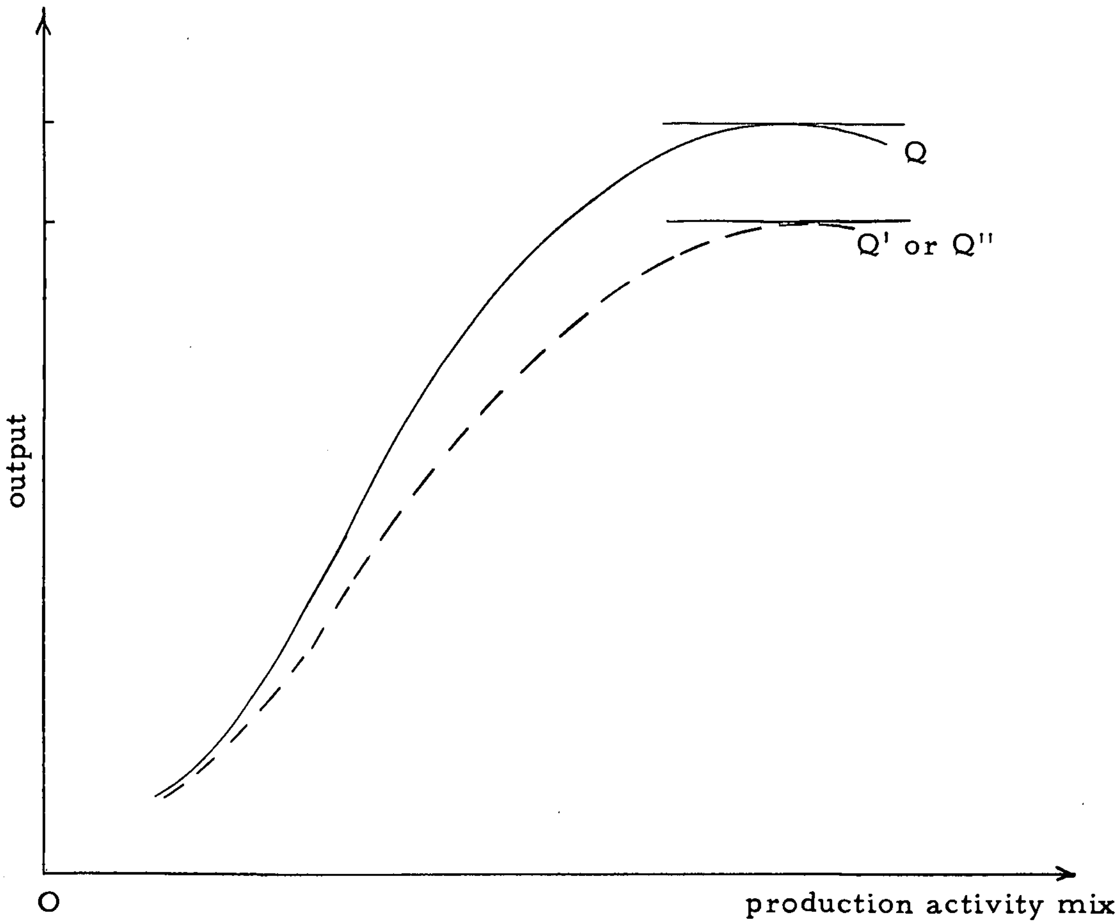

Figure 1. Production function before and after the imposition of controls on open field burning.

undesirable to Oregon producers, may be desirable from a social viewpoint.

With the advent of institutional controls on open burning, relatively more expensive substitute production activities would increase the total costs of grass seed production. Assuming no economies of scale are involved in the substitute production activity or activities, the change in costs following the implementation of controls would shift the long-run marginal cost function of individual producers in Oregon and, therefore, the aggregate Oregon supply function. Of course, the magnitude of shift would vary depending upon the type of controls imposed. In any case, imposition of institutional controls on open field burning would change grass seed output and prices, and consequently impose costs on society in terms of the value of goods and services foregone.[14]

Application of Partial Welfare Analysis

To estimate costs of alternative institutional controls on open field burning, partial welfare analysis may be used. Whereas Little (1960) has seriously questioned the validity of this type of analysis, Hicks (1940, p. 110) has argued that "there are few branches of

[14]This does not imply that controls on open field burning would impose costs on society <u>only</u> by changing output and prices. Even if output and prices exhibit <u>no</u> change, the increased costs of seed production would lower the returns to specialized resources in Oregon, and thereby impose costs on society.

economic theory which have greater practical use." Referring to this type of analysis Currie, Murphy, and Schmitz (1971) concluded that it is easy to raise objections but for policy making it is difficult to find any workable alternatives.

Since in the real world, because of the complexities of inter-relationships involved, it is not feasible to determine all possible effects of a change in a given industry, partial welfare analysis provides useful, though qualified, results for policy purposes.

In partial welfare analysis, the concepts of consumers' and producers' surplus are most commonly used analytical tools. Traditionally, consumers' surplus is defined as the area under the demand curve and above the competitive equilibrium price; and producers' surplus as the area above the competitive supply curve and below the equilibrium price. These concepts have been applied to a wide variety of economic problems including resource misallocation (Lerner, 1934; Harberger, 1954; Nerlove, 1958a; Wallace, 1962; and Johnson, 1965), gains and losses from international trade (Cordon, 1957; Bhagwati and Johnson, 1960; Johnson, 1960; Dardis and Dennisson, 1969), price instability (Waugh, 1944; Massell, 1969 and 1970), and evaluation of public and private investments (Griliches, 1958; Peterson, 1967; Schmitz and Seckler, 1970).[15]

[15] For a recent survey of the literature on economic surplus, see Currie, Murphy, and Schmitz (1971).

The basic model used to evaluate the welfare effects of investments is depicted in Figure 2, which is identical to the figure that Schmitz and Seckler (1970) employ to explain their method of computing the rate of return on investment in the development of the mechanized tomato harvester. This figure is reproduced here for two reasons: (1) it conveniently initiates illustration of the basic concepts used in this study to measure some effects of regulating open field burning in the Willamette Valley, and (2) it also illustrates why "obvious" procedures for measuring producers' surplus may result in unrealistic estimates clearly inconsistent with basic microeconomic theory.

Following Schmitz and Seckler, suppose that some technological innovation reduces production costs for the entire industry, thereby shifting the supply curve in Figure 2 from S_o to S'_o.[16] The gain in consumers' surplus is measured as the area E + G + F, while the gain in producers' surplus is H + I - E. However, if the initial supply curve had been perfectly elastic, the only gain to society would be the gain in consumers' surplus E + G + F since producers' surplus does not exist. Schmitz and Seckler define the sum of producers' and consumers' surpluses to be the gross social gain from the postulated technological change. They also go one step further than previous

[16]The authors do not mention explicitly whether they are referring to a short- or long-run supply curve.

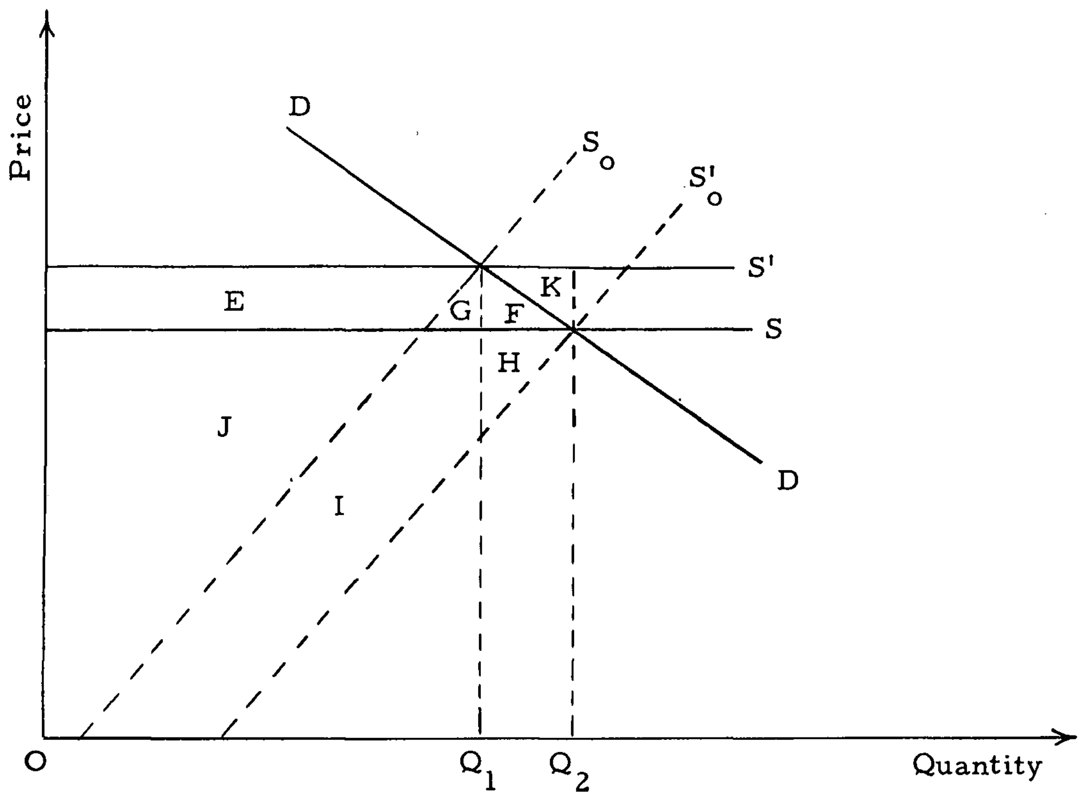

Figure 2. Gains from a technological innovation.

researchers and calculate the net social gain to society. They define the net social gain to be the gross social gain minus the aggregate wages that would have been paid to workers displaced by the innovation.

As already indicated, producers' surplus is traditionally defined as the area above the supply curve and below the price line. Consequently, what this area actually measures depends upon the nature of the supply curve postulated, that is, whether it is a short- or long-run supply curve, whether it excludes or includes rents, etc. With respect to long-run supply curve of an industry employing two factors of production: Labor and capital, Mishan (1968, p. 1277) pointed out:

> . . . the industry supply curve is, admittedly, an average cost curve including rents -- the rents of both factors in fact, since these alter as the industry's equilibrium output expands. But it is not also a marginal curve excluding rent (as in the Ricardian average cost curve). An average curve including rent, equal to a marginal curve excluding rent, can be derived only in those cases in which rent accrues to a single fixed factor, all other factors being infinitely elastic. In the more general case, however, where the changes in rents of all factors are fully taken account of in the average curve, including of course the rental of capital (but no Knightian profit), the area above the rising industry supply curve carries no economic significance.

Shepherd, on the other hand, expressed disagreement with Mishan (1970). He distinguished between the Ricardian and the Paretian concept of economic rent, and maintained that, in deriving welfare propositions, economists are correct to view the area above the long-run industry curve as a relevant measure of economic rent in the Paretian sense.

Despite the controversy over what supply curve and what concept of economic rent to employ in measuring producers' surplus, one conclusion seems inescapable. Economists in general would agree that for a competitive industry, short- and long-run marginal costs of production may be zero only in very rare circumstances. Therefore, Schmitz and Seckler made a significant error in the construction of Figure 2. In this figure both S_o and S_o' intersect the quantity-axis in positive quadrant, thereby implying that per unit producers' surplus at initial levels of output equals price. Hence, Figure 2 must be regarded as constructed in a theoretically unjustifiable fashion.[17]

For measurement of producers' surplus, empirically estimated industry supply curves are unrealistic tools to employ for two very practical reasons. First, such supply curves often have either positive quantity-intercepts implying zero marginal costs at low output levels <u>or</u> positive price-intercepts substantially different from long-run marginal costs excluding all quasirents to variable factors. Second, even if price-intercepts were forced to approximate marginal

[17]Similar error can be found in an empirical study of externalities in the farm use of pesticides by Edwards (1970). Edwards employs linear supply functions derived from his econometric study of vegetable and fruit supply-response functions in Dade, County, Florida, to estimate producers' surplus. Two (for tomato and beans) of his six supply functions have positive quantity-intercepts. However, Edwards makes this error without constructing a theoretically unrealistic figure to define producers' surplus. In contrast, Schmitz and Seckler construct a theoretically unrealistic figure to define producers' surplus, but they do not calculate a measure of producers' surplus.

costs, there is no necessary correspondence between the slope and degree of curvature of the estimated and "true" supply curves. Moreover, Mishan has observed, while the concept of economic rent is "perfectly symmetric" with the concept of consumers' surplus, the area above the true supply curve is strictly comparable to the consumer's surplus only under special circumstances in the short-run. Therefore, to avoid confusion and follow Mishan, the term "producers' surplus" is henceforth replaced by "aggregate industry rents."

Aggregate industry rents are defined here as the sum of returns to those factors of production typically regarded as perfectly or highly inelastic in supply to the industry in the short-run.[18] Such rents per unit of output are measured as price minus average variable costs in the industry. Here, changes in aggregate industry rents represent an empirical measure of the welfare (income) changes experienced by owners of specialized resources.

Of course, the definition of aggregate industry rents posited here does not provide the measure of rents as they are traditionally defined.[19] There are at least two reasons for this. First, this definition does not include quasirents received by variable factors.

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[18] The word aggregate appears in the definition because this investigation attempts to measure the sum of returns to all specialized factors of production in the industry.

[19] Even traditionally there is no single accepted definition of economic rent. For some alternative views on economic rent, see Mishan (1959) and Shepherd (1970).

Second, the non-pecuniary benefits of particular employments and occupations would only rarely equal the total payments received by the owners of land, specialized facilities, equipment, entreprenuerial ability, etc. Despite these limitations, aggregate industry rents as defined here probably provide a more meaningful measure of welfare changes experienced by the owners of specialized resources when compared to traditionally estimated changes in producers' surplus.

If some subset of the factors of production are truly specialized to an industry affected by a pollution control policy, then any decline in aggregate industry rents would necessarily be entirely borne by those specialized factors. Moreover, if some of these factors do leave the policy-affected industry, those which remain because they lack employment opportunities elsewhere, must also bear the entire change in aggregate rents. Consequently, an ability to measure changes in such rents is equivalent to an ability to measure the change in returns to an industry's "specialized" resources.

Model to Estimate Changes in Consumers' Surplus and Producers' Rents

Based on these theoretical considerations, a model to estimate the costs of an institutional control or a regulatory policy affecting open field burning is specified below. The costs of such controls or regulatory policies as defined here are measured by changes in consumers' surplus and producers' rents.

The basic model is depicted in Figures 3 through 5. These figures differ from one another in terms of assumptions concerning the elasticity of relevant long-run supply curves. Here,

OP = price of grass seed

OC = average variable costs of production in Oregon

OQ_o = Oregon output

OQ_{no} = non-Oregon output

D_u = demand curve for current utilization of seed in the U.S.

D_{es} = demand curve for ending stocks in the U.S.

D_A = aggregate demand curve

S_o = long-run Oregon supply curve

S_{no} = long-run non-Oregon supply curve

S_A = long-run aggregate supply curve

In Figure 3, assume that the imposition of an institutional control on open field burning increases average variable costs to OC', shifts S_o to S_o', and therefore S_A to S_A'. As a consequence, the loss in consumers' surplus, decrease in Oregon producers' rents, and gains in non-Oregon producers' rents[20] are given, respectively,

[20] The measurement of gains to non-Oregon producers, however, is specified on the basis of traditional concept of producers' surplus. The lack of information on costs of production of grass seeds in states other than Oregon necessitated this procedure.

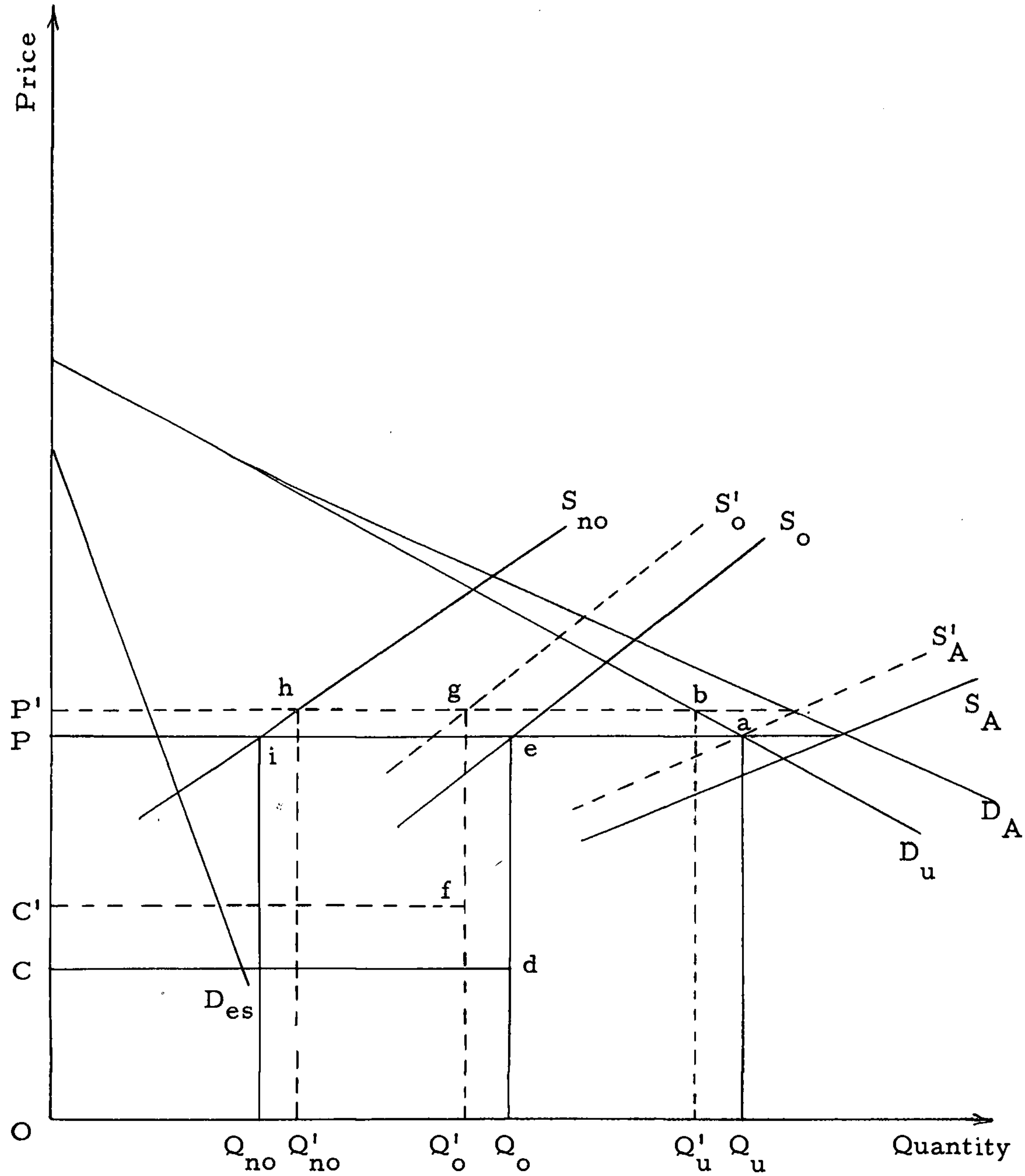

Figure 3. Positively-sloped supply curves and changes in consumers' surplus and producers' rents.

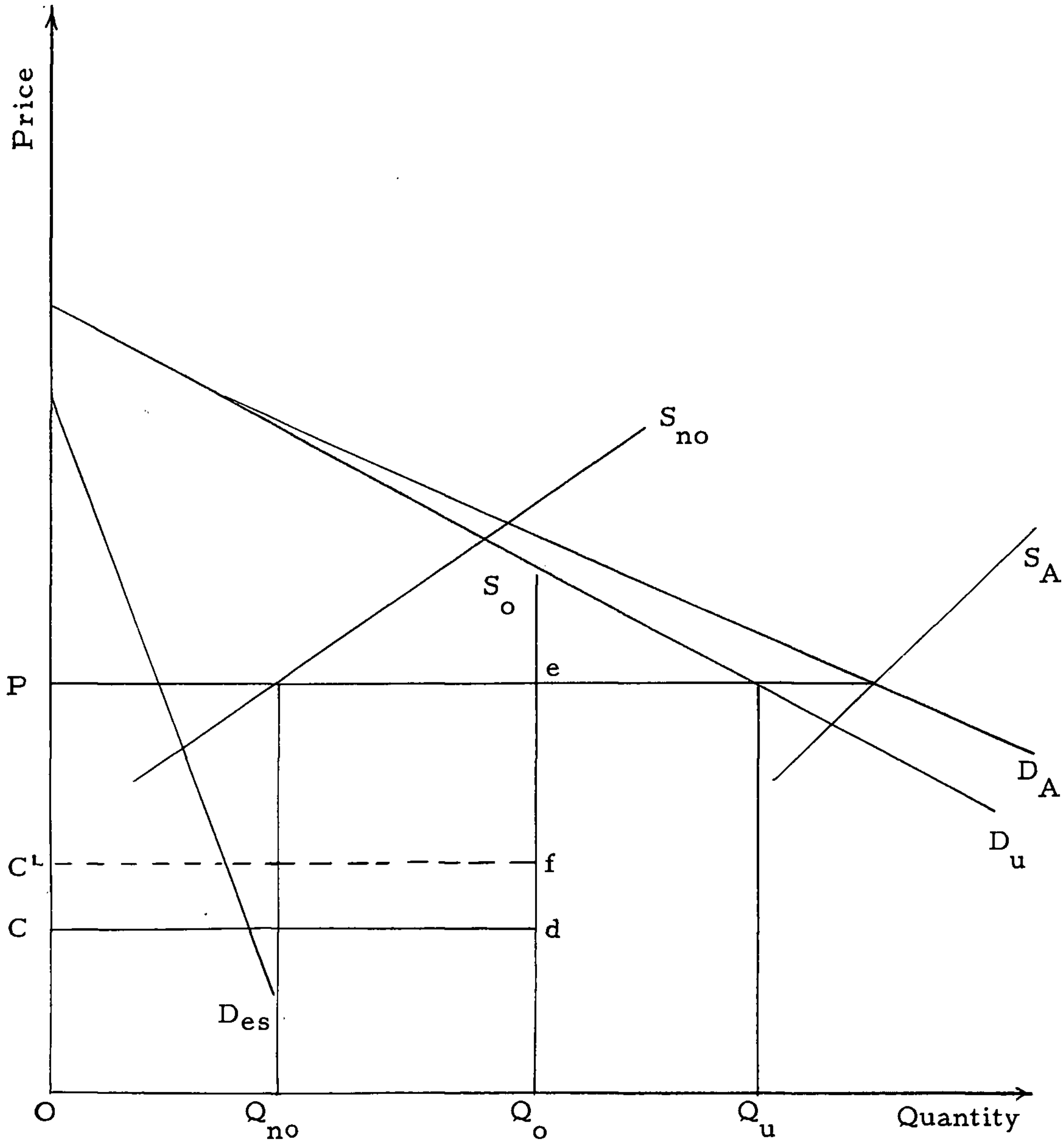

Figure 4. Perfectly inelastic Oregon supply curve and changes in producers' rents in Oregon.

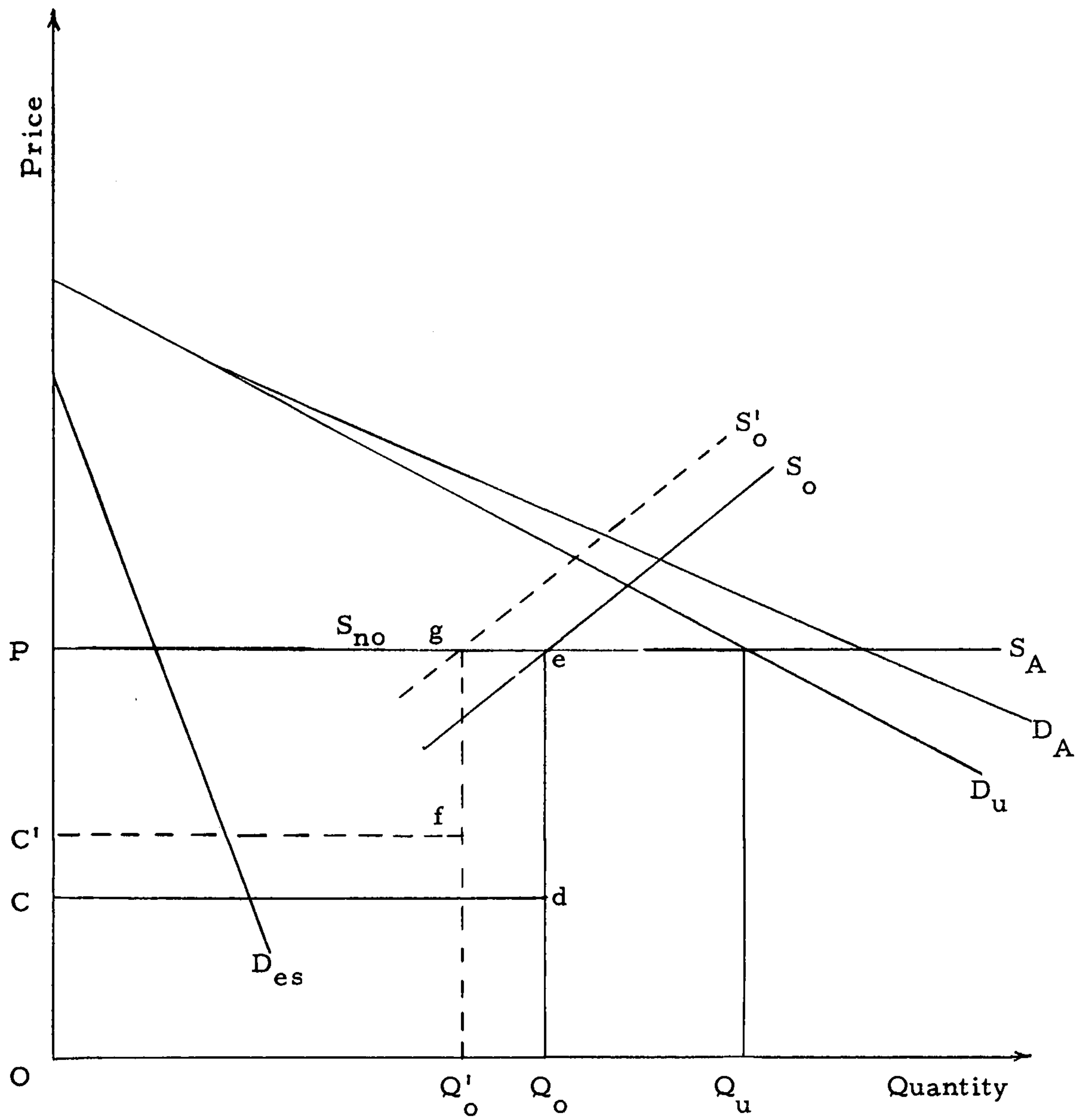

Figure 5. Perfectly elastic non-Oregon supply curve and changes in producers' rents in Oregon.

by the areas PabP', PCde-P'C'fg, PihP'.

If the Oregon supply curve is perfectly inelastic at an output level of OQ_o, and non-Oregon supply curve is given by S_{no} (see Figure 3) implementation of a regulatory policy would have no affect on consumers' surplus and non-Oregon rents. However, the increase in variable costs to OC' due to controls on open field burning would result in a decline in Oregon producers' rents equivalent to the area PCde-PC'fe.

Figure 5 portrays a situation where the non-Oregon supply curve is perfectly elastic at the current price, and the Oregon supply curve is positively-sloped. In this case again, the imposition of controls on open burning would have zero effect on consumers' surplus and non-Oregon producers' rents. The decline in Oregon rents would now be measured by the area PCde-PC'fg, however.

From the preceding discussion it follows that the magnitude of changes in consumers' surplus and rents to Oregon as well as non-Oregon owners of specialized resources depends upon the assumptions concerning the elasticity of relevant supply curves.

Shift in the Demand for Grass Seed Land and its Impact on Land Values

As indicated in Chapter I, land is one of the most important specialized resources employed in grass seed production. Consequently, land owners along with the owners of specialized capital, entrepreneurial ability, etc., would share the losses in rents to Oregon seed producers. Figure 6 illustrates a conceptual model to translate the aggregate rent losses to Oregon seed producers into decreases in the value of land presently in grass seed production in Oregon. In this figure

D_s = demand for land to raise grass seeds

D_{ou} = demand for land in other uses

D_A = aggregate demand for land

S_s = supply of grass seed land

S_A = aggregate supply of land

The model postulates that imposition of controls on open burning of straw and stubbles in Oregon's seed fields would shift the demand for land to raise grass seeds leftward from D_s to D'_s, thereby lowering the price of seed land at the margin from OP to OP'.

Since the marginal land presently in seed production has other potential agricultural and/or non-agricultural uses, the model does <u>not</u> postulate a situation in which the supply of land for raising grass seeds is perfectly inelastic. To emphasize this point, panel (b) of Figure 6 was constructed to represent the demand curves in panel (a) to demonstrate that the demand curve for land in uses other than grass seed production, D_{ou}, may also be interpreted as the supply curve of seed land.[21] Thus, the magnitude of change in grass seed land values

[21] Panel (b) of Figure 6 is constructed in a fashion similar to the one used by Stigler (1966) to analyze the price determination of storeable goods with fixed supplies.

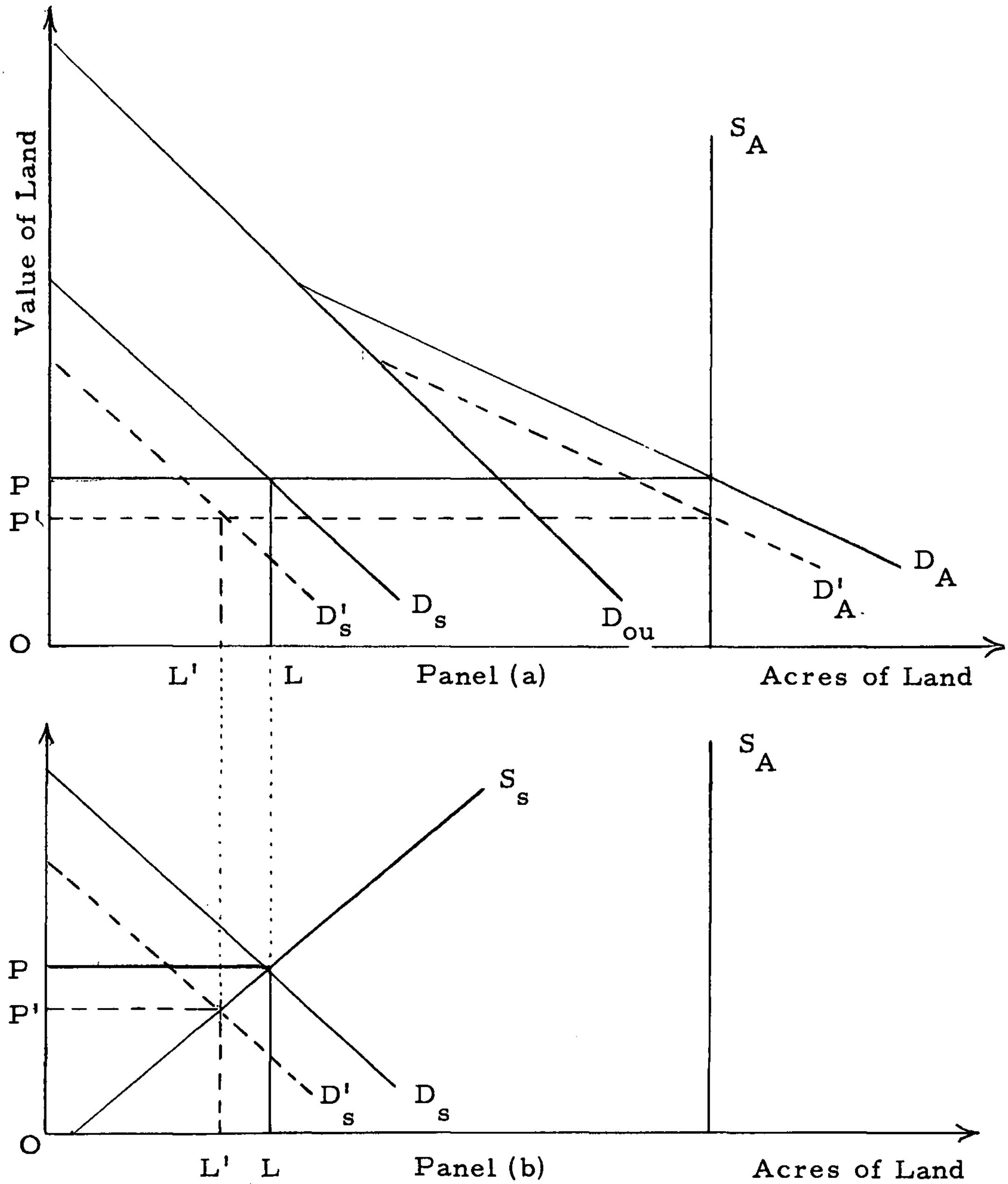

Figure 6. A hypothetical model illustrating shift in demand for grass seed land in Oregon and its impact on land values.

would depend not only on the nature of controls on open field burning but also on the demands for land in other uses.

Following the implementation of controls, however, the demands for land in other uses may increase. This could result from the increased attractiveness of the Valley to potential residents and footloose firms because of improvements in the quality of natural environment. However, the model assumes that the increase in demands for land in other uses, though possible, is not significant.

III. AN ECONOMETRIC MODEL OF DEMAND AND SUPPLY RELATIONSHIPS FOR SIX GRASS SEEDS RAISED IN THE WILLAMETTE VALLEY

This chapter presents the specification of a simple dynamic model of demand and supply relationships for six grass seeds raised in the Willamette Valley and reports the analytical results.[22]

The primary objective is to estimate price elasticities of demand and supply for the six grass seeds. These elasticity estimates provide the basis to calculate linear demand and supply equations which are reported at the end of this chapter. These calculated equations are employed to estimate changes in consumers' surplus and producers' rents in Chapter IV of this dissertation.

Specification of Demand and Supply Relationships

Demand and supply relationships in the grass seed industry are complex and difficult to specify. Domestic and world seed prices are determined by the simultaneous interaction of supplies and demand at various marketing levels (farm, wholesale, and retail) and outlets (domestic utilization, exports, and carryover). For these marketing levels and outlets only limited, and in some respects unreliable, data exists. More particularly, the perennial nature of many seeds makes specification of supply-response functions difficult, and the fact that

[22]The six grass seeds included in the analysis are: ryegrass, tall fescue, red fescue, chewings fescue, Merion-Kentucky bluegrass, and bentgrass.

most seeds are sold at retail in various mixtures makes a truly adequate specification of independent demand functions at retail levels quite impossible.

The Demand Relationships

For various grass seeds there are three major outlets: (1) domestic demand for current utilization, (2) domestic demand for ending stocks, and (3) foreign demand. On theoretical grounds one would prefer to estimate a demand function for each outlet (Fox, 1953). However, since data on grass seed exports prior to 1966 are not available, estimation of an independent export demand function is not possible. As a consequence, the specification of demand for current utilization includes a foreign shift variable accounting for some portion of exports.

In this study two demand relationships in the U.S. are specified, one for current utilization and the other for ending stocks (carryover). It is hypothesized that, given total commercial availability (current production plus beginning stocks), the price of a grass seed at the farm level is jointly determined by the interaction of the demands for current utilization and ending stocks.

Demand for Current Utilization

The demand for current utilization in the U.S. is specified at the farm level. For most of the grass seeds reliable retail price data are not available whereas, price and quantity data at wholesale level are available for only 12 or fewer years.

The marketing of various grass seeds involves several activities undertaken by producers, wholesalers, and retailers. To develop a complete model one must postulate marketing group behavior relations reflecting the various activities undertaken at different marketing levels. Limited data availability and unknown quantities of stocks carried forward at each marketing level preclude the possibility of incorporating a complete set of behavioral variables in the model.[23] Consequently, the model is required to assume that behavioral relationships are constant during the period of analysis or else the change is not significant to bias the estimation of the specified relationships.

The demands for forage grasses are not final consumer demands. These grasses are utilized as inputs in livestock industry. However, for analytical convenience, it is assumed that forage grasses in livestock production are used in technically fixed proportions and,

[23] For derivation of marketing group's behavioral relation, see Foote (1958).

therefore, the current quantity utilized vary directly with the number of cattle.[24]

The model postulates four major hypotheses concerning the demands for utilization of grass seeds at the farm level. Each of these hypotheses is equivalent to those commonly tested in econometric studies of demand functions.

The first two hypotheses state that the quantity of a seed demanded for current utilization varies (1) inversely with its price, and (2) directly with prices of substitute seeds. Empirical experimentation would be employed to determine the closest substitute for each forage and turf grass seed.

The third hypothesis concerns the appropriate domestic and foreign demand shift variables for forage and turf grasses. The model hypothesizes direct relationships between (i) demands for forage seeds and number of cattle in the 12 southern U.S. states and in Canada, West Germany, and France; and (ii) demands for turf seeds and the number of housing starts in the United States.

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[24]Ideally, in specifying a derived demand function one should include the price of output. But, in this instance, the demand for livestock itself is a derived demand, and hence, to avoid complexities, the assumption of fixed production coefficients is made. Moreover, Hildreth and Jarret (1955, p. 108), in a study of livestock production and marketing, indicated that, in deriving demand equations by eliminating endogenous variables such as price of output, "it is always possible to imagine a more fundamental explanation of the phenomenon we observe, involving more equations and more endogenous variables." Based on this reasoning and given the broad objectives of this study, therefore, the specification presented here is regarded reasonable, though imperfect.

Finally, it would not be expected that consumers adjust to price and other changes instantaneously -- more likely they would adjust their utilization gradually to the long-run equilibrium level. This final hypothesis derives from Nerlove's brilliant insight that we rarely observe long-run equilibrium prices and quantities in competitive markets (1958b).

In sum, hypotheses concerning demands for utilization can be written as follows:

$$Q_{it}^{d*} = F_i\,(P_{it},\ P_{jt},\ Z_t^d\ ,\ Z_t^f\ ) \qquad \text{(a)}$$

where:

Q_{it}^{d*} = long-run equilibrium quantity demanded of i^{th} grass seed for utilization in year t,

P_{it} = average price of i^{th} grass seed received by farmers in year, t,

P_{jt} = average price of j^{th} grass seed received by farmers in year t, where j^{th} seed is a substitute for the i^{th} seed,

Z_{it}^d = domestic shift variable: number of cattle in 12 southern states, <u>or</u> number of housing starts in the U. S.

Z_{it}^f = foreign shift variable: number of cattle in Canada, West Germany, and France,

and:

$$Q_{it}^d - Q_{i,\,t-1}^d = \lambda_i^d\ (Q_{it}^{d*} - Q_{i,\,t-1}^d) \quad 0 < \lambda_i^d \leq 1 \qquad \text{(b)}$$

where:

λ_i^d = coefficient (or elasticity if quantities are expressed in logarithms) of adjustment,

Q_{it}^d = actual quantity utilized in year t,

$Q_{i,t-1}^d$ = Q_{it}^d lagged one year.

Equation (a) expresses the first three hypotheses at long-run equilibrium level, while equation (b) is the postulated adjustment function. The adjustment function states that the observed change in quantities utilized is some fraction of the difference between the actual utilization in the previous year and the long-run equilibrium level of utilization. Substituting (a) for Q_{it}^{d*} in adjustment function (b), the following demand relationships are obtained:

$$Q_{it}^d = \lambda_i^d F_i (P_{it}, P_{jt}, Z_{it}^d, Z_{it}^f) + (1-\lambda_i^d) Q_{i,t-1}^d \quad (1)$$

Both short- and long-run price elasticity of demand for current utilization may be estimated from this equation.

Demand for Ending Stocks

Ending commercial stocks are the other important outlet for grass seeds. Ending stocks as percent of total commercial availability in the U.S. vary considerably from year to year, as well as among grass seed types. In 1969, for example, ending stocks as a percentage of commercial availability varied from 18 percent for bentgrass to 30 percent for Merion-Kentucky bluegrass. These stocks of seed are presumably held in expectation of a higher price in the following season. Consequently, the model hypothesizes that the demand for ending stocks is directly related to total commercial availability and inversely related to current price (Vandenborre, 1970).

More precisely,

$$Q_{it}^{es} = G_i \, (P_{it}, Q_{it}^{ca}) \qquad (2)$$

Q_{it}^{es} = quantity of ending stocks of i^{th} seed held by farmers, dealers, and government in year t,

P_{it} = average price of i^{th} grass seed received by farmers in year t,

Q_{it}^{ca} = total commercial availability (i.e., current production plus beginning stocks) of i^{th} grass seed in year t.

The Supply-Response Relationships

The specification of aggregate Oregon supply-response functions for the six grass seeds presented here is based on time-series data. Although the supply functions can be derived from production functions, as well as by budgeting and linear programming, these approaches have been subjected to considerable criticism (Barker and Stanton, 1960; Wipf and Bawden[25], 1969).

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[25] Wipf and Bawden, op. cit., concluded that the supply functions derived from production functions are not empirically relevant when compared with those estimated by regression analysis of time series data.

The supply-response relationships specified on the basis of time-series data have also been criticized because they are based on the past reactions of producers (Cowling and Gardner, 1963). Since the principal objective of this study is to estimate the changes in consumers' surplus and producers' rents that would have occurred in the recent past if controls on open field burning had been imposed, it is in fact an advantage that the supply relationships are based on producers' typical past reactions to changes in relevant variables.

The three hypotheses that underlie the specification presented here are as follows:

First, the producers base their production decisions on previous year's harvest prices (Behrman, 1968). Other things equal, the higher the price received by seed producers in the previous year, the greater the current quantity produced.

Second, the current quantity produced is directly related to time trend. Time trend, here, is assumed to be "a measure of sources of continuous systematic variation for which no data are available" (Foote, 1958, p. 39). These sources may be technological or institutional in nature.

Finally, in response to changed economic conditions producers do not adjust output perfectly in one production period; rather, they make a gradual adjustment to the planned long-run equilibrium level of production.

Following Nerlove (1958b), the most convenient way to handle the imperfect adjustment phenomenon, as well as obtain the basic supply-resource relationships, is to specify (1) the supply-response function in terms of planned long-run equilibrium level of output, and (2) the adjustment function. Stated formally,

$$Q^{P*}_{it} = H_i\ (T,\ P_{i,t-1}) \qquad \text{(c)}$$

where:

Q^{P*}_{it} = planned long-run equilibrium output of the i^{th} grass in Oregon in year t,

T = time trend,

$P_{i,t-1}$ = P_{it} lagged one year,

and:

$$Q^{P}_{it} - Q^{P}_{i,t-1} = \lambda^{P}_{i}\ (Q^{P*}_{it} - Q^{P}_{i,t-1}) \quad 0 < \lambda^{P}_{i} \leq 1 \qquad \text{(d)}$$

where:

λ^{P}_{i} = coefficient (or elasticity if quantities are expressed in logarithms) of adjustment,

Q^{P}_{it} = actual quantity produced in year t,

$Q^{P}_{i,t-1}$ = Q^{P}_{it} lagged one year.

The adjustment function indicates that the actual change in production of a particular seed is some fraction of the difference between the actual production in the previous year and the planned long-run equilibrium level of production. Substituting (c) for Q^{P*}_{it} in (d), one obtains the required equation

$$Q^P_{it} = \lambda^P_i H_i (T, P_{i,t-1}) + (1 - \lambda^P_i) Q^P_{i,t-1} \qquad (3)$$

which enables to estimate short- and long-run price-elasticity of supply-response.[26]

Estimated Demand and Supply Relationships

This section presents and discusses the econometric estimates of demand and supply-response relationships for six major grass seed crops (ryegrass, tall fescue, red fescue, chewings fescue, Merion-Kentucky bluegrass and bentgrass). The analysis did not include orchardgrass because data on Oregon production were available for only 12 years -- too few for a meaningful statistical analysis. The time period of the analysis varies among grass seed crops: 1947-69 for ryegrass, 1956-69 for Merion-Kentucky bluegrass, and 1950-69 for the remaining four crops.

The data on prices, quantities and stocks were obtained from Seed Crops (Annual Summary), statistical Reporting Service, USDA. Agricultural Statistics and Economic Report of the President were the sources of data on the number of cattle and new housing starts, respectively.

[26] Allowing for such an adjustment by including lagged dependent variable, among predetermined variables, may create the problem of autocorrelation. However, recently Tomek (1972) pointed out that autocorrelation could possibly arise from the omission of lagged dependent variables, as well.

Although both additive and multiplicative functional forms were employed to estimate demand and supply-response functions by ordinary least squares (OLS), the two stage least squares (TSLS) was used only in the case of demand functions of the additive type. The results are reported in Tables 3 through 9.

The Demand Relationships

Demand for Current Utilization

Since ryegrass and tall fescue are principally used as livestock forage grasses, the number of cattle in the 12 southern U. S. states and three foreign countries (Canada, West Germany, and France) became the domestic and foreign demand-shift variables, respectively, For the other four grasses which are chiefly used for turf, new housing starts were hypothesized to be responsible for major shifts in demand. However, all of the specified exogenous variables do not appear in the estimated equations reported in Tables 3 through 8. Early regression runs revealed that the number of cattle in the three foreign countries was highly correlated with its domestic equivalent. The transformation of data into logarithmic first differences did not eliminate the problem of multicollinearity, and the foreign demand

Table 3. Estimated demand relationships for ryegrass, 1947-69.

Form and method of estimation	Regression Coefficients for Z_t^d	P_{it}	P_{jt}	Q_{t-1}^d	Q_t^{ca}	Inter-cept	R^2	F-Statistic	Degrees of Freedom	Short-run price Elasticity	Long-run price Elasticity	Durbin Watson Statistic
Demand for Utilization												
O.L.S.	8.7482[a]	-11.5535[a]	0.6154	-0.0461		-49.4281	.9311	60.8040	18	-0.6412		2.0938*
	(5.226)	(5.504)	(0.929)	(0.289)		(1.538)						
O.L.S.		- 6.6883[b]	-0.2035	0.7027[a]		88.4874	.8265	30.1762	19	-0.3712	-1.2486	2.6513**
		(2.302)	(0.205)	(6.508)		(3.124)						
L.L.S	1.9732[a]	- 0.6132[a]	0.0558	0.1386		-0.6408	.9285	58.4714	18	-0.6132	-0.7119	1.9483*
	(4.088)	(4.464)	(0.784)	(0.890)		(1.471)						
L.L.S.		- 0.3830[b]	-0.1369	0.7129[a]		0.9395	.8622	39.7400	19	-0.3830	-1.3341	2.5450**
		(2.262)	(0.147)	(7.849)		(3.462)						
TSLS	10.8006[a]	-17.3563[a]	1.2263[a]	-0.3155[a]		-43.4817	.9771	192.1912	18	-0.9633		2.7137**
	(10.575)	(11.290)	(3.108)	(3.096)		(2.345)						
TSLS		-20.3675[a]	1.0253[b]	0.4277[a]		200.8887	.9593	149.3020	19	-1.1304	-1.9752	2.1193*
		(9.197)	(2.090)	(6.834)		(10.230)						
Demand for Ending Stocks												
O.L.S.		-3.0136[c]			0.2142[a]	22.1242	.7883	37.2448	20	-0.5810		2.1340*
		(1.833)			(4.419)	(1.246)						
L.L.S.		-0.6484[c]			1.1317[a]	-0.4438	.8488	56.2071	20	-0.6484		2.4458*
		(1.977)			(6.083)	(0.713)						
TSLS		-5.8808[d]			0.1524	51.5389	.7708	33.6249	20	-1.1326		1.6872*
		(1.427)			(1.125)	(1.063)						

Note: Figures in parentheses are t-statistic.

P_{jt} = Average price per 100 lbs of timothy seed received by farmers.

a, b, c, and d indicate significance at the 1, 5, 10, and 20 percent levels, respectively.

*Reject the hypothesis that auto-correlation is present at the 95 percent confidence level.

**The Durbin-Watson Statistic is inconclusive.

Table 4. Estimated demand relationships for tall fescue, 1950-69.

Form and method of estimation	Regression Coefficients for Z^d_{tt}	P_{it}	P_{jt}	Q^d_{t-1}	Q^{ca}_t	Intercept	R^2	F-Statistic	Degrees of Freedom	Short-run price Elasticity	Long-run price Elasticity	Durbin Watson Statistic
Demand for Utilization												
O.L.S.	2.9439[b]	-0.0562	-0.7393[d]	0.2913		-44.3839	.8337	17.5418	14	-0.0204	-0.0288	2.2236*
	(2.392)	(0.308)	(1.738)	(1.169)		(1.589)						
O.L.S.	2.3215[c]	-0.0904		0.3969[d]		-42.4295	.7978	19.7247	15	-0.0328	-0.0544	1.8776*
	(1.851)	(0.468)		(1.542)		(1.428)						
L.L.S.	2.5472[d]	-0.1008	-0.2655[d]	0.0865		-1.8565	.8333	17.3636	14	-0.1008	-0.1103	2.1397*
	(3.003)	(0.922)	(1.437)	(0.345)		(2.057)						
L.L.S.	2.2049[b]	-0.1488[d]		0.1316		-1.6973	.8087	21.1154	15	-0.1488	-0.1713	1.6632*
	(2.617)	(1.382)		(0.511		(1.831)						
TSLS	0.5938	-3.2594[d]	0.0691	-0.2746		80.6821	.9289	45.7543	14	-1.1796		2.3766**
	(0.612)	(4.358)	(0.206)	(1.316)		(2.365)						
TSLS	0.6961	-3.1723[a]		-0.2665[d]		77.2443	.9287	66.5882	15	-1.1500		2.4518**
	(0.863)	(5.309)		(1.344)		(2.681)						
Demand for Ending Stocks												
O.L.S.		0.0939			0.3049[a]	-5.1804	.4173	5.7294	16	0.1119		1.0694**
		(0.530)			(3.212)	(0.761)						
L.L.S.		0.2122			0.1858[a]	-2.4111	.5679	10.5063	16	0.2122		1.4255*
		(0.599)			(4.071)	(2.284)						
TSLS		2.4258[a]			0.8866[a]	-70.5516	.7492	23.8948	16	2.8918		2.1447*
		(4.671)			(6.297)	(4.742)						

Note: Figures in parentheses are t-statistic.

P_{jt} = Average price per 100 lbs of orchardgrass received by farmers.

a, b, c, and d indicate significance at the 1, 5, 10, and 20 percent levels respectively.

*Reject the hypothesis that auto-correlation is present at the 95 percent confidence level.

**The Durbin-Watson Statistic is inconclusive.

Table 5. Estimated demand relationships for red fescue, 1950-69.

Form and method of estimation	Regression Coefficients for					Intercept	R^2	F-Statistic	Degrees of Freedom	Short-run price Elasticity	Long-run price Elasticity	Durbin Watson Statistic
	Z_t^d	P_{it}	P_{jt}	Q_{t-1}^d	Q_t^{ca}							
Demand for Utilization												
O.L.S.	2.6589	-0.3844[d]	-0.3562[d]	0.6757[a]		3.3987	.7471	10.3372	14	-0.7605	-2.3450	1.9487*
	(0.447)	(1.508)	(1.385)	(3.772)		(0.330)						
O.L.S.		-0.3882[d]	0.3603[d]	0.6609[a]		7.4485	.7435	14.4897	15	-0.7680	-2.3682	2.0162*
		(1.565)	(1.441)	(3.859)		(1.564)						
L.L.S.		-0.6841[d]	0.7274[d]	0.7187[a]		0.3153	.8662	32.1746	15	-0.6841	-2.4319	2.6670**
		(1.447)	(1.544)	(6.828)		(0.985)						
TSLS	-0.6039	-4.5764[a]	4.3649[a]	-0.0210		31.3637	.9853	235.1980	14	-9.0539		1.1581**
	(0.417)	(16.332)	(16.245)	(0.321)		10.1866)						
TSLS	2.9499	-0.0365		0.6982[a]		22.7394	.7089	12.1779	15	-0.0722	-0.2392	2.0914*
	(0.478)	(0.412)		(3.660)		(0.211)						
Demand for Ending Stocks												
O.L.S.		-0.0839[c]			0.1540[d]	4.8231	.4391	6.2624	16	-0.5298		1.8962*
		(1.697)			(1.356)	(1.462)						
L.L.S.		-0.5239[d]			0.7525[b]	0.4586	.4970	7.9094	16	-0.5239		2.1462*
		(1.396)			(2.094)	(0.515)						
TSLS		-0.0680			0.1769[d]	3.9104	.3997	5.3239	16	-0.4294		1.7345*
		(1.281)			(1.483)	(1.114)						

Note: Figures in parentheses are t-statistic.

P_{jt} = Average price per 100 lbs of chewings fescue received by farmers.

a, b, c, and d indicate significance at the 1, 5, 10, and 20 percent levels, respectively.

*Reject the hypothesis that auto-correlation is present at the 95 percent confidence level.

**The Durbin-Watson statistic is inclusive.

Table 6. Estimated demand relationships for chewings fescue, 1950-69.

Form and method of estimation	Regression Coefficients for Z_t^d	P_{it}	P_{jt}	Q_{t-1}^d	Q_t^{ca}	Intercept	R^2	F-Statistic	Degrees of Freedom	Short-run price Elasticity	Long-run price Elasticity	Durbin Watson Statistic
Demand for Utilization												
O.L.S.	1.2321	-0.2434[b]	0.1436[d]	0.3268[b]		5.5782	.7390	9.9084	14	-1.0572	-1.5704	2.9279**
	(0.536)	(2.237)	(1.422)	(2.145)		(1.627)						
O.L.S.		-0.2398[b]	0.1430[d]	0.3332[b]		7.2219	.7336	13.7698	15	-1.0415	-1.5620	2.9433**
		(2.262)	(1.451)	(2.248)		(4.846)						
L.L.S.	0.1708	-0.9567[d]	0.4614	0.4404[b]		1.1303	.7363	9.7570	14	-0.9567	-1.7096	2.7118**
	(0.274)	(1.433)	(0.719	(2.793)		(3.628)						
L.L.S.		-0.9627[d]	0.4760	0.4403[b]		1.1443	.7349	13.8900	15	-0.9627	-1.7200	2.7223**
		(1.489)	(0.769)	(2.833)		(3.844)						
TSLS	1.7758	-0.6603[a]	0.5195[b]	0.1073		6.8090	.7878	12.9913	14	-2.8679	-3.2126	2.4142**
	(0.850)	(3.061)	(2.655)	(0.629)		(2.167)						
TSLS		-0.6356[a]	0.5010[b]	0.1267		9.0863	.7768	17.4031	15	-2.7606	-3.1611	2.4749*
		(3.002)	(2.601)	(0.756)		(5.583)						
Demand for Ending Stocks												
O.L.S.		0.0156			0.4985[a]	-2.1670	.6256	13.3698	16	0.1367		1.3352**
		(0.377)			(3.012)	(0.769)						
L.L.S.		-0.3499			0.7928[c]	0.1935	.6360	13.9875	16	-0.3499		1.2359**
		(0.916)			(2.015)	(0.215)						
TSLS		-0.0010			0.4418[b]	-1.0972	.6223	13.1818	16	-0.0087		1.2782**
		(0.022)			(2.532)	(0.365)						

Note: Figures in parentheses are t-statistic.

P_{jt} = Average price per 100 lbs of red fescue received by farmers.

a, b, c, and d indicate significance at the 1, 5, 10, and 20 percent levels, respectively.

*Reject the hypothesis that auto-correlation is present at the 95 percent confidence level.

**The Durbin-Watson statistic is inconclusive.

Table 7. Estimated demand relationships for Merion-Kentucky bluegrass, 1956-69.

Form and method of estimation	Regression Coefficients for Z_t^d	P_{it}	P_{jt}	Q_{t-1}^d	Q_t^{ca}	Inter-cept	R^2	F-Statistic	Degrees of Freedom	Short-run price Elasti-city	Long-run price Elasti-city	Durbin Watson Statis-tic
Demand for Utilization												
O.L.S.	2.4989[c] (2.070)	-0.0335[a] (4.502)	0.0390[d] (1.656)	0.2652[c] (1.915)		0.9127 (0.628)	.8870	17.6527	9	-0.8523	-1.1600	2.0916*
O.L.S.	3.5403[b] (2.919)	-0.0424[a] (6.475)	0.0507[c] (1.981)			0.7409 (0.454)	.8410	17.6040	10	-1.0788	-1.1360	1.4788**
L.L.S.	0.8754 (1.231)	-0.6799[b] (2.288)	0.1678 (0.722)	0.3312[c] (2.198)		1.2831 (3.351)	.8118	9.7039	9	-0.6797	-1.0163	2.8123**
TSLS	3.0925[b] (3.038)	-0.0449[a] (5.880)	0.0622[b] (2.898)	0.1333 (1.063)		0.8712 (0.731)	.9241	27.4052	9	-1.1424	-1.3181	2.9287**
Demand for Ending Stocks												
O.L.S.		-0.0251 (0.361)			0.4456[a] (4.489)	-0.2839 (0.264)	.8755	38.68	11	-1.1875		2.3606*
L.L.S.		-0.0519 (0.155)			1.2680[a] (4.404)	-0.5782 (0.717)	.8456	49.5247	11	-0.0519		2.6865**
TSLS		-0.0138[d] (4.692)			0.3110[b] (2.857)	1.3887 (1.121)	.9001		11	-0.6529		2.5407*

Note: Figures in parentheses are t-statistic

P_{jt} = Average price per 100 lbs of chewings fescue received by farmers.

a, b, c, and d indicate significance at the 1, 5, 10, and 20 percent levels, respectively.

*Reject the hypothesis that auto-correlation is present at the 95 percent confidence level.

**The Durbin-Watson statistic is inconclusive.

Table 8. Estimated demand relationships for bentgrass, 1950-69.

Form and method of estimation	Regression Coefficients for Z^d_t	P_{it}	P_{jt}	Q^d_{t-1}	Q^{ca}_t	Inter-cept	R^2	F-Statistic	Degrees of Freedom	Short-run price Elasti-city	Long-run price Elasti-city	Durbin Watson Statis-tic
Demand for Utilization												
O.L.S.	1.1803	-0.0689[b]	0.0191	0.5523[a]		3.2961	.8196	15.8996	14	-0.4675	-1.0513	2.0241*
	(0.549)	(2.433)	(0.758)	(3.826)		(1.065)						
O.L.S.		-0.0621[b]	0.0168	0.5589[a]		4.7539	.8157	22.1292	15	-0.4213	-0/9551	2.0050*
		(2.497)	(0.690)	(3.978)		(3.060)						
L.L.S.	0.3131	-0.3692[b]	0.0094	0.6663[a]		0.7836	.8943	29.6800	14	-0.3692	-1.1064	1.7170*
	(0.629)	(2.099)	(0.085)	(5.689)		(2.313)						
L.L.S.	0.3134	-0.3669[b]		0.6633[a]		0.7957	.8944	41.0833	15	-0.3669	-1.0865	1.6841**
	(0.651)	(2.183)		(6.141)		(2.679)						
TSLS	5.1896[a]	-0.1899[a]	0.0774[a]	0.2283[b]		2.5263	.9525	70.1454	14	-1.2884	01.6696	2.3020*
	(4.068)	(7.850)	(4.852)	(2.525)		(1.586)						
Demand for Ending Stocks												
O.L.S.		0.0141			0.3266[a]	-1.0101	.6105	12.5301	16	0.0274		0.9281**
		(0.896)			(3.779)	(.793)						
L.L.S.		0.2759			1.0658[a]	-1.0683	.6394	13.5819	16	0.5356		1.0284**
		(0.917)			(4.021)	(1.586)						
TSLS		0.0418[a]			0.4451[c]	-3.0931	.6587	14.2166	16	0.0811		0.8482**
		(3.965)			(1.785)	(1.704)						

Note: Figures in parentheses are t-statistic.

P_{jt} = Average price per 100 lbs of chewings fescue received by farmers.

a, b, and c, indicate significance at the 1, 5, and 10 percent levels, respectively.

*Reject the hypothesis that auto-correlation is present at the 95 percent confidence level.

**The Durbin-Watson statistic is inconclusive.

shift-variable was deleted from the analysis.[27] Certain other exogenous variables were also deleted from some equations. In each instance, either the regression coefficient was not significantly different from zero, or else the problem of multicollinearity required the deletion.

Nonetheless, with the exception of tall fescue, the model performed reasonably well, and the results are consistent with the theoretical expectations. For most seeds, TSLS performed rather better than OLS when judged by conventional statistical tests. However, in the case of red fescue (see Table 5), TSLS increased the significance of the own-price and price-of-substitute regression coefficients but resulted in a clearly unrealistic short-run price elasticity of demand.[28] Consequently, a priori reasoning and knowledge of the price elasticities for other seeds suggested that the TSLS red fescue regression coefficients are unreliable.

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[27] To eliminate multicollinearity by logarithmic first differences see Kane (1968).

The deletion of this variable because of multicollinearity might have introduced specification bias into the model. Later in this study, because of the same problem certain other variables are also deleted from some of the equations. To correct for multicollinearity econometricians also suggest to use a priori coefficient for one variable as a means of developing an accurate estimate of the coefficient for another variable. However, Rama Sastry (1969) has pointed out some of the difficulties raised by this method as well.

[28] Data for current utilization of red fescue included imports as well.

Typically, the regression coefficients of the lagged dependent variables have the anticipated signs and are statistically significant at the ten percent level or better. Therefore, the results generally support the hypothesis that the adjustment to the long-run equilibrium quantity utilized involves a significant distributed lag effect. It should be noted, however, that in certain cases specification changes not only resulted in a statistically insignificant coefficient of the lagged dependent variable but also changed its sign (see Table 5). This implies that, in certain cases, the conclusion about the existence of lagged response with respect to change in price and other variables depends upon the specification employed.[29]

In the case of ryegrass, because of high correlation between the demand shifter and the lagged dependent vairable, experimentation by deleting each variable one at a time, was undertaken. However, the results reported in Table 3 only indicate the deletion of the shift variable. In contrast, the demand shifters are not statistically significant for red- and chewings- fescues (see Tables 5 and 6).

Prices of several substitute seeds were included in initial regression runs for each of the six grass seeds. However, the estimates presented here include only those substitute-seed prices which provided

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[29] This result lends support to Tomek's finding with respect to cotton acreage supply-response functions. He observed that by changing the method of allowing for shifts in supply, the results did not support the hypothesis of lagged responses (1972).

the best statistical results. As Table 4 indicates, in the case of tall fescue, all substitute seed prices proved to have the unexpected sign or to be statistically insignificant. In contrast, the regression coefficients for substitute seed prices in other regressions do have the expected sign and are significant at a probability level of at least 20 percent.

With the single exception of tall fescue, estimated own-price regression coefficients have the expected signs and are significant at the 20 or better percent level. Although the tall fescue results are disappointing, they are relatively easy to explain. Tall fescue is an important export crop, but there are no data on exports prior to 1966. Therefore, the inclusion of exports in the current domestic utilization may be the reason for the insignificant own-price regression coefficients when estimated by OLS and LLS (logarithmic least squares). Interestingly, estimation of the tall fescue demand function by TSLS did result in a significant own-price regression coefficient, but this strong result is negated by the unexpected sign for the coefficient of the lagged dependent variable.

As one would expect, estimated short- and long-run price elasticities of demand vary with the assumed functional form, estimation method, and among grass seed types. When estimated at the mean, short-run price elasticities range from -0.37 to -2.87, and long-run elasticities vary from -0.71 to -3.21.[30] However, with the exception of TSLS estimations of chewings fescue demand relationships (see Table 6) the estimated short- and long-run price elasticities of demand for grass seeds are less than -1.30 and -2.50, respectively.

The best estimates of short- and long-run price elasticities of demand for five of the six seed crops are as follows:

Seed Type	Price Elasticity Short-run	Price Elasticity Long-run
Ryegrass	-1.13	-1.98
Red Fescue	-0.77	-2.37
Chewings Fescue	-1.06	-1.57
Merion-Kentucky Bluegrass	-1.14	-1.32
Bentgrass	-1.29	-1.67

As indicated previously, the model is unable to estimate a satisfactory demand function for tall fescue.

Demand for Ending Stocks

Although the empirical results for demands for ending stocks are less robust than those obtained for utilization demands (compare lower and upper halves of Tables 3 through 8), none of the major hypotheses were generally rejected. Theoretical considerations

[30] The range of elasticity estimates reported in the text does not encompass estimates derived from statistically insignificant regression coefficients.

suggested that, other things equal, demands for ending stocks would vary directly with total commercial availability (current production plus beginning stocks) and inversely with current price.

For all grasses, the regression coefficients for total commercial availability have the expected positive signs and are significantly different from zero at the 20 or better percent level. In contrast, however, only four grass seeds (ryegrass, red fescue, chewings fescue, and Merion-Kentucky bluegrass) have own-price regression coefficients with the anticipated negative signs. Tall fescue and bentgrass both have unexpected positively-signed own-price regression coefficients, but these coefficients are statistically insignificant except when estimated by TSLS. Even a diligent search did not reveal the cause(s) of these peculiar findings for tall fescue and bentgrass.

For the grasses with properly signed price-regression coefficients, estimated price elasticities of demand for ending stocks vary from -0. 52 to -1. 13.[31] The best estimates for the four individual grasses are as follows:

Seed Type	Elasticity
Ryegrass	-0. 65
Red Fescue	-0. 53
Chewings Fescue	-0. 35
Merion-Kentucky Bluegrass	-0. 65

[31]This range of elasticity estimates does not include estimates derived from statistically insignificant regression coefficients.

The Supply-Response Relationships

Estimated Supply-Response Functions

Table 9 reports the estimated supply-response relationships for the six grass seed types under investigation here. With the exception of chewings fescue, the model performed reasonably well when evaluated by the usual statistical tests, and both OLS and LLS regression estimates are rather similar. In the case of chewings fescue, five of six estimated regression coefficients have the expected signs, but none are significantly different from zero. For the other five grasses, however, all but two estimated regression coefficients have the expected positive signs and are significant at the five percent level; only the trend regression coefficient for Merion-Kentucky bluegrass and the coefficient of lagged dependent variable for bentgrass are not statistically significant.[32] Thus, none of the basic hypotheses concerning grass seed producers supply-response can be rejected on the basis of results reported in Table 9.

Excluding estimates based on statistically insignificant regression coefficients, the estimated short-run price elasticities of supply-response range from 0.24 for bentgrass to 0.70 for ryegrass, whereas long-run elasticities vary from 0.66 for bentgrass to 2.04 in the case of Merion-Kentucky bluegrass.

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[32] Problem of multicollinearity required the deletion of the trend variable from the estimated equations for red fescue and bentgrass.

Table 9. Estimated supply response relations for selected grass seed crops.

Type of grass seed	Form and method of estimation	Regression Coefficients for T	$P_{i,t-1}$	$Q_{i,t-1}$	Intercept	R^2	F-Statistic	Degrees of Freedom	Short-run price Elasticity	Long-run price Elasticity	Durbin Watson Statistic
Ryegrass	O.L.S.	4.3355[a] (3.310)	9.4672[b] (2.563)	0.4455[b] (2.091)	-245.3570	.7890	41.6731	19	0.5245	0.9459	2.0758*
	L.L.S.	1.9667[a] (2.976)	0.7028[a] (3.424)	0.6148[a] (3.351)	-3.2355	.8494	11.2305	19	0.7028	1.8245	1.9004*
Tall Fescue	O.L.S.	0.3234[a] (4.655)	0.1693[a] (4.557)	0.6233[a] (5.635)	-19.4357	.8930	41.7161	15	0.4079	1.0828	2.1602*
	L.L.S.	3.0576[a] (3.988)	0.6092[a] (4.002)	0.6582[a] (5.548)	-5.8607	.8462	27.4995	15	0.6092	1.7823	2.6909**
Red Fescue	O.L.S.		0.0242 (0.962)	0.8954[a] (5.476)	-0.0511 (0.038)	.7045	19.0690	16	0.1774	1.6960	2.6978**
	L.L.S.		0.3075 (1.237)	0.8365[a] (5.071)	-0.3180 (0.745)	.6695	17.6584	16	0.3075	1.8807	2.8287**
Chewings Fescue	O.L.S.	0.0528 (0.580)	-0.0180 (0.310)	0.2683 (0.801)	2.4719 (0.344)	.2361	1.6487	16	-0.0744		2.4002*
	L.L.S.	1.0001 (1.087)	0.0233 (1.049)	0.3442 (0.084)	-1.2720 (0.722)	.3047	2.3367	16	0.0233	0.0355	2.4961*
Merion-Kentucky Bluegrass	O.L.S.	0.0361 (0.312)	0.0059 (0.544)	0.6438 (0.725)	-2.2675	.3710	1.9662	10	0.3787	1.0632	2.0674*
	L.L.S.	2.1467 (1.143)	0.6317[b] (2.180)	0.6902[b] (2.239)	-5.0107	.5339	3.8178	10	0.6317	2.0390	2.3250*
Bentgrass	O.L.S.		0.0188 (0.738)	0.8092[a] (4.449)	0.6093 (0.312)	.6583	15.4133	16	0.1265	0.6630	2.3454*
	L.L.S.		0.2364[d] (1.567)	0.8460[a] (7.110)	-0.2307 (0.754)	.8200	36.4598	16	0.2364	1.5351	2.5363**

Note: Figures in parentheses are t-statistic.

a, b, and d indicate significance at the 1, 5, and 20 percent levels, respectively.

*Reject the hypothesis that auto-correlation is present at the 95 percent confidence level.

**The Durbin-Watson statistic is inconclusive.

The best estimates of short- and long-run price elasticities for the five seeds are as follows:

Seed Type	Elasticity	
	Short-run	Long-run
Ryegrass	0.70	1.82
Tall Fescue	0.61	1.78
Red Fescue	0.31	1.88
Merion-Kentucky Bluegrass	0.63	2.04
Bentgrass	0.24	1.54

Except for bluegrass, long-run elasticities of all grass seeds are less than 1.90. These rather low long-run price-elasticity estimates are consistent with independent evidence that alternative crops or land uses to grass seed production in the Willamette Valley are limited.[33]

Calculated Demand and Supply Equations

Tables 10 and 11 present the linear demand and supply equations that are employed in Chapter IV to estimate the changes in output, prices, consumers' surplus, and producers' rents associated with alternative open field burning control policies. Except for non-Oregon supply, each demand and Oregon-supply equation is calculated to

[33] For evidence concerning the limited alternatives available to farmers now raising grass seeds, see Conklin and Bradshaw (1971).

Table 10. Linear demand functions for the 1965-69 period, by seed type.

Seed Type	Average Prices and Quantites, 1965-69									
		Quantities-Demanded			Own-Price-Elasticities			Demand Function Equations		
	Prices (per 100 lbs)	Aggregate (million lbs)	Utili-zation (million lbs)	Ending Stocks (million lbs)	Aggre-gate	Utili-zation	Ending Stocks	Aggregate	Utilization	Ending Stocks
Ryegrass	6.86	164.289	158.585	5.704	-1.94	-1.98	-0.65	P= 10.4074-0.0216Q	P= 10.3247-0.0216Q	P=17.4140-0.2706Q
Tall fescue	12.08	74.743	60.040	14.703	-1.49	-1.85	0	P= 20.2085-0.1088Q	P= 18.6098-0.1088Q	Q^{es}=14.703
Red fescue	26.50	26.164	20.094	6.070	-1.94	-2.37	-0.53	P= 40.1375-0.5212Q	P= 37.6812-0.5565Q	P=76.5000-8.2372Q
Chewings fescue	26.70	11.760	9.235	2.525	-1.53	-1.57	-0.35	P= 48.3591-1.8416Q	P= 43.7090-1.8416Q	Q^{es}=2.525
Merion-Kentucky Bluegrass	68.90	7.262	4.512	2.750	-1.07	-1.32	-0.65	P=133.4991-8.8968Q	P=121.1551-11.5741Q	P=175.1931-38.6100Q
Bentgrass	37.70	9.962	7.444	2.518	-1.25	-1.67	0	P= 67.9208-3.0331Q	P= 60.25113-3.0331Q	Q^{es}=2.518

Note: Functions are calculated according to procedure described in text.

Table 11. Linear supply functions for the 1965-69 period, by seed type.

Seed Type	Prices (per 100 lbs)	Quantities-Supplied: Aggregate (million lbs)	Quantities-Supplied: Oregon (million lbs)	Quantities-Supplied: Non-Oregon (million lbs)	Price-Elasticities: Aggregate	Price-Elasticities: Oregon	Price-Elasticities: Non-Oregon	Supply Function Equations: Aggregate	Supply Function Equations: Oregon	Supply Function Equations: Non-Oregon
Ryegrass	6.86	164.289	158.585		1.73	1.82		P= 2.9044+0.0241Q	P= 3.0908+.0238Q	
Tall fescue	12.08	74.743	10.248	49.793	1.48	1.78	1.86	P= 3.9195+0.1091Q	P= 5.2933+0.6622Q	P= 5.5700+0.1307Q
Red fescue	26.50	26.164	6.724	13.370	1.10	1.88	1.45	P= 2.4316+0.9200Q	P=12.4048+2.0964Q	P= 8.2202+1.3672Q
Chewings fescue	26.70	11.760	6.800	2.435	1.35	1.75	1.44	P= 6.9446+1.6798Q	P=12.0302+2.1575Q	P= 8.2178+7.5873Q
M K blue grass	68.90	7.262	1.760	2.752	0.70	2.04	1.18	P=-30.1719+13.6426Q	P=35.1324+19.1939Q	P=10.5202+21.2314Q
Bentgrass	37.70	9.962	7.048	0.396	1.15	1.54	1.63	P= 5.0367+3.2787Q	P=13.2195+3.4734Q	P=14.5205+58.4795Q

Note: Functions are calculated according to procedure described in text.

satisfy two conditions:[34] (1) it passes through 1965-69 average prices and quantities with (2) a price elasticity at that point equal to the best long-run elasticity estimate for that seed type.[35] A hypothetical non-Oregon supply equation for each grass seed was calculated assuming that its intercept is equal to the average variable costs for high-cost Willamette Valley producers.[36]

Finally, it should be noted that the aggregate demand and supply equations, in fact, have kinks which are not shown in the tables. These equations are used only to obtain predicted prices and quantities, and the kinks do not affect the analysis.

[34] For an illustration of the method employed to calculate these equations, see Edwards (1972).

[35] The tall fescue demand equation, and the chewings fescue supply equation were calculated assuming elasticities equal to 1.85, and 1.75, respectively.

[36] This assumption seems quite appropriate. Because of Oregon's comparative advantage, the costs of grass seed production in other regions are higher.

The estimates of the average variable costs for high-cost Willamette Valley producers were obtained from Fisher (1972).

IV. ESTIMATED CHANGES IN CONSUMERS' SURPLUS AND PRODUCERS' RENTS

This chapter describes alternative policies to control pollution from open field burning in the Willamette Valley. A discussion of various supply situations and assumptions made to estimate changes in consumers' surplus and producers' rents is also included. Changes in consumers' surplus and producers' rents are estimated on the basis of the model specified in Chapter II. The presentation and discussion of results concludes the chapter.

Alternative Pollution Control Policies

Three alternative pollution control policies are postulated in this study:

A. A complete ban on open burning.

B. Open burning permitted once in three years.

C. Alternate year burning.

These policies would reduce total acres burned per season by 100, 67, and 50 percent, respectively, and each would improve seasonal visibility in the Willamette Valley to a different degree. Policy A postulates that grass seed producers have no right to pollute air, whereas policies B and C assume that they have some right to pollute air.

By totally or partially restricting open field burning, each of the above policies would increase costs of grass seed production regardless of the alternative residue removal technique and disease control measures adopted by the grass seed producers (see Table 2).[37]

With the advent of controls on open field burning, Oregon producers would adopt new methods to dispose of harvest residues. One method would employ the mobile field sanitizer.[38] The sanitizer would produce the same beneficial effects as open field burning and reduce smoke and unburned hydrocarbon emissions by about 90 and 99 percent, respectively (Conklin and Bradshaw, 1971).

Although an effective mobile field sanitizer is expected to increase costs of grass seed production by about $9.00 per acre, the sanitizer is economically attractive when compared with other alternatives.[39] Therefore, it is assumed that controls on open burning would induce Oregon seed producers to adopt sanitizers to dispose of

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[37] It is assumed that overall efficiency in the Oregon grass seed industry is not affected by the "pressure" that various pollution control policies would place on the industry. Such policies would be expected to induce rationalization of industry organization, and the costs of grass seed production may not in fact increase by the full amount of additional costs imposed by control policies.

[38] Mobile field sanitizer is a mechanical device developed by the Department of Agricultural Engineering, Oregon State University. This device is designed for controlled burning of all harvest residue in its path within a self-sustaining combustion chamber.

[39] ibid., p. 13-4.

harvest residues. However, since the sanitizer is not yet commercially available, the expected $9.00 per acre cost increase is based on limited experimentation with a prototype sanitizer. Therefore, alternate estimates of changes in consumers' surplus and producers' rents are developed assuming the increase in costs associated with the sanitizer equal $5.00, $9.00, and $13.00 per acre.[40]

Supply Situations

The changes in consumers' surplus and producers' rents for each policy under alternative cost increases are estimated assuming three different supply situations. This procedure seemed appropriate because (1) the effects of a given cost increase associated with a control policy are sensitive to assumptions concerning the elasticity of relevant supply curves, and (2) the available information on non-Oregon supply curves is very limited.

The three supply situations postulated in this study are depicted in Figures 3 through 5 in Chapter II and may be described as follows:

I. Normal Supply Situation: Positively-sloped Oregon and non-Oregon supply curves. This supply situation assumes "normal" reaction by Oregon producers to cost increases, and a "well" functioning market mechanism.

[40] These cost figures are employed at the suggestion of Dr. Frank S. Conklin who has expended considerable effort to develop realistic cost estimates for the sanitizer.

II. Polar Supply Situation (1): Perfectly inelastic Oregon supply curve, and positively sloped non-Oregon supply curve. This situation assumes that no alternatives to grass seed production exist in Oregon, and all cost increases would be "absorbed" by the owners of specialized resources.

III. Polar Supply Situation (2); Perfectly elastic non-Oregon supply curve, and positively-sloped Oregon supply curve. Since Oregon is the major grass seed producing area in the United States, this situation is patently unrealistic. This situation is postulated, nonetheless, because it establishes the maximum potential loss in Oregon producers' rents.

The supply and demand curves employed to predict the effects of alternative control policies on consumers' surplus and producers' rents were calculated in Chapter III (see Tables 10 and 11). These curves were based on (a) long-run price elasticity estimates, and (b) 1965-69 average prices and quantities at the farm level for each major seed type raised in Oregon. Therefore, the estimated changes in consumers' surplus and producers' rents represent changes that would have occurred if Oregon's grass seed industry had adjusted to the open field burning control policies in the late sixties.[41]

[41] For the purpose of computing changes in producers' rents in Oregon, average variable cost estimates were obtained from Fisher (1972).

Assumptions

To estimate changes in consumers' surplus, and Oregon and non-Oregon producers' rents, the following assumptions are made:

1. Each consumer has zero income elasticity of demand for grass seeds and the estimated demand curves coincide with the aggregate compensated demand curves.
2. Changes in area under the derived demand curves for forage grasses are approximately equal to changes in "true" consumers' surplus.[42]
3. The models of demand and supply for all the grass seeds are in equilibrium at 1965-69 average prices and quantities. This assumption is required because supply curves were calculated from elasticities derived from the coefficients of lagged prices and, therefore, would otherwise embody a cobweb relationship.
4. The cost increases associated with the adoption of mobile field sanitizers result in a parallel upward shift in average variable costs of seed production in Oregon and aggregate Oregon supply curve.

[42] Referring to the case of an intermediate good (input), Schmalensee (1971) pointed out that (1) for a small change in its price, and (2) if this good is purchased by perfectly competitive industries, the area under the derived demand curve approximately equals the "true" consumers' surplus. He further indicated that if the input-output ratio is technically fixed then the surplus estimated from a derived demand curve is the same as the "true" consumers' surplus.

5. The mobile field sanitizer has the same beneficial effects with respect to harvest residue disposal and disease control as open field burning and does not affect the seed yields.[43]

6. No economic use exists for grass straw.[44]

Results

The estimated changes in consumers' surplus, and Oregon and non-Oregon producers' rents are presented in Tables 12 through 15.[45] These results suggest the following observations.

1. Among all grass seeds, the absolute and relative decrease in consumers' surplus for ryegrass is largest under each policy. The reason for this is that the model allowed for the existence and elasticity of non-Oregon supplies except in the case of

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[43] Dr. David Chilcote of the Department of Agronomic Crop Sciences has some limited and very tentative evidence that the sanitizer may conceivably increase the yields by producing more uniform burn than open burning. If further research establishes this to be true, the estimates presented here would have upward bias.

[44] Economic and technical feasibility studies are being conducted to determine prospects for the use of straw as livestock feed, in making paper, fiberboard, prestologs, etc. If future research developments make some economic use of straw possible, then the results would overstate actual observed changes in surpluses and rents.

[45] These tables report only changes in consumers' surplus and producers' rents. See Appendix A for predicted prices, outputs, average variable costs, consumers' surplus and producers' rents by seed type, policy, supply situation, and cost per acre for the mobile field sanitizer under each policy for the three postulated supply situations.

Table 12. Estimated changes in consumers' surplus, Oregon and non-Oregon rents, by seed type, supply situation, control policy, and mobile sanitizer cost per acre (in dollars)

Seed Type and Supply Situation	Open Field Burning Control Policies and Mobile Sanitizer Cost per Acre								
	Ban on Open Burning			Once in Three Years Burning			Alternate Year Burning		
	$5	$9	$13	$5	$9	$13	$5	$9	$13
Ryegrass									
I. Consumers' Surplus	- 315,227	- 552,229	- 777,986	-213,046	- 375,484	- 532,917	-161,236	- 284,724	- 405,389
Oregon Rents	- 704,369	-1,243,857	-1,757,380	-477,578	- 841,604	-1,199,814	-354,266	- 635,131	- 909,515
Sum	-1,019,588	-1,796,086	-2,535,366	-690,628	-1,217,088	-1,732,731	-515,502	- 919,855	-1,514,904
II. Oregon Rents	- 656,383	-1,181,363	-1,706,438	-437,584	- 787,565	-1,137,625	-328,192	- 590,682	- 853,219
III. Oregon Rents	-1,319,285	-2,264,844	-3,104,929	-903,641	-1,563,869	-2,188,723	-682,206	-1,194,686	-1,683,997
Tall Fescue									
I. Consumers' Surplus	-214,336	-381,887	-544,252	-143,029	-256,700	-368,095	-107,040	-193,041	-277,744
Oregon Rents	- 63,059	-110,823	-156,895	- 42,647	- 75,158	-106,907	- 32,343	- 56,969	- 81,165
Non-Oregon Rents	+148,336	+273,301	+402,530	+ 97,525	+179,172	+262,726	+ 72,393	+133,004	+194,699
Sum	-129,059	-219,409	-298,617	- 88,151	-152,679	-212,276	- 66,990	-117,006	-164,210
II. Oregon Rents	- 60,566	-109,020	-157,475	- 40,377	- 72,680	-104,984	- 30,283	- 54,510	- 78,737
III. Oregon Rents	- 96,408	-211,000	-293,794	- 82,104	-133,723	-203,775	- 62,005	-109,742	-155,791
Red Fescue									
I. Consumers' Surplus	- 83,745	-149,086	-213,146	- 56,141	-100,199	-143,689	- 42,253	- 75,483	-108,394
Oregon Rents	- 90,170	-160,538	-228,714	- 60,566	-108,110	-154,772	- 45,511	- 81,467	-116,909
Non-Oregon Rents	+ 43,751	+ 79,112	+114,990	+ 29,112	+ 52,522	+ 76,139	+ 21,848	+ 39,324	+ 56,933
Sum	-130,164	-230,512	-326,870	- 87,595	-155,787	-222,322	- 65,916	-117,626	-168,370
II. Oregon Rents	- 60,039	-108,064	-156,092	- 40,012	- 72,043	-104,062	- 30,019	- 54,032	- 78,046
III. Oregon Rents	-140,487	-247,297	-349,243	- 94,536	-167,649	-238,581	- 71,244	-126,788	-181,098
Chewings Fescue									
I. Consumers' Surplus	- 54,269	- 96,869	-138,712	- 36,280	- 64,987	- 93,346	- 27,249	- 48,881	- 70,324
Oregon Rents	- 67,564	-120,359	-172,043	- 45,249	- 80,851	-115,952	- 34,020	- 60,879	- 87,488
Non-Oregon Rents	+ 11,613	+ 21,040	+ 30,644	+ 7,742	+ 13,959	+ 20,248	+ 5,824	+ 10,452	+ 15,127
Sum	-110,220	-196,188	-280,111	- 73,787	-131,879	-161,193	- 55,445	- 99,308	-142,685
II. Oregon Rents	- 60,712	-109,286	-157,857	- 40,546	- 72,857	-105,238	- 30,349	- 54,643	- 78,928
III. Oregon Rents	-105,171	-246,053	-347,686	- 93,989	-166,729	-237,369	- 70,839	-126,079	-180,137
Merion-Kentucky Bluegrass									
I. Consumers' Surplus	- 22,975	- 41,286	- 59,555	- 15,316	- 27,316	-139,788	- 11,463	- 20,670	- 29,854
Oregon Rents	- 24,749	- 43,787	- 62,670	- 16,843	- 29,193	- 42,201	- 12,762	- 22,318	- 31,889
Non-Oregon Rents	+ 7,936	+ 14,985	+ 22,036	+ 5,005	+ 9,693	+ 14,396	+ 3,541	+ 7,055	+ 10,574
Sum	- 39,788	- 70,088	-100,189	- 23,069	- 47,051	- 67,593	- 20,682	- 35,933	- 51,179
II. Oregon Rents	- 22,159	- 39,884	- 57,610	- 14,773	- 26,589	- 38,407	- 11,080	- 19,942	- 28,805
III. Oregon Rents	- 40,036	- 71,173	-101,938	- 23,076	- 47,473	- 93,782	- 20,317	- 36,105	- 51,725
Bentgrass									
I. Consumers' Surplus	- 70,163	-125,173	-178,984	- 46,958	- 84,014	-120,577	- 35,279	- 63,215	- 90,885
Oregon Rents	-114,057	-203,063	-289,895	- 76,286	-136,501	-195,719	- 57,269	-102,783	-147,691
Non-Oregon Rents	+ 2,938	+ 5,277	+ 7,709	+ 1,968	+ 3,518	+ 5,093	+ 1,492	+ 2,649	+ 3,821
Sum	-181,240	-322,899	-461,170	-121,276	-216,997	-311,203	- 91,056	-163,349	-234,755
II. Oregon Rents	-104,571	-188,225	-271,881	- 69,714	-125,484	-181,254	- 52,286	- 94,113	-135,940
III. Oregon Rents	-217,100	-381,634	-538,059	-146,141	-258,987	-368,252	-110,133	-195,964	-279,766

Source: Appendix A

Table 13. Estimated percentage changes in consumers' surplus, Oregon and non-Oregon rents, by seed type, supply situation, control policy, and mobile sanitizer cost per acre (in percent)

Seed Type and Supply Situation	Open Field Burning Control Policies and Mobile Sanitizer Cost per Acre								
	Ban on Open Burning			Once in Three Years Burning			Alternate Year Burning		
	$5	$9	$13	$5	$9	$13	$5	$9	$13
Ryegrass									
I. Consumers' Surplus	-10.82	-18.95	-26.70	- 7.31	-12.89	-18.29	- 5.53	- 9.77	-13.91
Oregon Rents	-10.63	-18.76	-26.51	- 7.20	-12.70	-18.10	- 5.34	- 9.58	-13.72
Sum	-10.68	-18.82	-26.57	- 7.24	-12.75	-18.16	- 5.40	- 9.64	-15.87
II. Oregon Rents	- 9.90	-17.82	-25.74	- 6.60	-11.88	-17.16	- 4.95	- 8.91	-12.87
III. Oregon Rents	-19.90	-34.17	-46.84	-13.63	-23.59	-33.02	-10.29	-18.02	-25.40
Tall Fescue									
I. Consumers' Surplus	- 7.06	-12.57	-17.92	- 4.71	- 8.45	-12.12	- 3.52	- 6.35	- 9.14
Oregon Rents	- 8.30	-14.59	-20.65	- 5.62	- 9.90	-14.08	- 4.26	- 7.50	-10.69
Non-Oregon Rents	+ 9.15	+16.86	+24.84	+ 6.02	+11.15	+16.21	+ 4.47	+ 8.21	+12.01
Sum	- 2.39	- 4.05	- 5.51	- 1.63	- 2.82	- 3.92	- 1.24	- 2.16	- 3.03
II. Oregon Rents	- 7.97	-14.35	-20.73	- 5.32	- 9.57	-13.82	- 3.99	- 7.18	-10.37
III. Oregon Rents	-12.69	-27.78	-38.68	-10.81	-18.13	-26.83	- 8.16	-14.45	-20.51
Red Fescue									
I. Consumers' Surplus	- 4.69	- 8.36	-11.95	- 3.15	- 5.62	- 8.05	- 2.37	- 4.23	- 6.08
Oregon Rents	- 6.79	-12.09	-17.22	- 4.56	- 8.14	-11.65	- 3.43	- 6.13	- 8.80
Non-Oregon Rents	+ 3.58	+ 6.47	+ 9.41	+ 2.38	+ 4.30	+ 6.23	+ 1.79	+ 3.22	+ 4.66
Sum	- 3.00	- 5.32	- 7.54	- 2.02	- 3.59	- 5.13	- 1.52	- 2.71	- 3.88
II. Oregon Rents	- 4.52	- 8.14	-11.75	- 3.01	- 5.42	- 7.83	- 2.26	- 4.07	- 5.88
III. Oregon Rents	-10.58	-18.62	-26.29	- 7.12	-12.62	-17.96	- 5.36	- 9.54	-13.63
Chewings Fescue									
I. Consumers' Surplus	- 4.26	- 7.61	-10.89	- 2.85	- 5.10	- 7.33	- 2.14	- 3.84	- 5.52
Oregon Rents	- 4.97	- 8.87	-12.68	- 3.33	- 5.96	- 8.54	- 2.51	- 4.49	- 6.45
Non-Oregon Rents	+ 5.16	+ 9.35	+13.62	+ 3.44	+ 6.20	+ 9.00	+ 2.59	+ 4.64	+ 6.72
Sum	- 3.86	- 6.87	- 9.81	- 2.58	- 4.62	- 5.64	- 1.94	- 3.48	- 5.00
II. Oregon Rents	- 4.47	- 8.05	-11.63	- 2.99	- 5.37	- 7.76	- 2.24	- 4.03	- 5.82
III. Oregon Rents	- 7.75	-18.13	-25.62	- 6.93	-12.29	-17.49	- 5.22	- 9.29	-13.27
Merion-Kentucky Bluegrass									
I. Consumers' Surplus	- 1.00	- 1.76	- 2.54	- 0.65	- 1.18	- 1.70	- 0.49	- 0.88	- 1.27
Oregon Rents	- 2.29	- 4.05	- 5.80	- 1.56	- 2.70	- 3.91	- 1.18	- 2.07	- 2.95
Non-Oregon Rents	+ 1.00	+ 1.87	+ 2.74	+ 0.62	+ 1.21	+ 1.79	+ 0.44	+ 0.88	+ 1.32
Sum	- 0.94	- 1.66	- 2.37	- 0.55	- 1.11	- 1.60	- 0.49	- 0.85	- 1.21
II. Oregon Rents	- 2.05	- 3.69	- 5.33	- 1.37	- 2.46	- 3.56	- 1.03	- 1.85	- 2.67
III. Oregon Rents	- 3.71	- 6.59	- 9.44	- 2.14	- 4.39	- 8.68	- 1.88	- 3.34	- 4.79
Bentgrass									
I. Consumers' Surplus	- 4.66	- 8.32	-11.89	- 3.12	- 5.58	- 8.01	- 2.34	- 4.20	6.04
Oregon Rents	- 5.82	-10.35	-14.78	- 3.89	- 6.96	- 9.98	- 2.92	- 5.24	7.53
Non-Oregon Rents	+ 6.40	+11.50	+16.80	+ 4.29	+ 7.67	+11.10	+ 3.25	+ 5.77	+ 8.33
Sum	- 5.16	- 9.19	-13.13	- 3.45	- 6.18	- 8.86	- 2.59	- 4.65	6.68
II. Oregon Rents	- 5.33	- 9.60	-13.86	- 3.55	- 6.40	- 9.24	- 2.67	- 4.80	6.93
III. Oregon Rents	-11.07	-19.46	-27.44	- 7.45	-13.21	-18.78	- 5.62	- 9.99	14.27

Source: Appendix A

Table 14. Estimated aggregate changes in consumer's surplus, Oregon and non-Oregon rents, by supply situation, control policy, and mobile sanitizer costs per acre.

Supply Situation	Open Field Burning Control Policy and Mobile Sanitizer Cost Per Acre								
	Ban on Burning			Once in Three Years Burning			Alternate Year Burning		
	$5	$9	$13	$5	$9	$13	$5	$9	$13
I Consumers' Surplus									
(thousand dollars)	- 761	-1,347	-1,913	- 511	- 909	-1,398	- 385	- 686	- 983
(percent)	- 5.92	-10.47	-14.88	- 3.97	- 7.07	-10.87	- 2.99	- 5.33	- 7.64
Oregon Rents									
(thousand dollars)	-1,064	-1,882	-2,668	- 719	-1,271	-1,815	- 536	- 960	-1,375
(percent)	- 8.11	-14.35	-20.34	- 5.48	- 9.69	-13.84	- 4.09	- 7.47	-10.48
Non-Oregon Rents									
(thousand dollars)	+ 215	+ 394	+ 578	+ 141	+ 245	+ 379	+ 105	+ 192	+ 281
(percent)	+ 5.49	+10.06	+14.76	+ 3.60	+ 6.26	+ 9.68	+ 2.68	+ 4.90	+ 7.17
Sum[1]									
(thousand dollars)	-1,610	-2,835	-4,002	-1,089	-1,935	-2,835	- 815	-1,453	-2,076
(percent)	- 5.39	- 9.50	-13.38	- 3.65	- 6.47	- 9.48	- 2.73	- 4.86	- 6.95
II Oregon Rents									
(thousand dollars)	- 964	-1,736	-2,507	- 643	-1,157	-1,672	- 483	- 868	-1,254
(percent)	- 7.35	-13.24	-19.12	- 4.90	- 8.82	-12.75	- 3.68	- 6.62	- 9.56
III Oregon Rents									
(thousand dollars)	-1,663	-2,921	-4,736	-1,343	-2,338	-3,330	-1,017	-1,789	-2,533
(percent)	-12,68	-22.27	-36.11	-10.24	-17.83	-25.39	- 7.75	-13.64	-19.31

[1] Sum may not add up due to rounding

Table 15. Comparison of aggregated estimated changes in Oregon producers' rents between supply situation I and II, by policy, and mobile sanitizer cost per acre.

	Open Field Burning Control Policy and Mobile Sanitizer Cost per Acre								
	Ban on Burning			Once in Three Years Burning			Alternate Year Burning		
Supply Situation	$5	$9	$13	$5	$9	$13	$5	$9	$13
I Oregon rents (thousand dollars)	-1,064	-1,882	-2,668	-719	-1,271	-1,815	-536	-960	-1,375
II Oregon rents (thousand dollars)	- 964	-1,736	-2,507	-643	-1,157	-1,672	-483	-868	-1,254
Difference (I-II)									
1. thousand dollars	-100	-146	-161	-76	-114	-143	-53	-92	-121
2. percent	-10.37	-8.41	-6.42	-11.82	-9.85	-8.55	-10.97	-10.60	9.64

ryegrass.[46] Therefore, excepting ryegrass, as Oregon producers react to cost increases due to controls on open-burning, non-Oregon output increases. Ceteris paribus, the resulting increase in prices and, therefore, decreases in consumers' surpluses are smaller in the case of seeds other than ryegrass.

2. Except in the case of tall fescue, the absolute decrease in consumers' surplus is less than the absolute decrease in Oregon producers' rents in supply situation I. This difference is most conspicuous in the case of ryegrass. The relative decrease in consumers' surplus for ryegrass is slightly greater than the relative decrease in Oregon producers' rents. However, for all seeds other than ryegrass, the relative decreases in consumers' surpluses are smaller than the relative decreases in producers' rents. The reason for this result is the same as given in (1), i.e., the increase in non-Oregon output for seeds other than ryegrass is responsible for this result. Finally, both absolute and relative decreases in consumers' surplus aggregated over all the grass seeds are smaller than the

[46] All U.S. grown ryegrass is essentially produced in the Willamette Valley. Therefore, no assumptions with respect to non-Oregon supply for this grass seed were made under supply situation I and II. However, supply situation III assumed perfectly elastic non-Oregon supply for ryegrass too. But, as already indicated, this situation is unrealistic.

aggregated changes in Oregon producers' rents[47] (see Table 14).

3. The most important results are obtained for the predicted decreases in Oregon producers' rents under supply situation I and II. It may be recalled that supply situation I assumed "normal" reactions by Oregon producers and a "well" functioning market mechanism, whereas situation II assumed that special climatic conditions and soil characteristics "box" Oregon producers into seed production. Interestingly, with a single exception of tall fescue for a total ban on open burning and sanitizer cost at $13.00 per acre, the absolute and relative decrease in Oregon producers' rents is larger in supply situation I than II. Excluding tall fescue, under all policies and for all cost increases, the decrease in Oregon rents is approximately five to ten percent larger under supply situation I than II. This result is most conspicuous in the case of red fescue where Oregon rents decrease by about 50 percent more under supply

[47] The estimated changes in consumers' surplus and producers' rents aggregated over all the six grass seeds included in the analysis must be interpreted with considerable care because changes for individual grass seeds are estimated assuming prices of substitute seeds as constant.

Wallace pointed out that a justifiable aggregation of such estimates should be based on "solutions to simultaneous sets of demand and supply relationships, that fully characterized the cross elasticities on both the demand and supply side" (1965, p. 587). However, Currie, Murphy, and Schmitz (1971) implied that there is no obvious way to sum economic surpluses for competitive and complementary commodities unless their prices always move proportionally.

situation I than II. The decrease in Oregon rents aggregated over all the grass seeds is invariably larger by approximately 6 to 12 percent in supply situation I than II.

These results may initially appear unusual, although they are perfectly consistent with economic theory. Where the price elasticity of demand for a commodity is greater than one, other things equal, declines in output would lower the total revenue. In the case of all grass seeds, the price elasticities of demands are greater than one. As Oregon producers react to cost increases, total output and total revenue simultaneously decline. Since Oregon producers' rents are measured as total revenue less average variable costs, the increase in average variable costs due to controls on open burning and the declines in total revenue because of elastic demands combine to produce larger decreases in rents in supply situation I than II.[48]

This result is most important from a policy viewpoint. Oregon grass seed producers face disadvantageous market conditions as well as limited opportunities to raise other crops.

4. The decrease in Oregon producers' rents in supply situation I and II is only 50 to 70 percent of the loss Oregon producers

[48] Recall that supply situation II assumed no changes in prices and Oregon quantities produced; therefore, total revenue before and after the controls on open burning remains unchanged.

would experience in supply situation III. Therefore, to the extent that non-Oregon supplies are more responsive to price than assumed in supply situation I, the decrease in Oregon rents would be greater.

5. The absolute increase in non-Oregon producers' rents exceeds the absolute decrease in Oregon rents only in the case of tall fescue. On the other hand, the relative increase in non-Oregon rents is larger than the relative decrease in Oregon rents for tall fescue, red fescue, chewings fescue, and bentgrass. However, the estimated gains in non-Oregon rents are based on hypothetical non-Oregon supply curves. Therefore, these gains and, for that matter, the "sum" of consumers' surplus, Oregon, and non-Oregon rents must be interpreted with considerable care. However, the relative decreases in the sum aggregated over all the six grass seeds under each policy are approximately equal to the relative decreases in consumers' surplus.

6. Finally, the assumed linearity in the demand and supply curves does result in absolute and relative changes in consumers' surplus and producers' rents that are proportional to the postulated changes in costs for all policies. This result, though not unusual, does indicate the limitations underlying common extrapolative procedures to predict changes consequent to introduction of new public policies.

V. DETERMINANTS OF GRASS SEED LAND VALUES IN THE WILLAMETTE VALLEY AND ESTIMATED DECLINE IN LAND VALUES

As indicated in Chapter I, land is one of the most important specialized resources in grass seed production. In 1970, grass seeds were raised on an estimated 260, 000 acres of land in the Willamette Valley. Much of this land, especially the land under ryegrass production, is of relatively poor quality and has restrictive drainage characteristics (Foote and Mack, 1969). In most cases, alternative farm crops or enterprises are not economically attractive.

Other things equal, the increase in costs of grass seed production due to controls on open field burning, would decrease earnings per acre in seed production. Following controls on open burning, therefore, land which would at least have equal or more profitable alternative uses would leave the seed industry, while the land which remained in grass seed production would accept relatively lower returns. Assuming that the capitalized sum of current returns is a major determinant of market value of a given parcel of land, the decrease in returns to seed land due to controls on open burning would lower their market values.

To investigate the impact of alternative policies affecting open field burning on market values of grass seed lands, a study of their determinants is undertaken. Primary emphasis in this study is given to determinants of the intra- and inter-county land values in the eight Willamette Valley counties where substantial quantities of grass seeds are raised. This seemed advisable because land use patterns, soil quality, and present urbanization manifest considerable variations among counties.

In this chapter, a model of the determinants of grass seed land values is specified and tested. Following discussion of the results, the chapter concludes by presenting the predicted decline in grass seed land values for each open field burning control policy under *ceteris paribus* conditions.

The Model

The basic hypothesis of the model is that the market value of a given parcel of land is functionally related to the current and expected future earnings from that parcel of land. Expected future earnings may be higher than current earnings due to speculation on the potential of land for future non-agricultural uses, such as urban, recreation, rural residences, etc. (Chryst, 1965), and more profitable other agricultural uses. Regardless of the reason, the greater the expected future income and the higher the probability of occurrence of these returns, the greater would be the current market value of a given parcel of land and the more likely such land would be converted to other uses.

To test the basic hypothesis, three subhypotheses are postulated:

(1) Current and expected future earnings in grass seed production and other agricultural uses are directly related to county assessor's estimate of the rent at which the land parcels could presently be leased.

Current earnings in grass seed production reflect current land use and enterpreneurial effort of the operator. On the other hand the expected future earnings in other agricultural uses may be regarded as determined by a parcel's soil quality. Of course, soil quality is dependent on factors such as soil texture, depth of surface soil, nature of sub-soil, fertility, etc., and a proxy for this variable in a land value study is typically difficult to specify.

In Oregon, however, county assessors estimate the rent at which a given parcel of land could presently be leased, placing "due" values on various dimensions of soil quality as well as earnings from the current land use. Therefore, the assessor's rent estimate consistently reflects, albeit imperfectly, the weights the market presently places on current and expected future earnings of a parcel of land in agriculture.

(2) Expected future earnings in non-agricultural uses are directly related to the relative accessibility of land parcels to the nearby urban centers.

For the purpose of this study, accessibility is measured in terms of (a) distance to the nearest town with a population of 1,000 or over, and (b) distance to the nearest state highway.[49] To avoid some bias in measuring accessibility, the distance to the nearest town and state highway are here measured for each of 161 different land parcels rather than for each of the 72 sampled farms. This practice avoids the bias associated with assuming each farm to consist of contiguous parcels of similar quality.

(3) The degree of association between accessibility variables and market values varies among counties according to the county's present urbanization, and among land parcels depending upon the size of the nearby urban centers.

To account for this variation in the importance of "urban influence," dummy variables reflecting the size of the nearest town are included in the model.

For the i^{th} parcel of land, the model may formally be stated as:

$$V_i = F_i (X_{1i}, X_{2i}, X_{3i}, D_{1i}, D_{2i})$$

[49] In a study of the determinants of residential land values, Brigham (1965) pointed out that distance variables are sometimes poor proxies for accessibility. He developed a "potential accessibility index" reflecting the type of transportation system, multiple-activity centers, etc.

However, since this investigation is primarily concerned with agricultural land values, the influences such as transportation system are not as important as they would be in the case of residential land values in or around an urban center.

where: V_i = assessed market value[50] per acre (in dollars) of the i^{th} parcel of land

X_{1i} = assessed rent per acre (in dollars) of the i^{th} parcel of land

X_{2i} = distance (in miles) from the i^{th} parcel to the nearest town of population 1,000 or over

X_{3i} = distance (in miles) from the i^{th} parcel to the nearest state highway

D_{1i} = dummy variable equal to 1 if population of the nearest town is greater than 1,000 but less than 10,000 and zero otherwise, and

D_{2i} = dummy variable equal to 1 if population of the nearest town is greater than 10,000 but less than 20,000 and zero otherwise.

Multiple regression analysis is the principal analytical tool employed to test the hypothesized relationships.

[50]The model of the determinants of grass seed land values is specified on the basis of assessed market values. This was necessitated because in the recent years there were very few sales of grass seed lands. However, it is assumed that assessed market values are very highly correlated with recorded market values. Given that the quality of property assessment in Oregon is among the best in the nation (Vars, 1972) this assumption does not seem unreasonable.

Sample and Data

The list of the sampled grass seed farms on which this study is based was obtained from Fisher (1972). This sample was selected by means of two-stage sampling technique. While eight Willamette Valley counties, viz., Benton, Clackamas, Lane, Linn, Marion, Polk, Washington, and Yamhill were selected purposively, grass seed operations within counties were a random selection.

The basic data were obtained from county tax assessment appraisal records. While the data on assessed market values were readily available, assessors' rent estimates were estimated from appraisal records.[51]

The population statistics for different cities were obtained from Center of Population Research and Census, Portland State University. The distance to town and state highway for individual land parcels was measured from county road maps. Since exact location of land parcels within 'sections' was not available, there may be some measurement error involved. It is assumed that this error is randomly distributed and does not affect the reliability of the estimator.

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[51] Agricultural lands in the Valley are taxed on the basis of farm use value which is the capitalized sum of assessed rent per acre. Given the prime rate of interest and the effective tax rate, land rents could be estimated from farm use values directly.

The number of sampled seed operations permitted intensive intra- and inter-county study of market value of grass seed lands only for Benton, Linn, and Marion counties. However, this appears quite appropriate. Linn and Benton counties are major producers of ryegrass and Marion county leads all other Oregon counties in the production of bentgrass, red fescue, and chewings fescue (Middlemiss and Coppedge, 1970). The model was also tested against land value market data for these three counties jointly as well as for all the eight Willamette Valley counties combined.

Statistical Results

Several different variants of the basic model were tested. These variants differed from one another in terms of their respective specifications and the assumed functional forms. The three model variants, for which the results are reported here, are as follows:[52]

I $V_i = F_i (X_{1i}, X_{2i})$

II $\text{Log } V_i = F_i (\text{Log } X_{1i}, \text{ Log } X_{2i})$

III $V_i = F_i (X_{1i}, X_{2i}, D_{1i}, D_{2i})$

The definition of the variables is as in the basic model. These model variants do not include distance to state highway. The early regression runs revealed that the coefficient of this variable was not

[52] The same three variants were employed to study the determinants of agricultural land value differentials. The results are reported in Appendix B.

significantly different from zero and, therefore, it was deleted from the analysis. The results are reported in Tables 16 through 18.

In general, model variant II (see Table 17) performed relatively better than either variant I or III (see Tables 16 and 18, respectively) when evaluated by usual statistical tests. The difference in performance of these variants is much more evident when one compares the results of variant II with those obtained from variants I and III for combined three and eight county data.

It is important to note that the results obtained from all the three model variants indicate that the regression coefficients of the assessed rent per acre and distance-to-town have the expected signs and support the hypothesized relationships. The regression coefficient of rent per acre is significant at the one percent level except in the case of model variant I and III for Marion County. Similarly, the coefficient of the distance-to-town variable is significant at the five or higher percent level except for Benton County results of model variant III.

With respect to dummy variables, a priori expectation that the influence of relatively large urban centers (D_2) would produce an upward shift in the intercept after the influence of small centers is removed, is generally supported by the results. The only exception was

Table 16. Land value results for model variant I.

Variable or Statistic	County or Counties				
	Benton	Linn	Marion	Three Counties	Eight Counties
Intercept	268.1636	181.1212	697.5259	312.8117	233.5416
Rent per acre	13.4541[a]	10.8166[a]	1.8875	8.7354[a]	10.9942[a]
	(8.526)	(7.041)	(.061)	(7.028)	(9.598)
Distance to town	-23.1971[a]	-13.9725[b]	-62.7178[a]	-21.9800[a]	-15.1824[a]
	(-4.654)	(-2.451)	(-6.783)	(-5.616)	(-4.409)
R^2	.7859	.5834	.7632	.5415	.4927
$\bar{R}^2$	.7733	.5667	.7450	.5336	.4863
F-statistic	62.4034	35.0103	41.9099	68.4915	76.7273
Degrees of freedom	34	50	26	116	158

Note: Figures in parentheses are t-statistics.

[a]Significant at the one percent level.

[b]Significant at the five percent level.

Table 17. Land value results for model variant II.

Variable or Statistic	County or Counties				
	Benton	Linn	Marion	Three Counties	Eight Counties
Intercept	2.0676	1.6597	2.3416	1.9587	1.8497
Rent per acre	0.6759[a]	0.7232[a]	0.4872[a]	0.5944[a]	0.6333[a]
	(10.154)	(10.63)	(3.194)	(10.886)	(12.975)
Distance to town	-0.4653[a]	-0.1432[a]	-0.5691[a]	-0.2652[a]	-0.1731[a]
	(-4.599)	(-2.97)	(-4.801)	(-5.625)	(-4.695)
R^2	.8197	.7479	.7144	.6581	.5980
$\bar{R}^2$	.8091	.7378	.6924	.6527	.5928
F-statistic	77.2835	14.83	32.5105	111.6228	117.5392
Degrees of freedom	34	50	26	116	158

Note: Figures in parentheses are t-statistics.

[a]Significant at the one percent level.

Table 18. Land value results for model variant III.

Variable or Statistic	County or Counties			
	Benton	Linn	Marion	Three Counties
Intercept	133.8253	139.1472	687.4362	326.6881
Rent per acre	13.4968[a]	10.6798[a]	1.9988	8.4352[a]
	(10.398)	(6.512)	(0.584)	(6.583)
Distance to town	-7.0758	-13.5581[b]	-62.2614[a]	-22.1400
	(-1.236)	(-2.313)	(-6.223)	(-5.466)
Dummy 1	-22.4137	42.0792	7.2854	-13.0011
	(-1.193)	(0.867)	(0.156)	(-0.515)
Dummy 2	110.8673[a]	58.2341	-4.1374	14.4446
	(3.252)	(1.120)	(-0.038)	(0.432)
R^2	.8643	.5942	.7636	.5467
$\bar{R}^2$	.8473	.5598	.7242	.5278
F-statistic	50.9357	17.5690	19.3794	34.3711
Degrees of freedom	32	48	24	114

Note: Figures in parentheses are t-statistics.

[a]Significant at the one percent level.

[b]Significant at the five percent level.

the results of model variant III for Marion County.[53]

Finally, three features of the results deserve special mention. First, all the model variants in the case of Marion County produced a relatively large coefficient for the distance-to-town variable. This result is consistent with the hypothesis that urbanization has had a greater influence on grass seed land values there than in Benton and Linn Counties. In fact, if urbanization is measured by aggregate county population or population of the largest city in the county, Marion County would be classified as more urbanized than either Benton or Linn counties.

Second, for model variant II, the size and statistical significance of the coefficient of assessed rent per acre for Linn County is relatively greater than for Benton and Marion counties. Such results are consistent with the hypothesis that Linn County grass seed land has the lowest relative potential convertibility to other agricultural and non-agricultural uses among the three counties.[54]

Third, despite inter-county differences in the relative importance of the factors that statistically account for variations in

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[53]This unexpected result in the case of Marion County was obtained because of high correlation between dummy 2 and the distance-to-town variable. However, the coefficient of dummy 2, though negatively signed, is not significantly different from zero.

[54]In fact, most of the Linn County land belongs to Amity and Dayton soil series and is poorly drained. High water table during winter months is a serious handicap in raising other crops.

grass seed land values, the model performed reasonably well when tested against all data from the major three and all eight Willamette Valley seed producing counties. These results suggest a relatively "well-behaved" grass seed land value surface extending throughout the Willamette Valley.

Estimated Changes in Grass Seed Land Values under Alternative Policies

The results reported earlier in this chapter are now employed to estimate the decreases in the value of grass seed lands in the Willamette Valley for alternative policies to control pollution from open field burning.

The model assumes that the adoption of the mobile field sanitizer has no impact on the marginal physical products of land, specialized capital, entrepreneurial ability, etc.[55] On this assumption, the percentage decrease in the margin between grass seed price and average variable costs after imposition of controls on open field burning would equal the percentage decrease in earnings in grass seed production.

The percentage decrease in the margin between price and average variable costs is estimated for each seed type, policy, and

[55]This assumption seems reasonable because use of the sanitizer would require no fundamental change in cultivation practices and, in addition, is assumed to have no impact on yields per acre. Hence, the sanitizer would raise costs per unit of output but not affect marginal products.

cost increase for supply situations I and II.[56] For each cost increase under each policy, these percentage decreases are aggregated over all grass seeds. In this aggregation, initial producers' rents in Oregon are used to provide the needed relative weights. In Table 19 Columns (1) and (2), respectively, present these relative decreases in earnings in grass seed production.

Of course, these percentage decreases, given the assumptions made in the basic model to predict post-control prices and outputs, would measure minimum and maximum percentage declines expected in seed land values <u>only if</u> land values equalled the capitalized value of current earnings in perpetuity. This, however, is not the case because (1) grass seed land values are considerably higher than the capitalized value of estimated rents (earnings) per acre at interest rates of eight or higher percent, and (2) the results reported earlier in this chapter provide substantial evidence that in addition to current earnings, expected future earnings in non-agricultural uses is also a very important influence in statistically explaining variations in land values.

From the above discussion it follows that, other things equal, the percentage decline in earnings in grass seed production would not be perfectly capitalized into lower land values.

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[56] This analysis was not extended to supply situation III because, as already indicated, situation III is rather unrealistic.

Table 19. Predicted percentage decreases in the value of grass seed land in Oregon for supply situations I and II, by policy, and mobile sanitizer cost per acre.

Policy	Mobile Sanitizer Cost per Acre	Estimated Decrease in Earnings in Grass Seed Production (%)		Predicted Decrease in Agricultural Land Values (%)		
		Supply Situation I (1)	Supply Situation II (2)	Supply[a] Situation I (3)	Supply[b] Situation II (4)	Average Estimate[c] (5)
Ban on Burning	$ 5	4.48	7.35	2.83	4.65	3.74
	9	6.61	13.24	4.19	8.38	6.29
	13	9.91	19.12	6.28	12.11	9.20
Once in Three Years Burning	5	2.61	4.90	1.65	3.10	2.48
	9	4.62	8.82	2.93	5.86	4.35
	13	6.69	12.75	4.23	8.07	6.15
Alternate Year Burning	5	1.92	3.68	1.22	2.33	1.88
	9	3.47	6.62	2.20	4.19	3.20
	13	5.01	9.56	3.17	6.05	4.61

[a]Col. (1) x 0.633

[b]Col. (2) x 0.633

[c][Col. (3) + Col. (4)] /2

To predict the decreases in grass seed land values under *ceteris paribus* conditions, the eight-county results of model variant II, presented in Table 17 are employed. In employing these results, the model assumes that the influence of expected future earnings in explaining the current market value of grass seed land is not affected by the imposition of controls on open field burning.[57]

Two limitations of using the estimated regression coefficient of rent per acre for predicting changes in the value of grass seed land should be noted. First, the specification of the basic regression model implies a perfectly inelastic supply of land. Second, this coefficient should usually be employed *only* to predict the change in the market value of a given parcel of land associated with a change in its earnings, given the earnings of all other parcels of land.

It should also be noted that *a priori* reasoning suggests that, in the absence of very special circumstances, the maximum magnitude of the estimated regression coefficient for current expected rent would be one consistent with perfect capitalization of the decrease in expected current earnings. However, since actual land values in the Willamette Valley greatly exceed the capitalized sum of current earnings, perfect capitalization of the decrease in current earnings would

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[57] This assumption is based on *a priori* judgement that demands for land in uses other than seed production would not shift because the attractiveness of the Valley increases as open field burning is controlled.

occur only if such decreases also meant equal decreases in expected future earnings. Such a possibility seems very unlikely because expected future earnings would often accrue from uses other than seed production.

In this instance, however, the estimated regression coefficients have magnitudes approximately equal or slightly larger than those which would imply perfect capitalization of decrease in earnings into lower land values. Therefore, the bias introduced by employing the estimated regression coefficient from Table 17 results in an overstatement of the decline in land values realistically expected following controls on open field burning.

Although the methodology employed here is not fully adequate because available data limitation precluded development of a well-specified land value model, the methodology can be employed to establish a reasonable upper limit on the expected decline in land values.

The estimated percentage decrease in grass seed land values for each policy under alternative mobile sanitizer costs, for supply situation I and II are presented in Table 19.[58] The last column of

[58] In extending this analysis to supply situation I, another methodological limitation needs mention. In estimating relative changes in earnings in grass seed production for this supply situation, the model allowed for some specialized resources to leave the industry. However, the technique used in estimating decrease in land values assumed perfectly inelastic supply for grass seed land. For this reason, the predicted decrease in land values is likely to overstate the "true" decline in the case of situation I.

this table averages the predicted decreases in land values under supply situation I and II to provide a "reasonable" estimate of the declines that would be associated with different control policies under alternative assumptions concerning mobile sanitizer costs per acre. These results suggest the following observations:

(1) In the case of supply situation II, where all specialized resources remain in grass seed production, the predicted percentage decrease in land values is approximately twice as large as the decrease in supply situation I, where some specialized resources leave grass seed industry to receive at least equivalent payments in other employments.

(2) The relative decrease in land values in the case of once in three years burning, and alternate year burning under each cost increase is approximately 33 and 50 percent lower, respectively, than the decrease when no burning is permitted.

(3) On the average, the predicted decrease in the value of grass seed lands in Oregon varies from approximately two to nine percent[59] depending upon the type of controls imposed on open field burning and the associated cost increase due to the adoption of mobile sanitizers.

[59]This predicted decrease in land values is expected to vary among counties because of the inter-county differences in relative importance of current earnings in statistically explaining land values (refer to results for Benton, Linn, and Marion counties in Tables 16 through 18). However, the decline in land values could not be predicted for important grass seed growing counties individually since it was not possible to estimate the decline in grass seed earnings for each county separately.

(4) Finally, it should be noted that due to methodological limitations an objective prediction of losses to each specialized resource consequent to regulation of production function in a competitive industry is extremely difficult. These results, therefore, should simply be viewed as providing additional perspective on the economic impacts of three alternative pollution control policies on Oregon's grass seed industry.

VI. SUMMARY AND CONCLUSIONS

Summary

The grass seed growers in the Willamette Valley of Oregon have traditionally adopted the least-cost practice of open field burning to dispose of harvest straw and stubbles. Some other beneficial effects of open burning include effective disease control, increased seed purity and yields, etc.

However, smoke produced by open burning of grass straw and stubbles pollutes Valley air, reduces visibility, causes soiling and other damage to property. Certain other effects of smokiness possibly harmful to human health are not clearly established.

Because of pressure from the affected population and increased national interest in environmental quality, Oregon authorities have declared a complete ban on open field burning effective January 1, 1975. Such a ban would have serious economic implications on Oregon's grass seed industry as a whole. For example, controls on open field burning would change the resource allocation in Oregon's seed industry, thereby imposing costs on society--costs in terms of the value of goods and services foregone.

The principal objective of this research effort was to estimate costs of alternative pollution control policies affecting open field burning in the Willamette Valley. Costs as defined in the study were measured in terms of decreases in consumers' surplus and producers' rents resulting from three alternative policies to control pollution. The three policies investigated were:

1. A complete ban on burning,
2. Open burning permitted once in three years, and
3. Alternate year burning.

It was assumed that controls on open field burning would lead grass seed growers to adopt mobile sanitizers to dispose of harvest residues, and thereby experience increases in costs of grass seed production alternately by $5.00, $9.00, and $13.00 per acre.

To accomplish the principal objective of this study, a simple dynamic model of demand and supply relationships for the six grass seeds raised in the Willamette Valley was developed. For each grass seed, the following demand and supply relationships were estimated:

1. Demand for current utilization in the U.S.,
2. demand for ending stocks in the U.S.,
3. aggregate Oregon supply-response function.

Ordinary least squares, logarithmic least squares, and two stage least squares were the principal tools employed in the analysis. The major emphasis was given on obtaining reliable estimates of price elasticities of demand and supply. Based on long-run elasticity estimates, linear demand and supply equations were calculated to estimate control-induced changes in consumers' surplus and producers' rents.

In estimating changes in consumers' surplus and producers' rents three alternative supply situations were postulated. Supply situation I assumed positively-sloped Oregon and non-Oregon supply curves, whereas, supply situation II assumed a positively-sloped non-Oregon supply curve and a perfectly inelastic Oregon supply curve. Finally, supply situation III postulated a perfectly elastic non-Oregon and a positively-sloped Oregon supply curve. Changes in consumers' surplus, and Oregon and non-Oregon producers' rents were estimated for each policy under alternative mobile sanitizer costs for supply situation I. For situations II and III, however, only changes in Oregon producers' rents were estimated because in these situations seed prices would not change and, hence, neither would the well-being of consumers and non-Oregon producers change.

To provide additional perspective on the possible economic impacts of regulating open burning, changes in earnings in grass seed production were translated into changes in the value of grass seed lands in the Willamette Valley. To accomplish this, a model of the determinants of grass seed land values was developed. Efforts were focused on developing a coefficient of responsiveness of land values with respect to changes in earnings in seed production. Due to controls on open field burning, percentage decreases in earnings in seed production were estimated and decline in land values predicted under *ceteris paribus* conditions.

Conclusions

Changes in Consumers' Surplus and Producers' Rents

In Chapter IV, several observations were made concerning the absolute and relative changes in consumers' surpluses and producers' rents for individual grass seeds, as well as for the six grass seeds combined.

In supply situation I, the absolute aggregate decrease in consumers' surplus varied among policies and according to mobile sanitizer costs from \$0.385 million to \$1.93 million, while the relative decreases ranged from approximately 3 percent to 15 percent. Both absolute and relative decreases, in aggregate Oregon rents, were estimated to be even larger. Oregon producers were predicted to lose an estimated sum of \$0.539 million to \$2.668 million, depending upon the nature of controls and the associated cost increase. The relative annual decrease in aggregate Oregon rents varied from approximately 4 percent to 20 percent. However, the decreases in Oregon rents were approximately 6 to 12 percent larger in supply situation I than II. This result is important from a public policy viewpoint because it suggests that Oregon seed producers face disadvantageous market conditions as well as limited alternatives to seed production.

The results of supply situation III indicated that, other things equal, where non-Oregon supplies are more responsive to price, the observed decrease in Oregon rents would be greater than the decreases estimated in supply situation I.

Interestingly, the gains in non-Oregon rents under each policy and assumed mobile sanitizer cost were only about 20 percent of the losses in Oregon rents in supply situation I. However, the absolute gains in non-Oregon rents varied from $0.105 million to $0.578 million.

From national viewpoint, the decrease in the "sum" of consumers' surplus and producers' rents (Oregon and non-Oregon) varied from a low of $0.815 million to a high of $4.002 million, annually. However, the relative decreases in the "sum" under each policy were approximately equal to the decreases in consumers' surplus.

The estimated changes in consumers' surplus and producers' rents were found to be proportional to the postulated increase in costs of production. This result was obtained because of assumed linearity in the demand and supply equations employed in the analysis.

In this study, a new measurement technique was employed to estimate changes in the economic well-being of Oregon producers. The new technique probably provides a more meaningful measure of welfare changes experienced by producers than would measurements based on the traditional concept of producers' surplus.

Changes in Grass Seed Land Values

The relative decreases in grass seed land values were estimated under *ceteris paribus* conditions for supply situation I and II. Supply situation I assumed that, due to controls on open field burning, some specialized resources leave the industry, whereas situation II assumed all such resources remain in seed production.

In general, the relative decrease in land values in supply situation II was almost double the decrease in situation I. On the average, depending upon the type of controls imposed on open field burning and the associated cost increase, the predicted decrease in land values varied from approximately two to nine percent.

Implications

A rational choice among public policies requires an objective evaluation of benefits and costs associated with each policy. The major contribution of this study is in providing information on one of these two important aspects of public choice -- costs.

However, costs of three alternative policies to control pollution from open field burning reported in this study must be interpreted bearing in mind the inherent methodological limitations. These costs manifested considerable variations depending upon the type of policy investigated and assumptions employed in the analysis.

Although among the three policies investigated in this study the differences in costs are substantial, each policy would improve environmental quality to a varying degree. In turn, the various levels of improvements in the quality of environment would create new economic and aesthetic benefits such as increased recreational activities, improved visibility, etc.

Given the value of new economic and aesthetic benefits of each policy, cost estimates reported in this study would help rationalize the choice among alternative policies to control pollution from open field burning in the Willamette Valley. Although not all of these estimates are costs in the sense that they measure the value of goods and services foregone by society as a result of controls on open field burning in Oregon, each change does measure the impact of controls on the well-being of groups potentially important in public policy formation.

Suggestions for Future Research

In this study, because of data limitations, truly adequate specification of grass seed land values was not possible. However, the review of the theoretical and empirical literature on land values indicated that additional theoretical work is required to develop fully adequate models of agricultural land values for rapidly urbanizing areas. Such models should simultaneously account for earnings in agricultural and non-agricultural uses over time, as well as predict how the time of conversion to other uses would change in response to changes in earnings in various uses, technology, land use restrictions, etc.

In recent years, public policy issues concerning environmental pollution (air, water, noise, etc.) have become increasingly important. In most cases of environmental pollution, however, the harmful effects are not very well established. On the other hand, aesthetic benefits created by improved environment are not easily measurable.[60] Increased research efforts should estimate the harmful effects of various types of environmental pollution as well as develop methodology to measure the aesthetic value of improved environmental quality. This would help economists quantify costs and benefits of various policies objectively to aid public policy makers to choose among alternative policies to control pollution.

Also, future research should be oriented more to look beyond the regional impacts of a given regulatory policy. A regulation which imposes costs on one segment of an industry in a certain region may create benefits for the same industry but in other regions.

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[60]For some of the inherent difficulties in measuring aesthetic value of improved environment, other environmental goods, and a suggested approach, see Pendse and Wyckoff (1972).

To facilitate evaluation of public policies from regional as well as national viewpoint, future research should make sustained efforts to develop methodology and study inter-regional impacts of such policies rather than be content with regional investigations.

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APPENDICES

Table A-1. Estimated consumers' surplus, Oregon and non-Oregon rents for ryegrass in supply situation I without and with alternative open field burning control policies at varying costs per acre for the mobile field sanitizer.

	Initial Situation	Open Field Burning Control Policies and Mobile Sanitizer Cost per Acre								
		Ban on Burning			Once in Three Years Burning			Alternate Year Burning		
		$5	$9	$13	$5	$9	$13	$5	$9	$13
Price per 100 lbs.	6.86	7.0568	7.2132	7.36971	6.9915	7.0959	7.2002	6.9589	7.0372	7.1154
Average variable cost per 100 lbs.	2.68000	3.09390	3.42494	3.74604	2.9595	3.1766	3.3974	2.8870	3.0525	3.2180
Aggregate Output (100 lbs)	1,643,890	1,551,225	1,478,788	1,406,337	1,581,416	1,533,125	1,484,823	1,596,510	1,560,291	1,524,066
Oregon Output (100 lbs)	1,585,850	1,494,987	1,421,511	1,348,068	1,525,610	1,476,629	1,427,635	1,540,918	1,504,184	1,467,479
Non-Oregon Output (100 lbs)	——	——	——	——	——	——	——	——	——	——
Consumers' Surplus	2,913,994	2,598,767	2,361,765	2,136,008	2,700,948	2,538,510	2,381,077	2,752,758	2,629,270	2,508,605
Change in Consumers' Surplus	(-)	315,227	552,229	777,986	213,046	375,484	532,917	161,236	284,724	405,389
Percentage Change	(-)	10.82	18.95	26.70	7.31	12.89	18.29	5.53	9.77	13.91
Oregon Rents	6,628,853	5,924,484	5,384,996	4,871,473	6,151,271	5,787,249	5,429,039	6,274,587	5,993,722	5,719,338
Change in Oregon Rents	(-)	704,369	1,243,857	1,757,380	477,578	841,604	1,199,814	354,266	635,131	909,515
Percentage Change	(-)	10.63	18.76	26.51	7.20	12.70	18.10	5.34	9.58	13.72
Non-Oregon Rents	——	——	——	——	——	——	——	——	——	——
Change in Non-Oregon Rents	——	——	——	——	——	——	——	——	——	——
Percentage Change	——	——	——	——	——	——	——	——	——	——
Sum of Surplus and Rents	9,542,847	8,523,251	7,746,761	7,007,481	8,852,219	8,325,759	7,810,116	9,027,345	8,622,992	8,227,943
Change in Sum	(-)	1,019,558	1,796,086	2,535,366	690,628	1,217,088	1,732,731	515,502	919,855	1,514,904
Percentage Change	(-)	10.68	18.82	26.57	7.24	12.75	18.16	5.40	9.64	15.87

Table A-2. Estimated consumers' surplus, Oregon and non-Oregon rents for tall fescue in supply situation I without and with alternative open field burning control policies at varying costs per acre for the mobile field sanitizer.

	Initial Situation	Open Field Burning Control Policies and Mobile Sanitizer Cost per Acre								
		Ban on Burning			Once in Three Years Burning			Alternate Year Burning		
		$5	$9	$13	$5	$9	$13	$5	$9	$13
Price per 100 lbs.	12.08	12.3703	12.60639	12.84247	12.2719	12.4239	12.5867	12.2228	12.3408	12.4588
Average variable cost per 100 lbs.	4.66780	5.25880	5.73162	6.20444	5.0618	5.3770	5.6922	4.9633	5.1997	5.4361
Agregate Output (100 lbs)	747,430	720,422	698,723	677,024	729,463	714,997	700,531	733,983	723,134	712,285
Oregon Output (100 lbs)	102,480	97,946	94,371	90,796	99,437	97,053	94,669	100,181	98,393	96,606
Non-Oregon Output (100 lbs)	497,930	520,298	538,362	556,425	512,773	524,814	536,857	509,009	518,041	527,073
Consumers' Surplus	3,037,742	2,823,406	2,655,855	2,493,490	2,894,713	2,781,045	2,669,647	2,930,702	2,844,701	2,759,998
Change in Consumers' Surplus	(-)	214,336	381,887	544,252	143,029	256,700	368,095	107,040	193,041	277,244
Percentage Change	(-)	7.06	12.57	17.92	4.71	8.45	12.12	3.52	6.35	9.14
Oregon Rents	759,602	696,543	648,779	602,707	716,955	684,448	652,695	727,259	702,633	678,437
Change in Oregon Rents	(-)	63,059	110,823	156,895	42,647	75,158	106,907	32,343	56,969	81,165
Percentage Change	(-)	8.30	14.59	20.65	5.62	9.90	14.08	4.26	7.50	10.69
Non-Oregon Rents	1,620,762	1,769,091	1,894,063	2.023,292	1,718,287	1,799,934	1,883,488	1,693,155	1,753,766	1,815,461
Change in Non-Oregon Rents	(+)	148,336	273,301	402,530	97,525	179,172	262,726	72,393	133,004	194,699
Percentage Change	(+)	9.15	16.86	24.84	6.02	11.15	16.21	4.47	8.21	12.01
Sum of Surplus and Rents	5,418,106	5,289,047	5,198,697	5,119,489	5,327,955	5,265,427	5,205,830	5,351,116	5,301,100	5,253,896
Change in Sum	(-)	129,059	219,409	298,617	88,151	152,679	212,276	66,990	117,006	164,210
Percentage Change	(-)	2.39	4.05	5.51	1.63	2.82	3.92	1.24	2.16	3.03

Table A-3. Estimated consumers' surplus, Oregon and non-Oregon rents for red fescue in supply situation I without and with alternative open field burning control policies at varying costs per acre for the mobile field sanitizer.

	Initial Situation	Open Field Burning Control Policies and Mobile Sanitizer Cost per Acre								
		Ban on Burning			Once in Three Years Burning			Alternate Year Burning		
		$5	$9	$13	$5	$9	$13	$5	$9	$13
Price per 100 lbs.	26.50	26.8243	27.0826	27.3409	26.7167	26.8889	27.0611	26.6629	26.7920	26.9212
Average variable cost per 100 lbs.	6.7446	7.6375	8.3517	9.0660	7.3399	7.8160	8.2922	7.1911	7.5482	7.9053
Agregate Output (100 lbs)	261,640	255,433	250,477	245,521	257,498	254,194	250,890	258,531	256,053	253,575
Oregon Output (100 lbs)	67,240	64,653	62,347	60,172	65,428	63,978	62,528	65,882	64,794	63,707
Non-Oregon Output (100 lbs)	133,700	136,073	137,960	139,849	135,283	136,543	137,802	134,890	135,834	136,779
Consumers' Surplus	1,784,058	1,700,313	1,634,972	1,570,912	1,727,917	1,683,859	1,640,369	1,741,805	1,708,575	1,675,664
Change in Consumers' Surplus	(-)	83,745	149,086	213,146	56,141	100,199	143,689	42,253	75,483	105,394
Percentage Change	(-)	4.69	8.36	11.95	3.15	5.62	8.05	2.37	4.23	6.08
Oregon Rents	1,328,353	1,238,183	1,167,815	1,099,639	1,267,787	1,220,243	1,173,581	1,282,842	1,246,886	1,24,444
Change in Oregon Rents	(-)	90,170	160,538	228,714	60,566	108,110	154,772	45,511	81,467	116,909
Percentage Change	(-)	6.79	12.09	17.22	4.56	8.14	11.65	3.43	6.13	8.80
Non-Oregon Rents	1,222,018	1,265,769	1,301,130	1,337,008	1.251,130	1,274,540	1,298,157	1,243,866	1,261,342	1,278,951
Change in Non-Oregon Rents	(+)	43,751	79,112	114,990	29,112	52,522	76,139	21,848	39,324	56,933
Percentage Change	(+)	3.58	6.47	9.41	2.38	4.30	6.23	1.79	3.22	4.66
Sum of Surplus and Rents	4,334,429	4,204,265	4,103,917	4,007,559	4,246,834	4,178,642	4,112,107	4,268,513	4,216,803	4,166,059
Change in Sum	(-)	130,164	230,512	326,870	87,595	155,787	222,322	65,916	117,626	168,370
Percentage Change	(-)	3.00	5.32	7.54	2.02	3.59	5.13	1.52	2.71	3.88

Table A-4. Estimated consumers' surplus, Oregon and non-Oregon rents for chewings fescue in supply situation I without and with alternative open field burning control policies at varying costs per acre for the mobile field sanitizer.

	Initial Situation	Open Field Burning Control Policies and Mobile Sanitizer Cost per Acre								
		Ban on Burning			Once in Three Years Burning			Alternate Year Burning		
		$5	$9	$13	$5	$9	$13	$5	$9	$13
Price per 100 lbs.	26.70	27.1674	27.54091	27.91443	27.0117	27.2607	27.5098	26.9339	27.1206	27.3074
Average variable cost per 100 lbs.	6.74460	7.63750	8.35174	9.06602	7.3399	7.8160	8.2922	7.1911	7.5482	7.9053
Aggregate Output (100 lbs)	117,600	115,072	113,044	111,016	115,918	114,565	113,213	116,340	115,326	114,312
Oregon Output (100 lbs)	68,000	66,022	64,443	62,864	66,680	65,628	64,577	67,009	66,220	65,430
Non-Oregon Output (100 lbs)	24,350	24,975	25,468	25,960	24,770	25,099	25,427	24,668	24,914	25,160
Consumers' Surplus	1,273,555	1,219,286	1,176,686	1,134,843	1,237,275	1,208,568	1,180,209	1,246,306	1,224,674	1,203,231
Change in Consumers' Surplus	(-)	54,269	96,869	138,712	36,280	64,987	93,346	27,249	48,881	70,324
Percentage Change	(-)	4.26	7.61	10.89	2.85	5.10	7.33	2.14	3.84	5.52
Oregon Rents	1,356,967	1,289,403	1,236,608	1,184,924	1,311,718	1,276,116	1,306,797	1,322,947	1,296,088	1,269,479
Change in Oregon Rents	(-)	67,564	120,359	172,043	45,249	80,851	115,952	34,020	60,879	87,488
Percentage Change	(-)	4.97	8.87	12.68	3.33	5.96	8.54	2.51	4.49	5.71
Non-Oregon Rents	225,021	236,634	246,061	255,665	232,763	238,980	245,269	230,845	235,473	240,148
Change in Non-Oregon Rents	(+)	11,613	21,040	30,644	7,742	13,959	20,248	5,324	10,452	15,127
Percentage Change	(+)	5.16	9.35	13.62	3.44	6.20	9.00	2.59	4.64	6.72
Sum of Surplus and Rents	2,855,543	2,745,323	2,659,355	2,575,432	2,781,756	2,723,664	2,694,350	2,800,098	2,756,235	2,712,858
Change in Sum	(-)	110,220	196,188	280,111	73,787	131,879	161,193	55,445	99,308	142,685
Percentage Change	(-)	3.86	6.87	9.81	2.58	4.62	5.64	1.94	3.48	5.00

Table A-5. Estimated consumers' surplus, Oregon and non-Oregon rents for Merion Kentucky bluegrass in supply situation I without and with alternative open field burning control policies at varying costs per acre for the mobile field sanitizer.

	Initial Situation	Open Field Burning Control Policies and Mobile Sanitizer Cost per Acre								
		Ban on Burning			Once in Three Years Burning			Alternate Year Burning		
		$5	$9	$13	$5	$9	$13	$5	$9	$13
Price per 100 lbs.	68.90	69.2123	69.46657	69.72078	69.1064	69.2758	69.4454	69.0533	69.1806	69.3077
Average variable cost per 100 lbs.	7.52170	8.32690	8.97097	9.61509	8.0585	8.4679	8.9173	7.9243	8.2463	8.5684
Aggregate Output (100 lbs)	72,620	72,258	71973	71,687	72,439	72,187	71,996	72,437	72,294	72,151
Oregon Output (100 lbs)	17,600	17,336	17,133	16,930	17,483	17,285	17,150	17,463	17,362	17,260
Non-Oregon Output (100 lbs)	27,520	27,644	27,764	27,883	27,594	27,674	27,754	27,569	24,914	27,689
Consumers' Surplus	2,345,593	2,322,618	2,304,307	2,286,038	2,330,277	2,318,042	2,305,805	2,334,130	2,324,923	2,315,739
Change in Consumers' Surplus	(-)	22,975	41,286	59,555	15,316	27,551	39,788	11,463	20,670	29,854
Percentage Change	(-)	1.00	1.76	2.54	0.65	1.18	1.70	0.49	0.88	1.27
Oregon Rents	1,080,258	1,055,509	1,036,471	1,017,588	1,071,085	1,051,065	1,038,057	1,067,498	1,057,940	1,048,359
Change in Oregon Rents	(-)	24,749	43,787	62,670	16,843	29,193	42,201	12,762	22,318	31,889
Percentage Change	(-)	2.29	4.05	5.80	1.56	2.70	3.91	1.18	2.07	2.95
Non-Oregon Rents	803,309	811,245	818,294	825,345	808,514	813,002	817,705	806,850	810,364	813,883
Change in Non-Oregon Rents	(+)	7,936	14,985	22,036	5,005	9,693	14,396	3,541	7,055	10,574
Percentage Change	(+)	1.0	1.87	2.74	0.62	1.21	1.79	0.44	0.88	1.32
Sum of Surplus and Rents	4,229,160	4,189,372	4,159,072	4,128,971	4,206,091	4,182,109	4,161,567	4,208,478	4,193,227	4,177,981
Change in Sum	(-)	39,788	70,088	100,189	23,069	47,051	67,593	20,682	35,933	51,179
Percentage Change	(-)	0.94	1.66	2.37	0.55	1.11	1.60	0.49	0.85	1.21

Table A-6. Eatimated consumera' aurplus, Oregon and non-Oregon rents for bentgrasa in aupply situation I without and with alternative open field burning control policies at varying costs per acre for the mobile field sanitizer.

	Initial Situation	Open Field Burning Control Policies and Mobile Sanitizer Cost per Acre								
		Ban on Burning			Once in Three Years Burning			Alternate Year Burning		
		$5	$9	$13	$5	$9	$13	$5	$9	$13
Price per 100 lbs.	37.70	38.4153	38.9855	39.5559	38.1776	38.5579	38.9381	38.0588	38.3439	38.6290
Average variable coat per 100 lbs.	9.8754	11.3591	12.5460	13.7330	10.8645	11.6558	12.4471	10.6173	11.2107	11.8042
Aggregate Output (100 lbs.)	99,620	97,279	95,398	93,518	98,062	96,808	95,555	98,454	97,514	96,574
Oregon Output (100 lbs.)	70,480	68,267	66,492	64,717	69,007	67,823	66,640	69,377	68,488	67,601
Non-Oregon Output (100 lbs.)	3,960	4,086	4,182	4,281	4,045	4,110	4,175	4,025	4,074	4,123
Consumera' Surplus	1,505,298	1,435,135	1,380185	1,326,314	1,458,340	1,421,284	1,384,721	1,470,019	1,442,083	1,414,413
Change in Consumers' Surplus	(-)	70,163	125,173	178,984	46,958	84,014	120,577	35,279	63,215	90,885
Parcentage Change	(-)	4.66	8.32	11.89	3.12	5.58	8.01	2.34	4.20	6.04
Oregon Renta	1,961,088	1,847,043	1,758,015	1,671,183	1,884,792	1,824,577	1,765,359	1,903,809	1,858,295	1,813,387
Change in Oregon Rents	(-)	114,057	203,063	289,895	76,286	136,501	195,719	57,269	102,783	147,691
Percentage Change	(-)	5.82	10.35	14.78	3.89	6.96	9.98	2.92	5.24	7.53
Non-Oregon Renta	45,879	48,817	51,156	53.588	47,847	49,397	50,972	47,371	48,528	49,700
Change in Non-Oregon Rents	(+)	2,938	4,277	7,709	1,968	3,518	5,093	1,492	2,649	3,821
Percentage Change	(+)	6.40	11.50	16.80	4.29	7.67	11.10	3.25	5.77	8.33
Sum of Surplua and Renta	3,512,255	3,330,995	3,189,356	3,051,085	3,390,974	3,295,258	3,201,052	3,421,199	3,348,906	3,277,500
Change in Sum	(-)	181,240	322,899	461,170	121,276	216,997	311,203	91,056	163,349	234,755
Percentage Chsnge	(-)	5.16	9.19	13.13	3.45	6.18	8.86	2.59	4.65	6.68

Table A-7. Estimated Oregon rents for various grass seeds in supply situation II without and with alternative open field burning control policies at varying costs per acre for the mobile field sanitizer.

Seed Type	Initial Situation	Open Field Burning Control Policies and Mobile Sanitizer Cost per Acre								
		Ban on Burning			Once in Three Years			Alternate Year Burning		
		$5	$9	$13	$5	$9	$13	$5	$9	$13
Ryegrass										
Price per 100 lbs.	6.8600									
Average variable costs per 100 lbs.	2.6800	3.0939	3.4249	3.7460	2.9595	3.1766	3.3974	2.8870	3.0525	3.2180
Oregon output (100 lbs.)	1,585,850									
Change in Oregon rents (-)		656,383	1,181,363	1,706,438	437,584	787,565	1,137,625	328,192	590,682	853.219
Percentage change in Oregon rents (-)		9.90	17.82	25.74	6.60	11.88	17.16	4.95	8.91	12.87
Tall Fescue										
Price per 100 lbs.	12.0800									
Average variable costs per 100 lbs.	4.6678	5.2588	5.7316	6.2044	5.0618	5.3770	5.6922	4.9633	5.1997	5.4361
Oregon output (100 lbs.)	102,480									
Change in Oregon rents (-)		60,566	109,020	157,475	40,377	72,680	104,984	30,283	54,510	78,737
Percentage change in Oregon rents (-)		7.97	14.35	20.73	5.32	9.57	13.82	3.99	7.18	10.37
Red Fescue										
Price per 100 lbs.	26.5000									
Average variable costs per 100 lbs.	6.7446	7.6375	8.3517	9.0660	7.3399	7.8160	8.2922	7.1911	7.5482	7.9053
Oregon output (100 lbs.)	67,240									
Change in Oregon rents (-)		60,039	108.064	156,092	40,012	72,043	104,062	30,019	54,032	78,046
Percentage change in Oregon rents (-)		4.52	8.14	11.75	3.01	5.42	7.83	2.26	4.07	5.88
Chewings Fescue										
Price per 100 lbs.	26.7000									
Average variable costs per 100 lbs.	6.7446	7.6375	8.3517	9.0660	7.3399	7.8160	8.2922	7.1911	7.5482	7.9053
Oregon output (100 lbs.)	68,000									
Change in Oregon rents (-)		60,712	109,286	157,857	40,546	72,857	105,238	30,359	54,643	78,928
Percentage change in Oregon rents (-)		4.47	8.05	11.63	2.99	5.37	7.76	2.24	4.03	5.82
Merion-Kentucky Bluegrass										
Price per 100 lbs.	68.4000									
Average variable costs per 100 lbs.	7.5217	8.3269	8.9710	9.6151	8.0585	8.4679	8.9173	7.9243	8.2463	8.5684
Oregon output (100 lbs.)	27,520									
Change in Oregon rents (-)		22,159	39,884	57,610	14,773	26,589	38,407	11,080	19,942	28,805
Percentage change in Oregon rents (-)		2.05	3.89	5.33	1.37	2.46	3.56	1.03	1.85	2.67
Bentgrass										
Price per 100 lbs.	37.70									
Average variable costs per 100 lbs.	9.8754	11.3591	12.5460	13.7330	10.8645	11.6558	12.4471	10.6173	11.2107	11.8042
Oregon output (100 lbs.)	70.480									
Change in Oregon rents (-)		104,571	188,225	271,881	69,714	125,484	181,254	52,286	94,113	135,940
Percentage change in Oregon rents (-)		5.33	9.60	13.86	3.55	6.40	9.24	2.67	4.80	6.93

Table A-B. Estimated Oregon renta for various grass seeds in supply situation III without and with alternative open field burning control policiea at varying costs per acre for the mobile field sanitizer.

Seed Type	Initial Situation	Open Field Burning Control Policies and Mobile Sanitizer Cost per Acre								
		Ban on Burning			Once in Three Years			Alternate Year Burning		
		$5	$9	$13	$5	$9	$13	$5	$9	$13
Ryegrass										
Price per 100 lba.	6.86									
Average variable costs per 100 lbs.	2.68	3.0939	3.42494	3.74604	2.9595	3.1766	3.3974	2.8870	3.0525	3.2180
Oregon output (100 lbs.)	1,585,850	1,409,832	1,270,417	1,131,639	1,467,815	1,375,084	1,282,311	1,496,765	1,427,227	1,357,731
Change in Oregon rents (-)		1,319,285	2,264,844	3,104,929	903,641	1,563,869	2,188,723	682,206	1,194,686	1,683,997
Percentage change in Oregon rents (-)		19.90	34.17	46.84	13.63	23.59	33.02	10.29	18.02	25.40
Tall Fescue										
Price per 100 lbs.	12.08									
Average variable costs per 100 lbs.	4.6678	5.2588	5.73162	6.2044	5.0618	5,3770	5.6922	4.9633	5.1997	5.4361
Oregon output (100 lbs.)	102,880	93,563	86,422	79,282	96,537	92,779	87,017	98,025	94,455	90,885
Change in Oregon rents (-)		96,408	211,000	293,794	82,104	133,723	203,775	62,005	109,742	155,791
Percentage change in Oregon rents (-)		12.69	27.78	36.68	10.81	18.13	26.83	8.16	14.45	20.51
Red Fescue										
Price per 100 lbs.	26.50									
Average variable costs per 100 lbs.	6.7446	7.6375	8.3517	9.0660	7.3399	7.8160	8.2922	7.1911	7.5482	7.9053
Oregon output (100 lbs.)	67,240	62,975	59,568	56,161	64,395	62,123	59,852	65,105	63,401	61,698
Change in Oregon rents (-)		140,487	247,297	349,243	94,536	167,649	238,581	71,244	126,788	181,098
Percentage change in Oregon rents (-)		10.58	18.62	26.29	7.12	12.62	17.96	5.36	9.54	13.63
Chewings Fescue										
Price per 100 lbs.	26.70									
Average variable costs per 100 lbs.	6.7446	7.6375	8.3517	9.0660	7.3399	7.8160	8.2922	7.1911	7.5482	7.9053
Oregon output (100 lbs.)	68,000	65,668	60,546	57,235	65,236	63,029	60,822	65,925	64,270	62,615
Change in Oregon rents (-)		105,171	246,053	347,686	93,989	166,729	237,369	70,839	126,079	180,137
Percentage change in Oregon rents (-)		7.75	18.13	25.62	6.93	12.29	17.49	5.22	9.29	13.27
Merion-Kentucky Bluegrass										
Price per 100 lbs.	68,90									
Average variable costs per 100 lbs.	7.5217	8.3269	8.9710	9.6151	8.0585	8.4679	8.9173	7.9243	8.2463	8.5684
Oregon output (100 lbs.)	27,520	17,173	16,838	16,502	17,376	17,090	16,446	7,383	17,215	17,048
Change in Oregon rents (-)		40,036	71,173	101,938	23,076	47,473	93,782	20,317	36,105	51,725
Percentage change in Oregon rents (-)		3.71	6.59	9.44	2.14	4.39	8.68	1.88	3.34	4.79
Bentgrass										
Price per 100 lbs.	37.70									
Average variable costs per 100 lbs.	9.8754	11.3591	12.5460	13.7330	10.8645	11.6558	12.4471	10.6173	11.2107	11.8042
Oregon output (100 lbs.)	70,480	66,208	62,791	59,374	67,632	65,354	63,075	68,344	66,635	64,926
Change in Oregon rents (-)		217,100	381,634	538,059	146,141	258,987	368,252	110,133	195,964	279,766
Percentage change in Oregon rents (-)		11.07	19.46	27.44	7.45	13.21	18.78	5.62	9.99	14.27

APPENDIX B

DETERMINANTS OF GRASS SEED LAND VALUE DIFFERENTIALS

The model of grass seed land values developed in Chapter V was also employed to study the determinants of land value differentials. Land value differentials are defined here as the difference between the market and farm use values of agricultural land, where farm use value equals the capitalized value of the assessor's estimate of the rent per acre at which a given parcel of land could presently be leased.

Determinants of land value differentials are investigated because such differentials are large, positive, exhibit greater variance than market values, and necessarily reflect the future earnings anticipated from the Willamette Valley land presently in grass seed production.

The same three variants of the basic model were used. Determinants of land value differentials were investigated for Benton, Linn, and Marion counties individually and jointly, as well as for the eight Willamette Valley counties combined. The results are reported in Tables B-1 through B-3.

In general, the model performs less satisfactorily for land value differentials than for market values. However, as in the case of market values, model variant II performs better than variants I and III. The multiplicative functional form assumed for variant II once

Table B-1. Estimated determinants of land value differentials -- model variant I.

Variable or Statistic	county or counties: Benton	Linn	Marion	Three Counties	All Counties
Intercept	279.9287	165.4939	768.8398	311.3299	234.6726
Rent per Acre	2.8872	0.4198	-10.1798[a]	-2.0002	0.3904
	(1.832)	(0.265)	(-3.4187)	(-1.574)	(0.333)
Distance to town	-23.9125[a]	-13.1903[b]	-69.7724[a]	-21.2569[a]	-14.9188[a]
	(-4.804)	(-2.240)	(-7.8276)	(-5.311)	(-4.229)
R^2	.4972	.1045	.7132	.1982	.1171
$\bar{R}^2$	.4676	.0687	.6911	.1844	.1059
F-statistic	16.8120	2.9163	32.3231	14.3379	10.4816
Degrees of freedom	34	50	116	158	

Note: Figures in parentheses are t-statistics.

[a]Significant at the one percent level.

[b]Significant at the five percent level.

Table B-2. Estimated determinants of land value differentials -- model variant II.

Variable or Statistics	County or Counties				
	Benton	Linn	Marion	Three Counties	All Counties
Intercept	2.6075	1.9992	2.8629	2.3788	2.1778
Rent per acre	0.3180[b]	0.1838	0.3649	0.0487	0.1325
	(2.152)	(0.997)	(0.097)	(0.361)	(1.127)
Distance to town	-1.0240[a]	-0.4046[a]	-1.0638[a]	-0.5185[a]	-0.3492[a]
	(-4.599)	(-3.095)	(-3.625)	(-4.454)	(-3.930
R^2	.4828	.2072	.4097	.1730	.1130
$\bar{R}^2$	.4528	.1755	.3643	.1588	.1018
F-statistic	15.8718	6.5354	9.0237	12.1366	10.0744
Degrees of freedom	34	50	26	116	158

Note: Figures in parentheses are t-statistics.

[a]Significant at the one percent level.

[b]Significant at the five percent level.

Table B-3. Estimated determinants of land value differentials -- model variant III.

Variable or Statistic	County		
	Benton	Linn	Marion
Intercept	120.5948	130.6073	700.1061
Rent per acre	3.1019[b]	0.2898	-8.7482[b]
	(2.489)	(0.170)	(-2.586)
Distance to town	-5.4457	112.8631[b]	-63.3860[a]
	(-1.006)	(-2.115)	(-6.415)
Dummy 1	-21.1583	35.2514	4.5226
	(-1.175)	(0.700)	(0.098)
Dummy 2	126.4737[a]	49.6798	-2.9568
	(4.008)	(0.921)	(-0.028)
R^2	.7147	.1204	.6670
$\bar{R}^2$	.6790	.0456	.6115
F-statistic	20.0400	1.6419	12.0167
Degrees of freedom	32	48	24

Note: Figures in parentheses are t-statistics.

[a]Significant at the one percent level.

[b]Significant at the five percent level.

again appears more appropriate than the additive form most often used in land value studies.

The statistical significance for the distance-to-town variable supports the hypothesis that expected future earnings in non-agricultural uses are the most important determinant of land value differentials. In most cases, the regression coefficient of the rent variable is either statistically insignificant or has an unexpected sign.

Since land value differentials are calculated to minimize, though not eliminate, the influence of current earnings in grass seed production, these results usefully supplement the market value results reported in Chapter V.