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KENNETH JOSEPH ROBERTS for the DOCTOR OF PHILOSOPHY
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Title: ECONOMIC AND ENVIRONMENTAL TRADE-OFFS IN AN ESTUARINE BASED ECONOMY: A MODIFIED INPUT-OUTPUT MODEL OF CLATSOP COUNTY, OREGON

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R. Bruce Rettig

This study attempts to specify the environmental effects of economic activity in the Clatsop County, Oregon, economy. Investigation of this topic complements a previous input-output analysis of the economic impact of a major change (addition of an aluminum plant) in the county's economy. Despite an estimated impact of $36 million annually, construction of the aluminum plant has been forestalled due, in part, to public concern over the accompanying environmental impact.

The premise of this study is that monetary relationships revealed by input-output analysis provide incomplete insight to the trade-offs surrounding local economy growth. Consequently, environmental information is related to the economic sectors of Clatsop County in a modified input-output model. Linkages of economic sectors to the environment include data on non-market inputs

required from the natural resource system and the generation of residuals. Non-market inputs include the domestic, process, cooling, and total water requirements of economic sectors. Particulates, hydrocarbons, BOD, suspended solids, and logging residues are among the air, water, and solid waste residuals included in the analysis. Environmentally-provided, non-market inputs and the residuals are related to economic activity by means of a matrix, termed the ecologic matrix. This matrix identifies natural resource inputs used by economic sectors as imports from the environment and treats residuals flowing from economic activity as exports to the environment. Post-multiplying the ecologic matrix by the Leontief inverse reveals the first, second, etc., round environmental effects per dollar of delivery to final demand.

The model provides information as to the source(s) of environmental linkage with the economy, the corresponding magnitudes, and a proxy monetary choice indicator--supply price. This information is used to delineate the economic and environmental characteristics of growth. Analysis of the choice involving the aluminum plant reveals the following annual impacts: 1) $36 million of increased economic activity, 2) the release of; (a) approximately one million pounds of particulates, (b) approximately 40,000 pounds of BOD, (c) approximately six million pounds of suspended solids, and 3) the intake of approximately 14 and 38 million gallons of cooling and process water, respectively.

In the absence of an environmental inventory for Clatsop County and a delineation of relationships within the natural resource system to provide insight to the impact of residuals and non-market input utilization, alternative strategies for economic activity are developed from linear programming models using the author's perception of community goals. The ecologic and Leontief matrices provide values for the coefficients of the objective function and the constraint equations. Business income multipliers are the objective function's coefficients and deliveries to final demand are the unknowns. Constraints include maximum and minimum values for the unknowns and maximum allowable use of selected environmental goods. Three linear programming problems are designed to reveal trade-offs involving: 1) considerations of air quality and economic growth, 2) generation of water-borne residuals and economic growth, 3) combined air quality, water input, water-borne residuals, and solid waste considerations and economic growth.

Economic and Environmental Trade-Offs in an Estuarine Based Economy: A Modified Input-Output Model of Clatsop County, Oregon

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Head of Department of Agricultural Economics

Dean of Graduate School

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CHAPTER I

THE PHYSICAL, INSTITUTIONAL, AND THEORETICAL SETTING

Physical Features of Estuaries

The meeting of marine water and continental landforms presents man with a multitude of opportunities. Approximately one-third of the nation's twenty-six million estuarine acres serve as key habitat for a variety of biological activities (U. S. D. I. , 1970). Coastlines, in general, are also the base for many human activities. These activities include marine commercial and sport fishing, location of population centers, water-borne commerce, manufacturing and use of environmental goods.[1] In some coastal areas one or two uses predominate, while it is more common to witness a large number of uses. Multiple uses of the coastline occur most frequently in those areas of the

[1]Environmental goods include the physical units and services provided by the natural resource system without benefit of transfer through markets. The term is inclusive of final, intermediate, and assimilative use of non-market resources.

coastline that exhibit attributes deemed desirable by individuals, businesses, and institutions.

Judging from the different possible uses of the coastline, one would expect that places where many users discover desirable attributes would be places of transition. Such a location would have land and sea resources, thus supporting those uses dependent on either or both. The more severe the land-sea transition, the less desirable the area for man and animal alike. A gentle land-sea transition provides the attributes desired by many potential users. The coastal areas most subject to multiple use are estuaries, places of gentle transition. It would be tautological to define estuaries as coastal areas of multiple use. Estuaries should be defined in physical, geological, and biological terms.

The most widely accepted definition of an estuary was formulated by Pritchard:

> An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage (1967, p. 3).

The definition describes an area of transition from fresh to salt water, and from open sea to protected waters. This transition is not uniform across all estuaries. Drowned river valley estuaries exhibit a much gentler land-sea transition than do fjords or bar-built estuaries. The Oregon coastline has a preponderance of drowned river valley estuaries. They are known to be beneficial to populations of both terrestrial and aquatic environments.

The biological production that takes place in estuaries often surpasses that of the open sea and agricultural pursuits on land. Productivity is high due to the mixing of inflowing fresh water and nutrient-laden sea water in a semi-enclosed yet dynamic environment. Tidal marshes and mud flats are the source of a great deal of the food available in estuaries. The organic matter produced at such locations is bacterially changed to a basic food source called detritus. From this base extends a complex food web which includes the species man finds desirable to pursue for commercial and recreational purposes.

Estuary Multiple Use

The settlement of the North American continent by Europeans required safe harbors and direct access to ocean shipping. It was quite natural for initial settlements to locate near estuaries. Capital and labor were combined with natural resources in varied endeavors throughout the historic growth of the coastal area. Though the roots of this combination are historical, estuaries continue to be the site of much economic activity. Coastal counties in the United States contain approximately one-third of the total population. Nearly 40 percent of the country's industry is located in the area (U. S. D. I., 1970). Some components of the associated economic activity, marine recreation and commercial fishing, in particular, require biological healthiness of estuaries.

The uses that exist in estuaries as a result of the growth process are similar to those found in other areas. National concern has been expressed that the similarity is approaching identity! Estuaries, it is reasoned, offer unique features that are required by certain economic pursuits. Water-borne transportation, commercial fishing, and marine recreation are estuarine dependent. Use of estuarine resources by entities not dependent on the uniqueness of the resources adds to the scarcity problem of dependent uses. Multiple use is a fact. The situation is not one where designated administrators need to consider replacing a single use with several. This process was experienced by the U. S. Forest Service in their endeavor to plan for multiple use. The task confronting estuarine managers at all decision levels in many instances approaches an antithesis of the Forest Service management problem.

There are numerous biological, economic, and biological-economic interdependencies existing in any given estuary. In the biophysical sense alone all estuaries are subject to multiple use. Within limits, however, it is not these interdependencies that result in resource use problems. Multiple use problems arise primarily from economic interdependencies or biological-economic interdependencies. Thus, the biological and economic advantages of estuaries also often result in resource use problems via interdependencies.

Multiple Use as a Management Scheme

Combined private and public control of estuarine resources is the rule and not the exception. The varied resources available are managed by nearly three dozen federal, state, and local agencies. No agency has complete public responsibility although the San Francisco Bay Area Development Commission has set a precedent that may likely be followed. The experience in San Francisco indicates that as fragmented authority in coastal states is replaced by coordinated management, public goals and administrative responsibilities become more explicit. Oregon's Coastal Conservation and Development Commission (OCCDC), created by the 1972 legislature, has similar responsibility for planning the use of Oregon's coastal resources.

The multiple use concept is frequently referred to during the development of the management framework of coastal authorities (E. P. A., 1971). As the delineation of administrative responsibilities progresses, public management will receive a new opportunity. The status quo of estuarine resource utilization combined with a national policy supportive of multiple use suggest that local public management may approach allocation problems with multiple use as a goal. The wisdom of this approach needs to be analyzed following comments directed at the national level goal statement.

The nature of the national goal is such that a critic would have few sympathizers. Studies of estuaries at the national level in fact have found it uncontroversial. Perhaps the appeal is because "multiple use" implies that everyone is going to get some of the resource in question. However, it is very likely that application of this philosophy will leave resource users and managers equally dissatisfied. Estuarine conflicts seldom surface because of lack of access to resources. Rather, the problem is one of gaining the desired share. Multiple use as a management scheme is inoperable in this sense. No strategy exists for implementing the multiple use philosophy of allocating resources among the public and private rights typically found in estuaries.

The criticism of federal study recommendations (e. g., E. P. A., 1971) may appear as being in opposition with the comments of Ralph D'Arge (1971). In addressing the subject in general he has emphasized that the role of the policy maker is to identify broad objectives. D'Arge reasons further that objectives so stated are useful in the planning process in the following ways:

1. These national objectives. . . have meaning to policy-makers and the body public, i. e., they are able to

conceptualize and establish priorities in terms of multi-faceted aggregative objectives.

2. The relationship between a national objective such as enhancement of the quality of the environment and a subordinate statement (or sub-objective) defining its domain such as improved water quality is generally not empirically measurable but can be subjectively evaluated as to sign.

3. By determining the logical subordinates of national objectives and the logical subordinates of logical subordinates, in many instances this process will yield a subordinate list which is quantitatively measurable (1971, p. 82).

The comment is logically applicable to the objectives of greater social well-being, increased national economic growth, enhanced environmental quality, and greater regional development recently set forward by the Water Resources Council (1970). However, the multiple use objective represents a narrowing of the optimum use objective implied by the Water Resources Council Report without a concomitant aid to decision makers.

The multiple use objective as commonly stated refers to positive and negative aspects of choices. For example, the National Estuarine Pollution Study yielded the following statement of objectives:

> . . . while people need commercial development and use, they want a safe and enjoyable environment at the same time. Effective management, therefore, should direct its efforts not toward excluding some uses, but toward accommodating all uses without environmental damage (1970, p. 186).

Viewing environmental damage as a cost of maximum economic development to be minimized or forced to zero raises a more fundamental objection than that outlined previously. National level multiple use objective statements may represent impossible tasks for public policy. The probability of achieving the simultaneous maximization of monetary benefits from estuarine resource utilization and minimization of related environmental costs is zero. To be certain, benefit-cost considerations are essential elements of public choice. However, simultaneous maximization and minimization represents an ubiquity to those entrusted with public choice.

Comments directed at the national level focused on the possibility that objectives of public estuarine policy may be incorrectly stated. Returning to the multiple use objective at the local level, the topic of suboptimization comes to the surface. Local level emphasis is to be directed at the infatuation of local decision makers with multiple use objectives.[2] The reference to D'Arge (1971) points out the desired relationship between national and subordinate objectives. Local management unit adoption of a high-level objective can lead to results inconsistent to those sought at the national level. McKean (1964) has written of the sub-optimizing results of inconsistency between "high-level" and "low-level" objectives within private firms.[3] Sub-optimizing

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[2] For example, the development goal of Yaquina Bay, Oregon, has been stated as:

> . . . provision of space for all types of water-oriented economic development, preservation of natural resources, and protection of major public facilities (Gloege, 1969, p. 94).

[3] The logic of public firm decision making applied to joint product problems is not generally applicable to the coastal zone

can be experienced if local level objectives are consistent with the national level. A direct application of multiple use objectives in local analysis of resource allocation problems requires recognition of the possibility that single use could replace multiple use, a possibility that a national level multiple use objective for a total resource should not be construed to exclude. Likewise, the arguments to be developed in the following sections will serve to indicate that multiple use should not be implied to mean there are no limits to the number and extent of approved uses. Multiple use, for analytical purposes, is a concept allowing for exclusion of some (including n-1 where n uses exist) uses from a particular area and for varying usage levels for those uses which are permitted.

Coastal Zone Management in the Public Arena

The previous section contained a discussion of the wisdom of viewing a strict interpretation of multiple use as a goal *per se*. In the public arena, however, attempts at agency control of coastal resource

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problem. Public firms (agencies) are evident in the coastal zone as well as private firms. The decision calculus, as well as the objectives, differ between them. The implications of this difference have been emphasized by Kelso:

> When resource use is under the joint control of two (or more) public and/or private firms, maximum net social product will result from its use only when the goals and expectations of the firms are alike, only when the time pattern of their inputs (costs) are comparable, and only when they share in returns comparable to their share in costs (1952, p. 137).

utilization generally focus on delineating bounds of power. Federal, state, and local governments have designated agencies to oversee coastal resource use. Generally, the agencies operate within local mandates and congressionally defined responsibilities. The implementation of various instruments, however, in meeting designated responsibilities seldom functions smoothly. The presence of fixed and mobile resources in coastal areas combined with the private use of common property create nebulous areas in which responsibilities are not, in practice, well defined. This situation occurs within each of the three governmental levels. Between levels the responsibilities for regulation and management are no less the source of disputes and inefficiencies. This discussion does not imply the political environment in which management of the coastal zone functions is atypical. Indeed, that adjective would better describe the absence of such conditions.

The report of the Stratton Commission popularized the concept of coastal zone management. The substance of the findings of the Commission and those emerging from the National Estuarine Pollution Study are worthy of review.

Stratton Commission

The Commission culminated from earlier efforts (e. g. , Marine Resources and Engineering Development Act of 1966) at focusing national interest on developing United States policy for use of the sea. Coastal zone management, actually the lack thereof, was a subject that received much attention. The Commission outlined the reasons for the coastal zone situation and formulated a management plan. Although federal, state, and local governments share the responsibility of allocating coastal resources, the states received most of the criticism. A lack of state support for marine activities combined with the lack of long-range planning were cited. States were logically depicted as the tie between local and federal decision makers. The lack of leadership and planning at the state level resulted in states reacting to stimuli rather than assuming an action role. In essence, the situation was depicted as one where regulations were substituted for management.

The Commission recommended legislation designed to encourage states to plan for management of the coastal zone. A Coastal Management Act was proposed for consideration by Congress. As proposed, the Act provided for financial assistance to the states interested in establishing Coastal Zone Management Authorities. The assistance was to be directed at both operating costs and the cost of planning studies experienced by the Authorities. States were to receive one-half of the operating cost for the first two years of work. Additional recommendations dealt with the composition and powers of the Authority. Each state has a somewhat different bundle of coastal resources as well as its own institutional framework. For this reason the Commission did not formulate a model organization to be followed. The focus was on allowing for existing agency representation, but not domination by any particular one, in addition to participation by individuals not formally associated with existing government agencies. Planning, regulatory activities, land acquisition, and provision of needed public facilities are among the suggested powers. It was judged that these are the powers necessary for securing the designated end of the authorities, to maximize net social return. The proposed authorities were to work toward this end by employing their powers so as to bring about "the widest possible variety of beneficial uses" in the coastal zone (Our Nation and the Sea, 1969, p. 57). Multiple use is again cast as a necessary and sufficient prerequisite to achieving maximum social return.

National Estuarine Pollution Study

Provisions in the Clean Water Restoration Act of 1966 required that a national study of estuaries be conducted by the United States Department of the Interior. The task was to determine the current status of the resources of the coastal zone, particularly the estuaries. In addition, recommendations for a national program in the coastal zone and a delineation of responsibilities for federal, state, and local governments were made. The status report described a situation in which the land, water, and human resources of the areas were being poorly utilized. Water pollution and estuarine filling were among many problems that prevented the attainment of higher social and economic values.

Recommendations concerning regulatory responsibility were directed to existing public institutions. There was no effort to design national legislation. Federal grants, however, were suggested to encourage the development of intrastate coastal management organizations. In addition to serving as a source of funds, the federal government was viewed as being responsible for protecting the federal interest in the resources of the zone, aiding commerce and navigation, and assuring the nation's coastal security (National Estuarine Pollution Study, 1970, p. 344).

The findings of the U. S. Department of Interior indicate the states were in a strategic position regarding resolution of coastal zone resource allocation problems. The states are responsible for water and public land management. In an effort to meet this responsibility, as well as being a link between the local and federal levels, the states must develop interagency organizations with the authority to resolve conflicts. The state-local linkage was represented as being the key to the successful exercise of local government responsibility. Local governments make the day-to-day decisions that have the greatest impact on striking a balance between private and public use. However, this is also the level at which financial, research, and regulatory resources are in short supply relative to the management requirements. Public sector resources will be required if local governmental units are to be successful in meeting their responsibility for shoreline land use, waste treatment, and economic development. It is the author's understanding that the resource redistribution could take place by indirect means. Such would be the case if the federal and state agencies served as resources to aid, not substitute for, local decision making.

Economic Theory and Coastal Resource Use Conflicts

The preceding discourse on estuary multiple use centered on describing current conditions. It was emphasized that the conditions were a result of competitive forces at work in the utilization of the nation's estuaries. In order to gain an understanding of the reasons behind the described interactions, reference will be made to economic theory. Of particular interest is an explanation of the goods produced from estuarine resources, the private and public rights to the resources, and the relationship of these factors to the socially desired mix of goods.

Product Possibilities

Estuaries are typically subject to many uses due to the diverse resources present within their somewhat arbitrarily specified confines. Without exception, the resources are not managed by a single decision maker. This situation is one of contrast to the agriculturist. Decisions as to which products should flow from the available resources are made by the farmer. The bundle of resources are subject to the exclusive use and control of the farmer. The magnitude of the returns to management is dependent upon his ability to properly identify product interdependencies. Assuming that the resources utilized by the farmer are available for his exclusive use once secured by contract, the product interdependencies are generally not subject to alteration by the actions of other farmers. In the case of estuaries, product interdependencies are synonymous with resource user interdependencies. The source of the disparity between agricultural and estuarine production relationships is found in the nature of many estuarine resources.

Individual economic units generally employ an internal decision calculus when evaluating product interdependencies prior to selecting the desired product mix. In the economic theory of joint production this can be represented by the production possibilities curve. The production possibilities curve provides the decision maker with a means of identifying the most desirable combination of products. In the simple case of two products (Figure 1) the choice between feasible combinations of products Y and Z, represented by the production

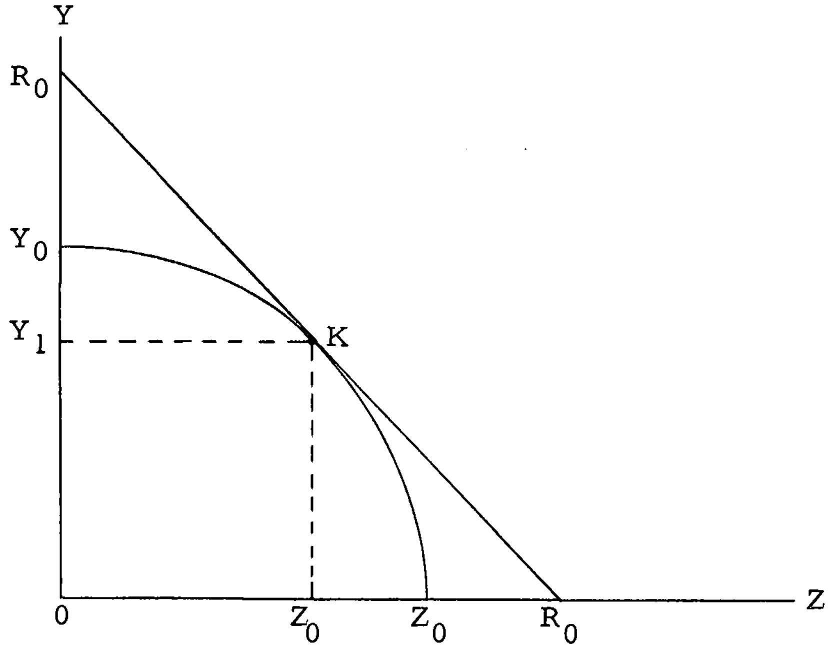

Figure 1. Hypothetical Production Possibilities and Iso-Revenue Curves.

possibilities curve Y_oZ_o, can be simplified by adopting the iso-revenue line R_oR_o. This framework is generally used to determine which combination of two products is the most profitable given some level of an input or input bundle. In the process of determining that combination (K), the product-product interdependencies are revealed. Product-product relationships can be classified as competitive, supplementary or complementary depending upon the production possibilities from a given bundle of resources. A competitive relationship exists if more of one product requires that less of the other be produced from the given resources (Figure 1).

Two products are said to be supplementary when more of one product does not necessitate that a smaller magnitude of the other be produced. In essence this can be interpreted as a situation where independence of products exists. A similar beneficial situation prevails when complementary products are involved. Here the increased production of both products can take place. The relationship of complementary products is one of mutual benefit. Thus, in joint production, one productive process may complement or be independent of another. It must be emphasized though, that while this relationship is not uncommon, it seldom proceeds indefinitely. Competitive relationships generally prevail in production endeavors.

Product-product relationships in estuarine systems merit elaboration in relation to representation by means of the production possibilities framework. Production possibilities curves as typically employed in agricultural production problems are static; the curve illustrates the maximum amount of Y that can be produced in a period given a level of Z. A means of allowing for the dynamic situation where one producer's strategy over time is tied to another producer's strategy over time would be a desirable format for inspection of production alternatives involving common property resources and externalities. An alternate format will be presented following discussion of common property and externality implications to product possibilities.

Few estuarine resource users have the ability or opportunity to obtain exclusive use of a quantity of some desired input. The semi-enclosed dynamic system in estuaries provides a second complexity to a theoretical treatment of product possibilities, externalities. The first complexity obstructs the simple application of the production possibilities approach because some resources fall into the common property classification. An implicit assumption of the production possibilities approach is that the producer has exclusive use of a certain level of productive factor. Without deeded ownership or ownership acquired through market purchase, the resource user embarks upon a decision calculus far afield from that found in the traditional implementation of production possibility theory. The common property nature of a fish stock (biomass) can serve as an example. A prime determinant of the level of output, fish, is the magnitude of the fish stock prior to fishing. For illustration, assume a representative fisherman has a well defined production function which can formally be stated as:

$$F = h(n, e, S) \tag{1.1}$$

The volume of fish, F, he lands is not determined solely by his actions on the existing stock, S. The common property aspect of the total stock forces him to consider the effects of boat numbers, n, and effort per boat, e. A fisherman's decision calculus becomes quite simple in this case, catch as many fish as possible. To husband the resource by evaluating the product possibilities of catch versus escape will result in foregoing output to other vessels. The common property aspect of the fishery forces the individual fisherman to view the fish stock (an input) purely as an exploitable output.

A second force, externalities, is often at work in estuarine areas to further complicate product (user) relationships. This is a situation whereby the outcome of a firm's decision has an impact on other productive endeavors. The effect is termed an external diseconomy if it is detrimental to the receiving firm's effort to achieve a designated goal. Thus, external diseconomies lead to distortions of the recipient's product possibilities. The distortions are frequently represented as the source of disputes between two fresh water users, the downstream user suffering from the waste discharge of the upstream producer. When private property rights are affected, as will be the case if the downstream user is a riparian land owner, public institutions must be utilized for corrective action. Exercise of the legal process by the downstream user often occurs. A suit can result in the payment of damages by enforcement of a punitive law or an agreement to cease the contested practice. If the judicial system experiences a large number of such cases or public rights to the water are being usurped, controls on the productive processes of all users may be established. This involves the genesis of public institutions on a local, state, and regional basis.

Though an estuarine system has few physical and biological similarities to fresh water streams, externalities within their confines cannot be considered anomalies. Treatment of the problem requires inputs from the public sector to a larger degree than the previously mentioned situation inland.[4] The common property nature of some estuarine resources interferes with attempts, employing voluntary agreements, to improve the situation. Legal action between involved parties is also negated. Private property rights generally serve as a basis of most claims but in this case their absence precludes determination of guilt. The common property problem and that of external diseconomies are then closely related. This is particularly evident when considering the product possibilities of people within the same industry. Fishermen, for instance, that harvest the same species are directly affected by individual actions. As previously mentioned, economic incentives to husband the resource are non-existent. This is due to the collective good aspect of the benefits generated from individual action as opposed to the incidence of the cost. Should a fisherman, as a member of an assumed perfectly competitive industry, invest in next season's harvest by taking fewer

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[4] The word "treatment" is used despite frequent use of "solution" in the resource utilization literature. Buchanan and Stubblebine, as well as Kneese and Ayres, have recently provided valuable insight that questions the wisdom (and ability) of the public sector's attempt to eradicate external diseconomies. Reference will be made to their contribution in the following section.

of the fish this season, his expectations of returns to investment will not be realized. Since all fishermen view the results of unilateral action as a negative return to individual investment, the product possibilities of the fish stock are restricted.

The potential of an estuary to yield a mix of products is also affected by the productive interdependence of firms producing different products. Commercial and sport fishermen frequently find the creation of marketable real estate from marshland a threat to their well being. Private rights to the marshland do not allow unrestricted dredging and filling. The processes remove or diminish an input felt to be essential to the productivity of fish stocks. Using the marshland as strictly a quantity variable, the production function of an estuarine dependent fish stock can be represented by equation 1.2.

$$X = f(K_1, \ldots, K_n; M) \tag{1.2}$$

where $K_1, \ldots, K_n$ is a group of unspecified biological factors and M is the quantity of marshland. Fishing interests have initiated legal action on occasion in an effort to protect their source of income. The legal action generally involves the claim that proper institutional channels were not followed prior to the modifications. Dredging permits, environmental impact statements, and zoning changes are examples of requirements established by the public sector to protect marshland.

A direct settlement is a theoretical possibility and a real world anomaly. Assuming one fisherman and one real estate developer to be involved in a dispute, there exists an avenue for agreement. For example, diking and filling of the marsh may enable the developer to realize an annual $4,000 profit. The harmful effects of this procedure to the fisherman may result in a $6,000 lower net return.[5] In the presence of zero or low contracting costs (those costs associated with reaching an agreement) the situation presents the opponents with an incentive to become traders. The developer would be as well off, financially, if he could secure a payment from the fisherman of $4,000 or greater. The fisherman would be willing to pay a sum of less than $6,000 to secure a trade of the developer's real estate plan. A final agreement will fall in the interval, the greatest percentage of the $2,000 being secured by the party demonstrating the most bargaining expertise.

Real world complexities, such as numerous fishermen instead of one, render the cited case as trivial. In the presence of many fishermen the benefits of an agreement to the industry may be sizable yet they contain an element of collectivism. The collective-good aspects of the benefits result in the same inaction outlined previously among

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[5] The net return may drop due to an increase in costs as the fisherman must search and fish more intensively to maintain his harvest. It is also possible that the fish stock can be so altered by the depletion of its food web that total revenue falls. Of course, a combination of the two factors could occur.

individuals within the same industry. An additional complication stems from the existence of contracting costs. A team of researchers at Massachusetts Institute of Technology (MIT) has made specific reference to the endeavors of the public sector to remedy the situation and consequently alter the trend of reduced product possibilities. To quote:

> Strictly speaking, a private market can achieve Pareto-efficiency only if the social costs of achieving and insuring the voluntary agreements through which the market operates, and of providing the information upon which these agreements should be based, are zero.
>
> In situations where contracting costs are large, reliance on governmental allocation mechanisms may be more efficient than the use of the market for government need not incur the costs of securing the consent of all those who would have to be a party to a voluntary agreement (1971, p. 29).

A proliferation of federal, state, and local controls is being proposed to handle the job of resolving estuarine user disputes. Many timely studies could be developed around the composition of the regulatory agencies. Specification of the economic relationships among productive endeavors will provide information valuable to the individuals determining the make-up of estuarine resource managers. This is particularly important in light of the known benefits to each party in the example involving zero contracting costs. Both parties can financially benefit from trade. The essential task facing administrators is to design government allocation mechanisms so as to preserve the opportunity for mutual benefit. In fact, it has been suggested that this capability be a demonstrated capability of newly proposed regulatory agencies.

The Phase-Space Concept

The presence and intensity of common property and externality issues of estuarine resource allocations indicate that public choice in the coastal zone involves product bundles not efficient points. Boulding (1970) has outlined a framework depicting dynamic relationships among natural populations that can be extended to economic sectors for an alternate view of resource utilization. The diversion is from the traditional efficiency oriented approach to one representing multi-firm product bundles of mutually necessary non-market resources.

An elementary example of Boulding's (1970, p. 26) phase-space approach involves populations of lions and tigers (Figure 2). Assuming the lions and tigers live off similar resources, lions and tigers are interdependent populations. Two product curves are required to represent the system: a lion curve (LL') depicting the number of lions in equilibrium given a population of tigers; a tiger curve (TT') depicting the number of tigers in equilibrium given a population of lions. The two "curves" intersect at E, a stable equilibrium point of OG tigers and GE lions. Observable points in Figure 2, unlike the feasible range of a possibility curve, include those exterior to LL' and TT'. Assume three food sources, α, β, and γ, are available to

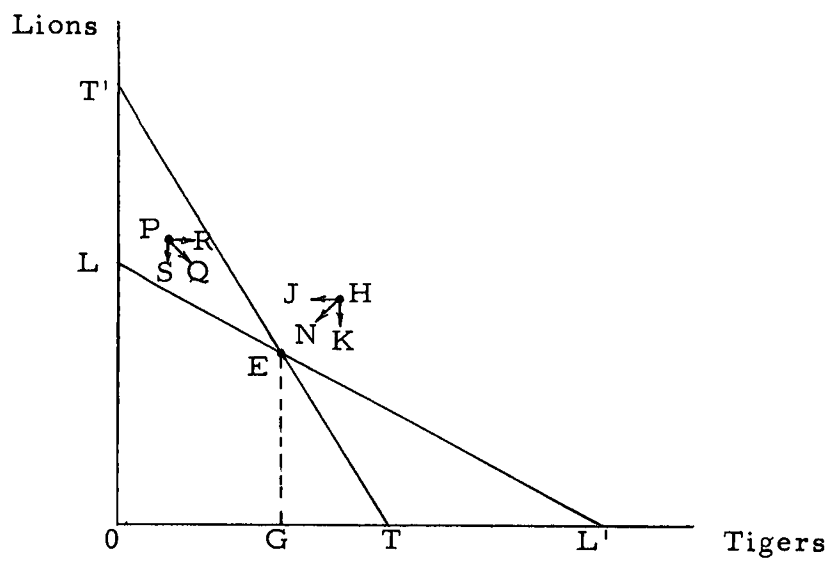

Figure 2. Hypothetical Representation of Stable Equilibrium of Lion and Tiger Populations.

the two populations: both species feed on α, lions also require β, and tigers also feed on γ. Choosing a point such as H will indicate that the tiger population tends toward the tiger curve via vector J, and the lion population tends toward LL', via vector K. The implication being that α, β, and γ are in such short supply that both populations decrease. The assumption giving rise to vectors J and K is of the same nature as that of Cournot's in the classical solution to the duopoly problem, i. e. , J and K involve the behavioral assumption that each population proceeds as if the rival population were static. Since the populations are assumed to be interdependent, the population change will be toward E, a stable equilibrium point of OG tigers and

GE lions, by the more direct route of vector N. Point P in Figure 2 characterizes a situation involving adequate amounts of α and γ to permit the tiger population to expand (R) but a shortage of food unique to lions (β). Consequently, the lion population declines via S. The interdependency of the populations again can be traced toward E by vector Q.

Application of the phase-space concept to resource utilization suggests that economic sectors be substituted for biological populations. Furthermore, that the development of the "curves" be based on all resource relationships and not simply on the market dominated production relationship common to the product possibilities method. As with the production possibilities curve, competitive, complementary, and supplementary relationships are possible among economic sectors. However, incorporation of non-market resource complexities such as externalities brings about the possibility of stable or unstable equilibria.

A competitive relationship between economic sectors A and B resulting in a stable equilibrium is shown in Figure 3. For purposes of illustration it can be assumed that the two sectors are dependent on tideland resources. If the output level of B is equal to zero, OA_1 units of A would be produced. If OA_2 of B is produced, there will be no A. Similarly, if there is zero of A, OB_1 units of B are produced and if OB_2 units of A are produced, there will be no B. Choosing any point

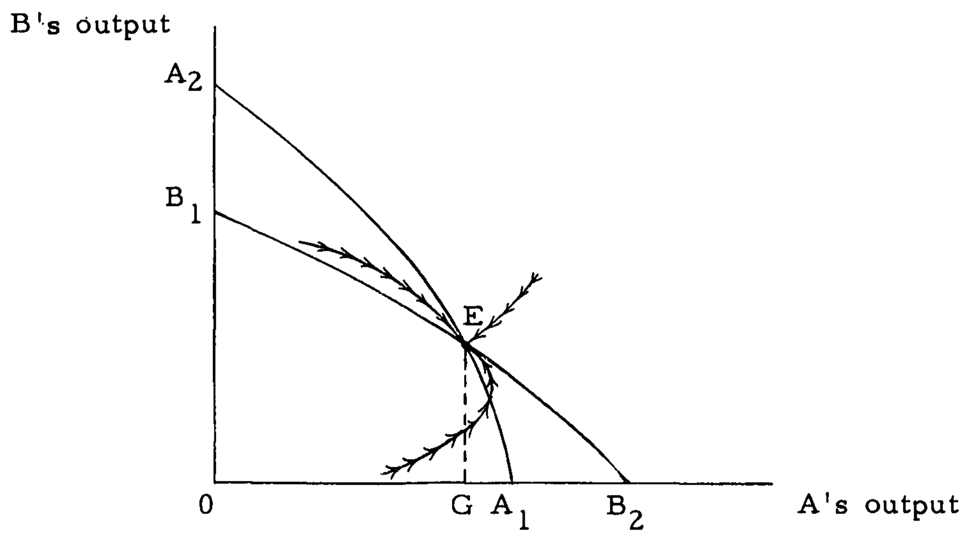

Figure 3. Hypothetical Representation of Stable Equilibrium Resulting from Competitive Economic Relationships.

in the space other than E will result in vector movement toward E. The possible vector paths are indicated by a series of connected arrows. Product levels at the stable equilibrium point, E, are OG of sector A and GE of sector B. The existence of a stable equilibrium point does not assure the production of the equilibrium level of either or both products. For example, it is possible that level GE of product B, though stable from a resource requirement standpoint, would prove to be an economically infeasible level of production.

In the midst of common property and externality problems public agencies seldom adopt a laissez-faire policy necessary to yield the corner solution in the above example. Management efforts to direct the economic activity could include, singly or in combination, land use planning, water and land zoning, effluent charges, effluent standards, environmental impact statements, etc. Graphically such efforts can be depicted as attempts to change the slope of B_1B_2 to B_1B_3 as shown in Figure 4. Sector A's use of the tideland resource has been altered in such a way as to permit sector B to exist in stable equilibrium at an economically feasible level of output, NR. Through public management the level of A produced falls by NG to permit B to increase from zero to NR units. An increase in B's activity requires a reduction in A because of the reciprocal nature of the competitive situation. Sector A would not experience reduced output if the A curve were vertical, i. e., sector A exhibits complete independence from B's output level.

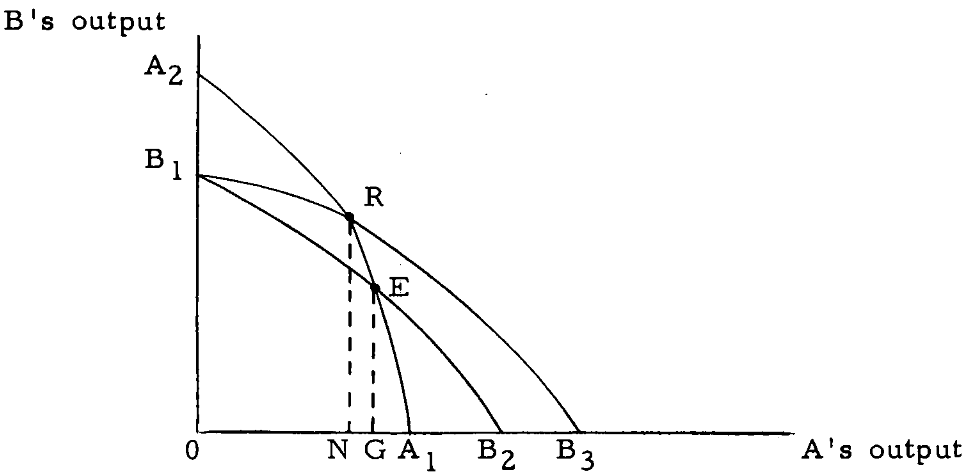

Figure 4. Hypothetical Representation of Changes in Stable Equilibrium Points.

Phase-space curves demonstrating complementary relationships at low output levels and competitive relationships at higher levels are also possible. Figure 5 represents two sectors, each of which is directly dependent on a certain resource and, consequently, indirectly dependent on the other sector's output. Two sets of vectors indicate the situation faced by public resource managers. Management efforts should be directed toward preserving a combination of output above line SRT. Output combination below SRT may be brought about by improper management of the common resource with the consequent failure of economic activity.[6] The issues in both cases have a definite normative political economy flavor, i. e., a certain decision must be reached and management tools applied.

Estimation of trade-offs between economic sector activity and related non-market resources and residuals is the real world paradigm of the conceptual matters discussed in the above examples. In this light, the task of Chapters II and III will be to delineate a model, give it empirical life, and evaluate the results.

Market Allocation

The preceding discourse related economic nomenclature to

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[6] Wantrup's (1968) statement of irreversibility and correlated argument for safe minimum standards of resource utilization is an effort to avert collapse of economic sectors dependent on the common resource, i. e., points below SRT (Figure 5).

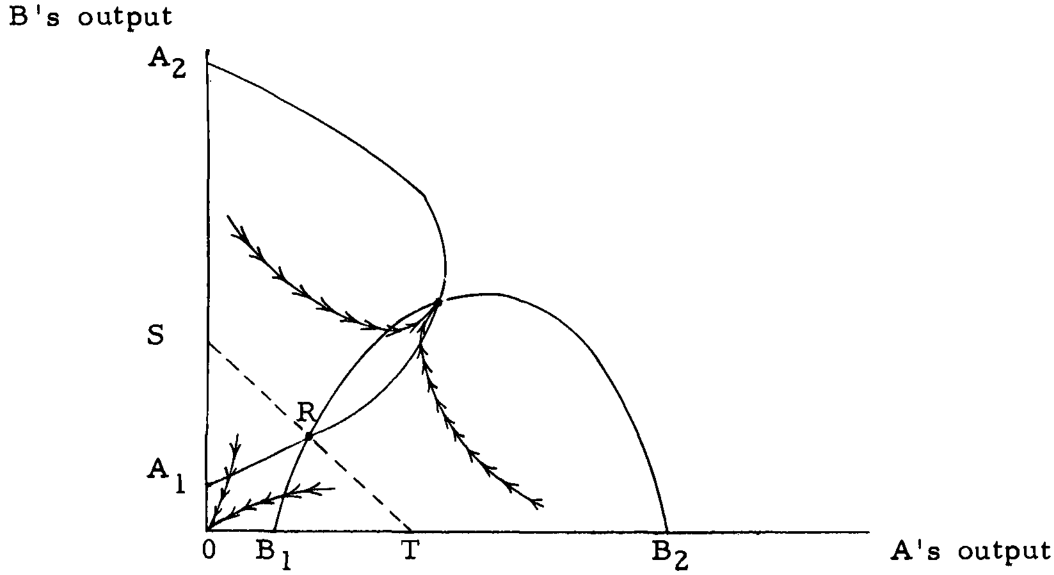

Figure 5. Hypothetical Representation of Combined Complementary and Competitive Relationships.

resource use problems typically encountered in the estuarine component of the coastal zone. This facilitated an explanation of the source of utilization difficulties. Further explanation, however, is required to grasp an understanding of the societal significance of the events. Economists frequently employ the theory of welfare economics to assess the implications. This author will not be an exception.

Welfare economics provides academic ammunition for both positive and normative economists. For current purposes the input it can make to explain the significance of certain situations is of most interest. A logical beginning involves a comparison of the real world with that outlined in welfare theory. Many authors have written of the requirements to attain the maximum of society's welfare. Bator describes it with the following terms:

> It is the central theorem of modern welfare economics that under certain strong assumptions about technology, tastes and producer's motivations, the equilibrium conditions which characterize a system of competitive markets will exactly correspond to the requirements of Paretial efficiency. Further, if competitively imputed incomes are continuously redistributed in costless lump-sum fashion so as to achieve the income-distribution implied by a social welfare function, then the competitive market solution will correspond to the one electronically calculated Pareto-efficient solution which maximizes, subject only to tastes, technology and initial endowments, that particular welfare function (1958, p. 351).

In essence, Bator reached the same conclusion as did Adam Smith. Smith concluded that self-interest as the basis of individual action will result in a situation found desirable by society as a whole. The "invisible hand" thus works by means of the same binary relationship as that outlined by Bator.

The operating perfection required to obtain a Pareto efficient point means perfectly functioning markets for all goods. Given such markets, the prices determined will be those that lead to a Pareto efficient combination of goods. The theoretical development of Pareto efficiency conditions includes efficiency in production, consumption, and exchange. The occurrence of factors that prevent the realization of such conditions generates waste. This is the essence of the appeal to welfare economics to yield insight to the social significance of estuarine resource use problems. Krutilla addresses the subject in the following manner.

> When we address the question of what, in lay terminology, is waste, we confront what, in economic terminology, is economic inefficiency or misallocation of resources. To understand misallocation, we need to define an optimal allocation, and we find ourselves in the midst of the issues and problems of welfare economics (1969, p. 1).

Common property and external diseconomies, the phenomena discussed in the previous section, are of significance because they represent aberrations in perfectly functioning markets. With the former it is evident that non-existent or unclear institutional specifications of property rights to fishery resources and bottomlands has often led to the collective good problem. Producers under such circumstances are unable to acquire exclusive rights to the benefits that would be generated by conserving rather than mining the resource. The significance of the situation has been outlined in an MIT study:

> In general, then, the unaided price mechanism cannot be expected to operate toward a Pareto-efficient configuration in cases where private property rights (exclusion) cannot be established efficiently. On the goods (output) side this leads to underprovision of collective goods by the private market, and <u>on the resource (input) side it leads to over-exploitation of those resources for which private property rights cannot or have not been established</u> (emphasis added) (1970, p. 22).

The outputs of the biological and physical processes occurring in the coastal zone are the basis of life for some of the resources on the input side. Though indirectly valuable to many people, the provision of biological outputs necessary for the productive process will not be undertaken by an individual. By ensuring the productive base for the resource side of the market an individual creates equal opportunities to those that fail to follow suit. The absence of property rights to the benefits of unilateral action spawns a lack of investment for such purposes and a consequent underprovision of resources basic to many economic endeavors. Whether the right to exclude does not exist due to inadequacy of institutional specification or the presence of sizable contracting costs, the result is identical, i.e., a production or use strategy evolves different from that which would exist under perfectly functioning Pareto efficient markets.

External diseconomies are the second important influence that can short-circuit markets. When technological external diseconomies between fiscally independent firms go uncompensated, misallocation of resources occurs and the full benefits to society of resource utilization never materialize. In addressing the subject, Coase (1960) and Buchanan and Stubblebine (1962) have developed a framework which suggests that Pareto optimality is not necessarily synonymous with the absence of technological externalities.

The more recent contribution was made by Buchanan and Stubblebine. Essentially they incorporate the exchange or trade concept in an evaluation of the rationale of reflex extra-market intervention. Theorists had represented externalities as an immediate stimulus for such action. The devotion by theorists to the party inflicting the undesired effort focused undue attention on the order of events. The topic of externalities merits academic resources due to their effect on economic efficiency and not on the basis of equity considerations. Consequently, Buchanan and Stubblebine employed the trade concept in dealing with externalities. Referring to their contribution indicates the significance to an understanding of the relationship between externalities and Pareto efficiency:

> An externality is defined to be Pareto-relevant when the extent of the activity may be modified in such a way that the externally affected party, A, can be made better off without the acting party, B, being made worse off. That is to say, "gains from trade" characterize the Pareto-relevant externality, trade that takes the form of some change in the activity of B as his part of the bargain. . . . What vanishes in Pareto equilibrium are the Pareto-relevant externalities. . . . This point has significant policy implications for it suggests that the observation of external effects, taken alone, cannot provide a basis for judgement concerning the desirability of some modification in an existing state of affairs. There is not a prima facie case for intervention in all cases where an externality is observed to exist (1962, p. 374).

Prior to the Buchanan-Stubblebine analysis, Coase addressed the problem of extra-market intervention. While Buchanan and Stubblebine suggested that extra-market intervention may be too frequently employed, Coase revealed similar conclusions. The implication of the former dealt with frequency and appropriateness while the latter revolved around incidence of intervention. The matter of who benefits and who pays in treating problems of social cost prompted Coase to reason:

> The traditional approach has tended to obscure the nature of the choice that has to be made. The question is commonly thought of as one in which A inflicts harm on B and what has to be decided is: how should we restrain A? But this is

> wrong. We are dealing with a problem of a reciprocal nature. To avoid the harm to B would inflict harm on A. The real question that has to be decided is: should A be allowed to harm B or should B be allowed to harm A? The problem is to avoid the more serious harm (1960, p. 2).

Actual observation of resource allocation in the coastal zone, particularly estuaries, clearly indicates that multiple use is the rule and not the exception. An equally obvious fact is that many private market imperfections exist within their confines. The Coase and the Buchanan and Stubblebine message is of notable importance to related management efforts. For instance, many of the goods "produced" in the coastal zone are public goods and public efforts to preserve the supply may run contrary to their reasoning. Additional complexities involving poorly delineated jurisdictions among agencies generate a competitive attitude to "solve" all imperfections. Thus, while a Pareto efficient point can generally be thought of as resulting in a combination of goods which implies multiple use of a resource base, the occurrence of multiple use (by market forces or design) does not necessarily imply Pareto efficiency.

CHAPTER II

THE MODEL

Clatsop Input-Output Analysis

Clatsop County, Oregon, is characterized by marine and estuarine coastline suitable for biological and economic activities. Within the county the activities include protein production through a complex natural food web, commercial and sport fishing, manufacturing, and marine shipping. Economic activity and population centers are predominately located on the estuarine shoreline. Geographic characteristics indicate that a definite marine orientation exists in the economy. As outlined in the preceding chapter, this factor indicates that decisions involving public choice in the community are indeed complex. Thus, Clatsop County can serve as the study area for the following investigation of the growth complexities to be found in coastal communities.

Clatsop County Economic Growth

Previous effort (Collin, 1970) has been devoted to the inter-industry analysis of new industry in Oregon's northwesternmost county, Clatsop County. A 1969 study dealt with the economic impact of a proportionally large industrial increase in the generally rural county (Collin, 1970). The new industry was that of aluminum. An indication of the existing economic relationships was required prior to the analysis of the economic impact of the aluminum plant. Personal interviews of private and public firms provided information suitable for description of the economic environment. The framework of input-output analysis was utilized to incorporate the sample information with that available for the new industry. The economic impact of the new industry when in operation was revealed. Relationships were specified for both private businesses and local government. Thus, a well-planned and conducted analysis of Clatsop County exists upon which to base further study.

Clatsop Input-Output: An Extension

Justification

This study will be directed toward a specification of the environmental effects of economic activity among selected sectors in a local economy. Investigation of the topic in the selected county will complement conventional input-output information. The input-output model provides information of the monetary relationship among specified economic sectors. Typically, the relationships are developed from a survey of purchasing patterns among firms. Implicit in the procedure is the assumption that all inter-sectoral monetary relationships have been represented. The premise of this study is that purchasing patterns provide incomplete insight into the economic relationships of various sectors to the local economy. A more complete analysis for decision purposes would include an appraisal of the opportunity cost associated with economic growth as well as an investigation of possible monetary relationships among sectors not related via market purchasing patterns.

Conceptually, economic relationships among sectors are not limited to market purchase of inputs. An attempt will be made to determine if the relationships can be represented empirically. The first step in the process requires a distinction between market and non-market inputs. Inputs purchased through the market provide information essential to the input-output technique. However, there is another bundle of inputs provided by the environment without the benefit of markets. Even though these inputs are seldom purchased, the inter-sector demands on them have economic overtones. Delineation of these conceptual economic relationships will provide additional information for decision makers. As will be indicated more fully at a later point, the state of the art in environmentally related disciplines is not conducive to the development of complete economic models.

Objectives

To the extent that local decisions in Clatsop County can be interpreted as concern over the bundle of pecuniary and environmental goods produced, the opportunity cost of various bundles of pecuniary goods would be valuable information. In essence this entails a more complete description of relationships specified in the standard input-output analysis. The general objective of the study is to develop a systematic evaluation of economic activity in Clatsop County, Oregon. Specific objectives in this context are to:

(1) Delineate the economic characteristics of estuary resource allocation problems.

(2) Represent the economic-ecologic linkages of key sectors via a modified input-output model.

(3) Predict the residuals generation and non-market good requirements of a proposed aluminum plant in Clatsop County, Oregon.

(4) Empirically evaluate trade-offs associated with perceived problems arising from the addition of an aluminum plant in Clatsop County, Oregon.

Procedure

Economic and environmental relationships were specified in a modified input-output model. The process required data on the input requirements and residuals production of designated economic sectors. A literature review yielded the majority of the required information. Additional data of a more detailed nature was available from environmental studies in progress within Clatsop County. The "environmental" information was related to economic sectors in an economic-ecologic model. Environmental implications of growth were projected from relationships explored in the modified input-output model. Economic and environmental relationships identified in the model were then included in a linear programming model to further identify possible growth trade-offs.

Interindustry Relationships

The conceptual base for the modified input-output model used in the study is rooted in the eighteenth century. In particular, Francis Quesnay in his Tableau Economique (1758) focused attention on the circular flow of goods at the macro level. His work contributed to understanding the interdependent nature of operations in an ideally competitive economy. The next plateau in the development of input-output analysis was reached by Leon Walras' Elements of Pure Economics, published in 1874. Walras, like Quesnay, was interested in interindustry relationships. This interest, however, focused on interindustry price relationships, not Quesnay's macro characteristics of wealth generation. Walras utilized a system of simultaneous equations, one equation per commodity, to represent a general equilibrium model to be used in the determination of prices. The prices were used in the commodity equations to determine aggregate demand.

Russian-born American economist Wassily Leontief used the earlier developments to codify his thoughts on a model for the United States economy. During the 1930's, Leontief breathed empirical life into the model. Thus, he was able to apply interindustry analysis in a manner not available to Quesnay and Walras. The age of Quesnay was that of laissez-faire, an age in which government had no economic role while Walras viewed the general equilibrium approach conceptually rich, but empirically impracticable. Input-output analysis was originally applied at the macro level by Leontief in 1936. Social scientists since that time have employed the model to analyze regional and local aspects of economic impact(s),[7] community development,[8] and public investment(s).[9]

Pecuniary Aspects of Growth

The Collin (1970) study of Clatsop County had the primary

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[7]See Rorholm, Lampe, Marshall and Farrell (1967) and Reiling (1971).

[8]See Collin (1970).

[9]See Bromley (1967).

purpose of revealing the economic relationship between the aluminum plant and other sectors of the economy. Projections of the pecuniary impact were made on the basis of a plant in operation. By including the aluminum plant in the model as a sector the analysis simulated the economy's view of the operation. Gains in business activity were differentiated from those accruing to the public sector. The private sector was to gain $8,000,000 in business activity. More than 87 percent of the gain was destined for the business products sector, primarily gas and electricity charges. Households would receive $3,000,000 in income over the $6,000,000 annual plant payrolls. Education and the Port Authority were the largest recipients of the additional $3,000,000 tax revenue generated.

Commercial fishing income was found to be the least affected by the new industry. The agriculture and fur sector impact was also relatively small, a $958 income increase as a result of the aluminum plant's $60,000,000 annual sales. The relationship of aluminum to fishery and agricultural activity is not surprising. Most interaction between two sectors, one directly dependent on natural resources the other not, cannot be revealed by analysis of market activities alone. Sectoral relationships in such cases occur through the environment. The magnitude of relationships developed via the environment and the related economic ramifications must be analyzed to more completely represent the community effects of interindustry economic activity.

Input-Output Identities

The implications of the market imperfections outlined in Chapter I and the previous section suggest potential adjustments in the mathematical representation of input-output analysis. Input-output analysis is based on a system of identities utilized to depict the assumed linear relationships of economic sectors. Total output, X_i, of each good in an $\underline{n}$ produced goods economy depends on interindustry use of good $\underline{i}$ by sector $\underline{j}$, X_{ij}, and final consumer uses, D_i (system 2. 1):

$$\begin{aligned} X_1 &= X_{11} + X_{12} + X_{13} + \ldots + X_{1n} + D_1 \\ X_2 &= X_{21} + X_{22} + X_{23} + \ldots X_{2n} + D_2 \\ &\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\ X_n &= X_{n1} + X_{n2} + X_{n3} + \ldots + X_{nn} + D_n \end{aligned} \qquad (2.1)$$

The linear system (2. 1) is generally converted from total figures, X_{ij}, to a per unit basis through

$$a_{ij} = \frac{X_{ij}}{X_j}.$$

Performing the per unit conversion and collecting output variables on the left yields system (2. 2):

$$\begin{aligned} X_1 - a_{11}X_1 - a_{12}X_2 - a_{13}X_3 - \ldots - a_{1n}X_n &= D_1 \\ \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad & \cdot \\ X_n - a_{n1}X_1 - a_{n2}X_2 - a_{n3}X_3 - \ldots - a_{nn}X_n &= D_n \end{aligned} \qquad (2.2)$$

where a_{ij} = amount of sector i production required per unit of j. The ability of a sector to deliver net output to final consumption then depends on the interindustry input requirements.

Input requirements of (2. 2) are developed from production function data or a sample of purchasing patterns among sectors. Both methods, in practice, measure market goods only, though there is perhaps merit in also examining non-market goods as outlined previously and suggested by Henderson and Quandt (1971). The production function method prescribes that non-market goods that are an integral part of the production process be included in the endogenous part of the input-output matrix (system 2. 3).

$$
\begin{aligned}
X_1 &= a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + \ldots + a_{1n}X_n + a_{1,n+1}X_{n+1} + D_1 \\
X_2 &= a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + \ldots + a_{2n}X_n + a_{2,n+1}X_{n+1} + D_2 \\
&\quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \qquad\qquad (2.\ 3) \\
X_n &= a_{n1}X_1 + a_{n2}X_2 + a_{n3}X_3 + \ldots + a_{nn}X_n + a_{n,n+1}X_{n+1} + D_n \\
X_{n+1} &= a_{n+1,1}X_1 + a_{n+1,2}X_2 + a_{n+1,3}X_3 + \ldots + a_{n+1,n}X_n \\
&\qquad + a_{n+1,n+1}X_{n+1} + D_{n+1}
\end{aligned}
$$

Sectors 1. . . n remain as before while sector n+1 can be termed the "non-market goods" sector. Row n+1 indicates the amount of the non-produced, non-purchasable goods used by the various sectors. The a_{ij}'s of row n+1 are positive while $a_{i,n+1}$ (i = 1., . . . n+1) of column n+1 are thought to be zero. If the latter holds, the coefficient matrix of system 2.3 is singular. The prospect of an inconsistent solution is heightened with the inclusion of a non-market sector.[10] Chapter III explores a method of circumventing this representation of environmentalists' criticisms of economic analysis.[11]

Information Generation

Public sector decisions related to economic activity in local economies are seldom made in the light of perfect information. Interindustry analysis at the local level provides economic information. The information provided is not perfect and the environmania of the 70's further complicates the information generating procedure. Methods of generating the information have been suggested by agencies and academicians. Federal, state, and local agencies are requesting environmental impact statements for selected growth proposals. Economists have continued to adjust the descriptive and predictive aspects of input-output, economic base, and public investment analysis. The role of residuals or environmental factors in the adjustment

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[10] In the case of an input-output model developed from sampling of purchases and sales of economic sectors (actually a from-to model), the allowance for non-produced, non-purchasable goods can be accomplished by estimating the value of non-purchasable inputs and incorporating them in the exogenous rows while non-market traded residuals are included in the exogenous columns as exports from the economic system to the natural system.

[11] A conceptual approach depicting public good implications to input-output identities is included in the Appendix.

process is the subject of the next section.

Environmental Linkages

The Clatsop County input-output model will be adapted to provide information relating the market and non-market aspects of pecuniary forces in the economy. Following the general process outlined by Isard (1967), economic and ecologic factors will be linked by means of matrix algebra. Isard developed an idealized input-output framework in which to explore questions concerning economic activity (Figure 6). As suggested in Figure 6, the economy is related directly to the natural resource base via input requirements (matrix H) and the emission of non-market residuals (matrix G). The natural resource system is represented in conventional input-output format by matrix I. Entries in matrix I are interpreted in the same manner (not the same units) as elements of a transactions table, F.

Ideally, the model would provide information concerning the all-encompassing nature of economic, social, and natural changes. Inclusion of the natural system matrix, however, adds a great degree of complexity. All of the criticisms of the standard input-output matrix would apply to the natural system matrix: aggregation of sectors and linear nature of the model. The data requirements of the matrix represent the most crucial problem. The data and expertise to construct the matrix are generally lacking. Thus, the operational

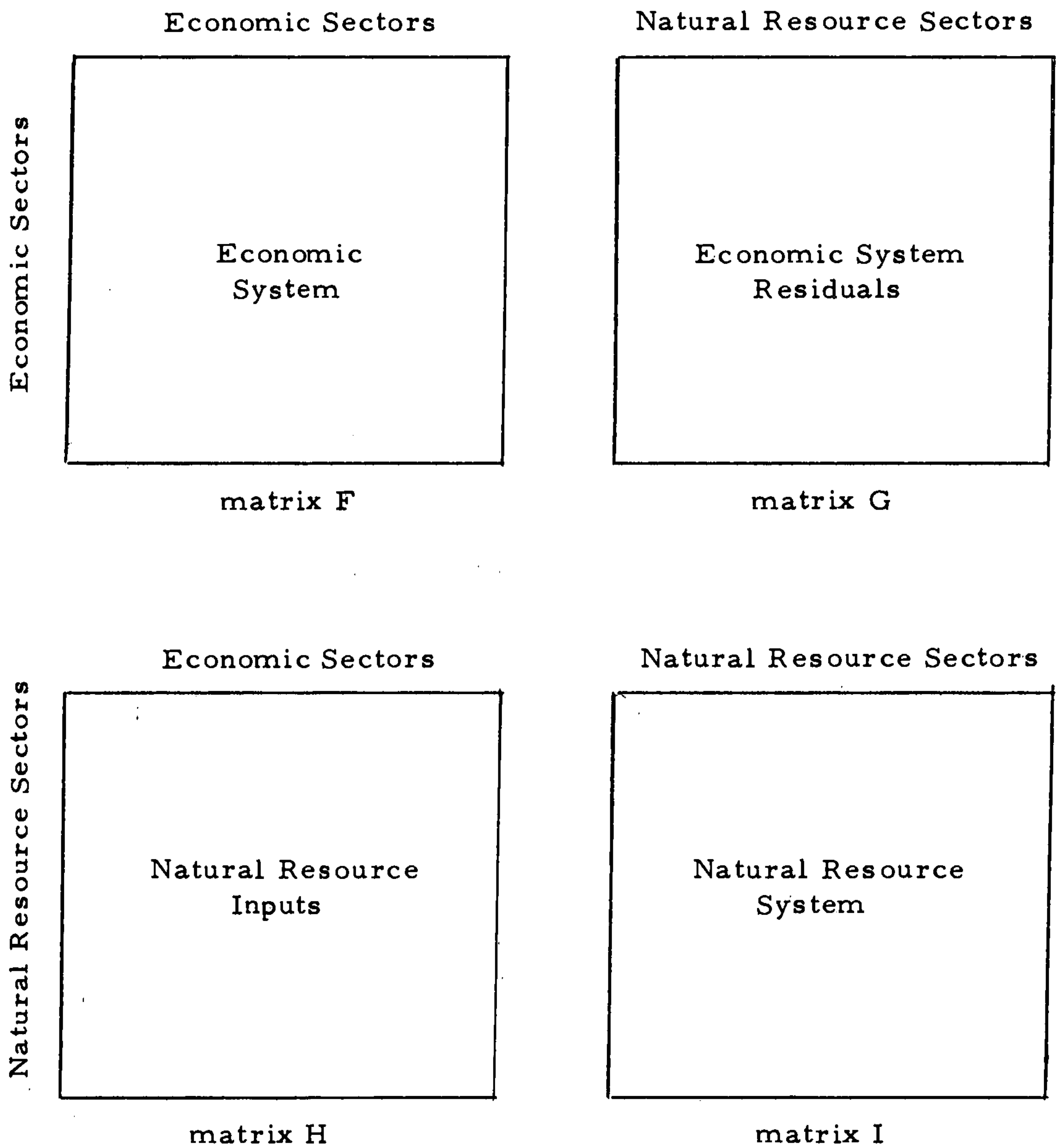

Figure 6. Hypothetical Matrix Representation of Economic and Natural Resource Systems.

significance of the complete model will be minimal until the state of ecologic science improves.

The problems faced by researchers desiring to use Isard's approach have resulted in few applications. Hite and Laurent (1971) used an adaptation of the model in an attempt to gain insight into different questions than those explored by Isard. They sought identification of economic-ecologic linkages and reasoned that such a task would not require Isard's comprehensive model. Consequently, matrix I was excluded from the Hite and Laurent analysis of the Charleston, South Carolina, economy. Three matrices remain with which to link the economic and ecologic system: the economic system, residuals, and input matrices. The source of inputs and the output of residuals are represented by further simplification of the Isard model. This process involves combination of matrices G and H into an ecologic matrix. The ecologic matrix identifies natural resource inputs used by matrix F as imports from the environment and treats residuals flowing from F as exports to the environment. A positive sign is associated with the former and a negative sign with the latter elements of the ecologic matrix.

Matrix notation is necessary to clearly indicate the relationship between a Leontief input-output matrix, F, and an ecologic matrix, A (2. 4). The A matrix consists of k linkages to the n economic sectors.

$$\overset{A}{\begin{bmatrix} a_{11} a_{12} \cdots & a_{1n} \\ a_{21} & \vdots \\ \vdots & \vdots \\ a_{k1} \cdots & a_{kn} \end{bmatrix}} \overset{F}{\begin{bmatrix} f_{11} f_{12} \cdots & f_{1n} \\ f_{21} & \vdots \\ \vdots & \vdots \\ f_{n1} \cdots & f_{nn} \end{bmatrix}} = \overset{E}{\begin{bmatrix} e_{11} e_{12} \cdots & e_{1n} \\ e_{21} & \vdots \\ \vdots & \vdots \\ e_{k1} \cdots & e_{kn} \end{bmatrix}} \qquad (2.4)$$

Thus, a_{ij} represents the amount of ecologic import, $i = 1, 2, \ldots k$, required to produce one dollar of gross output by economic sector j, $j = 1, 2, \ldots n$. To determine the direct effects on the environment of a dollar increase to final demand by a sector requires post-multiplying A by F. Elements, e_{ij}, of product matrix E, indicate the amount of import $\underline{i}$ required per dollar increase to final demand of the j^{th} sector. A one-dollar increase to final demand by sector $\underline{j}$ requires e_{ij} of import $\underline{i}$, where

$$e_{ij} = \sum_{c=1}^{n} a_{ic} f_{cj}$$

Additional insight can be attained if A is post-multiplied by F^1, the Leontief inverse. Elements of F^1 include direct and indirect requirements per dollar of final demand. The e^1_{ij} then represents the first, second, third, etc., round environmental requirements per dollar of final demand in each sector (system 2.5). Thus, the model can be manipulated to determine the total environmental imports of economic sectors in addition to provision of a framework to observe economic and ecologic systems.

$$\overset{A}{\begin{bmatrix} a_{11} a_{12} \dots a_{1n} \\ a_{21} \quad \vdots \\ \vdots \quad \vdots \\ a_{k1} \dots \dots a_{kn} \end{bmatrix}} \overset{F^1}{\begin{bmatrix} f^1_{11} f^1_{12} \dots f^1_{1n} \\ f^1_{21} \quad \vdots \\ \vdots \quad \vdots \\ f^1_{n1} \dots \dots f^1_{nn} \end{bmatrix}} = \overset{E^1}{\begin{bmatrix} e^1_{11} e^1_{12} \dots e^1_{1n} \\ e^1_{21} \quad \vdots \\ \vdots \quad \vdots \\ e^1_{k1} \dots \dots e^1_{kn} \end{bmatrix}} \qquad (2.5)$$

Consider an example of a four-sector economy, W, X, Y, and Z, with three ecologic factors of interest, BOD[12], cooling water, and marshland. Assume the following coefficients for A and F^1 (system 2.6):

$$\begin{array}{l} \\ \\ \text{BOD} \\ \text{Cooling water} \\ \text{Marsh} \\ \\ \end{array} \overset{\begin{array}{cccc} & A & & \\ W & X & Y & Z \end{array}}{\begin{bmatrix} -4 & -4 & -1 & -2 \\ 1 & 3 & 0 & 2 \\ 5 & 5 & 1 & 2 \end{bmatrix}} \overset{\begin{array}{cccc} & F^1 & & \\ W & X & Y & Z \end{array}}{\begin{bmatrix} 2 & 1 & 0 & 1 \\ 1 & 2 & 0 & 1 \\ 1 & 2 & 1 & 3 \\ 1 & 1 & 2 & 3 \end{bmatrix}} = \overset{\begin{array}{cccc} & E^1 & & \\ W & X & Y & Z \end{array}}{\begin{bmatrix} -15 & -16 & -5 & -17 \\ 7 & 9 & 4 & 10 \\ 18 & 19 & 5 & 19 \end{bmatrix}} \qquad (2.6)$$

These hypothetical figures show that each dollar increase in output to final demand by sector Z results in the use of 10 gallons of cooling water, 19 square feet of marshland, and the release of 17 pounds of BOD. Elements of E^1 represent the supply price of providing certain levels of environmental goods.

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[12] Biochemical oxygen demand.

Waste Treatment and Prices

The adjustments to input-output models formulated by Isard provide for the incorporation of waste generation, treatment, and feedback data. Matrix I, representing the natural resource system, allows for the feedback of raw and treated wastes into the economic system. Due to insufficient data and non-linearity of biological relationships the development of I is an empirical experiment. Economic sector relationships to the natural resource system are nonetheless important. Consequently, the previous example of linkage between economic and natural systems centered on the waste generation potential of economic activity. Only in rare instances do the wastes enter the resource system in an untreated state.

Allowance for waste treatment in the Clatsop County study will be presented in Chapter III. The method is more detailed than that suggested by Wassily Leontief (1970). Leontief traces through the sectoral generation of wastes and calculates prices associated with removal of wastes. As an example, a Leontief inverse of two economic sectors (Q_1 and Q_2) is adjusted by the addition of a "pollutant" row and an "elimination of pollutant" column. The result is an adjustment of the balance equations (system 2.7) similar to the adjustments in input-output math suggested previously.

$$(1-a_{11})Q_1 - a_{12}Q_2 - a_{13}Q_3 = Y_1$$
$$-a_{21}Q_1 + (1-a_{22})Q_2 - a_{23}Q_3 = Y_2 \qquad (2.7)$$
$$-a_{31}Q_1 - a_{32}Q_2 + (1-a_{33})Q_3 = Y_3$$

where:

Q_1 = total output of sector 1

Q_2 = total output of sector 2

Q_3 = total amount of eliminated pollutant

Y_1 = final demand for sector 1 output

Y_2 = final demand for sector 2 output

Y_3 = total amount of uneliminated pullutant;

a_{31} = amount of uneliminated pollutant per unit of Q_1

a_{32} = amount of uneliminated pollutant per unit of Q_2

a_{33} = amount of uneliminated pollutant per unit of Q_3

Interpretation of the equations is identical with that of standard input-output analysis. The third equation identifies the amount of uneliminated pollutant as dependent on the magnitude of eliminated pollutant (Q_3) less the uneliminated pollutant generated in sectors 1 and 2 as well as the pollutant eliminating sector (Q_3). Use of Cramer's rule provides for the representation of total output as a function of final demand (Y_1 and Y_2) and uneliminated pollutants (Y_3). The uneliminated pollutants are tolerated, not demanded. Solving (2. 7) for the general solution yields system (2. 8).

$$Q_1 = b_{11}Y_1 + b_{12}Y_2 + b_{13}Y_3$$

$$Q_2 = b_{21}Y_1 + b_{22}Y_2 + b_{23}Y_3 \qquad (2.8)$$

$$Q_3 = b_{31}Y_1 + b_{32}Y_2 + b_{33}Y_3$$

Assuming sector 1 to be seafood processing, total output (Q_1) depends on the levels of final demand in sectors 1 and 2 and the amount of pollutant remaining. The total amount of eliminated pollutant (Q_3) is determined by the waste treatment and final demand characteristics of each sector.

Rather than utilizing Leontief's nondescript composite "pollutant" sector, this study focuses on developing linkages of both non-market resources and wastes to the economic system. As a result, there is no calculation of product prices or prices required for the elimination of pollutants. Leontief (1970) uses system (2. 9) to generate prices given estimates of value added. Chapter III includes a discussion of the supply price of various bundles of goods. The supply prices are incorporated into descriptions of trade-offs rooted in the coastal zone externality and common property problems identified in Chapter I.

$$P_1 - a_{11}P_1 - a_{21}P_2 - a_{31}P_3 = V_1$$

$$P_2 - a_{12}P_1 - a_{22}P_2 - a_{31}P_3 = V_2 \qquad (2.9)$$

$$P_3 - a_{13}P_1 - a_{23}P_2 - a_{33}P_3 = V_3$$

CHAPTER III

CLATSOP COUNTY ENVIRONMENTAL LINKAGES

The thesis of Chapter I was that market imperfections exist in the nondescript coastal zone but are particularly evident in the coastal zone's well specified principal component, estuaries. Reference was made to the work of Coase and Buchanan-Stubblebine to indicate that the existence of allocative imperfections alone does not say anything about the character or existence of a solution until an alternative is specified. Overt concentration by decision makers on remedying imperfections tends to overlook the issue of alternative specification. A second effect may also be experienced. Failure to recognize the importance of the character and existence of a solution prior to extra-market intervention may result in reliance on sweeping institutional and political action rather than incremental changes or market adjustments. Both procedures require all available information concerning the ties between market and non-market goods. It is in this light that the procedure outlined in Chapter II to specify the supply prices involved in analyzing trade-offs would yield valuable decision making information.

Environmental Linkages

An issue worthy of consideration in all input-output studies is the level of aggregation of economic sectors. Establishments in the economy under study are typically grouped into sectors on the basis of product or output characteristics. Consequently, a larger number of sectors exist under a restrictive product definition as opposed to a general product description. The former yields the more specific answers but not without higher data collection costs. Descriptive and predictive results of an input-output system developed at a high degree of aggregation can be incorporated into the decision process with credibility to be placed on the direction of economic decisions and to a lesser degree on the distributive information generated. The situation can be likened to that of multicolinearity in regression analysis; the presence of multicolinearity does not detract from the sum of explained variation but rather from the reliability of the specified distribution of explained sums among variables. Therefore, a high degree of aggregation in input-output models yields results as to the total and sectoral impact of changes in economic activity around which broad confidence intervals must be placed.

The linkage of environmental and economic systems involves consideration of aggregation and linearity limitations to no less degree than does standard input-output analysis. Non-market resource inputs and residuals can be expected to be at least as sensitive to these factors as are market goods. To be environmentally accurate the level of aggregation should be the lowest possible consistent with budget and time constraints. An alternative to an entire study based on a low level of aggregation is the specification of "a priori" direct non-market good user industries. Industries so specified could be classified as sectors and detailed information presented on the key sectors. This procedure offers the possibility of increasing the sample size in the key sectors thus providing a sharply focused "snapshot" of the economy being analyzed. The Clatsop County model, though developed for study of the pecuniary aspects of growth, exhibits a low level of aggregation in sectors publicly identified as being linked to the environment.[13] Commercial Fishing, Seafood Processing, Aluminum, Port Authority, and Lumber are sectors of low aggregation. An additional factor of importance is the major role the key sectors also play in the economy's income and employment. The Clatsop County input-output model offers the researcher an opportunity to analyze the linkage of market and non-market aspects of economic activity in an economy with well specified and environmentally important sectors being one and the same.

The Linkage Matrix

The linkages to be given empirical life in the remainder of the study require a linearity assumption. However, the assumption offers more potential for generating pragmatic results than it does in the

[13] A definition of economic sectors in the Clatsop County model appears in Appendix Table 1.

Isard framework (see Chapter II). The omission of the natural resources system matrix from the Clatsop County analysis precludes representation of the environment as a series of linear biological and physical relationships. No attempt to simulate the internal working of the natural system will be made. Major emphasis will be placed on the direct interaction of natural and economic systems. The non-market inputs and residuals that join the systems will be analyzed without consideration of natural system safe minimum standards, finite resource supplies, regenerative processes, etc.

The direct interaction of natural and economic systems is represented in Table 1. Rows indicate non-market resource inputs and residuals of productive processes. No restriction on the number of rows allocated to each exists. The analysis can proceed regardless of the number of rows, units of measure, and presence of blanks in the matrix. Inputs to the economic sectors carry a positive sign and the residuals flowing from the economy are indicated by minuses. No connotation of "good" or "bad" is implied by the designation. An alternative to the labeling would be to denote residuals as reductions in an existing inventory of natural system elements. Reference to waste water residuals as producing certain alterations of dissolved oxygen (DO) once released as opposed to specifying bio-chemical oxygen demand (BOD) is an example of a labeling change.

Elements of the direct interaction matrix (DIM) (see Table 1),

Table 1. Direct Ecologic Linkages to the Clatsop County Economy: Resource Inputs and Waste Outputs per Dollar of Gross Output.

	Lumber	Commercial Fishing	Fish Processing	Agric. & Fur	Manufac.	Lodging	Cafes & Taverns	Service Stations	Auto Sales & Service	Communic. & Transp.
Particulates (lbs.)	-.02052							- .00871		
Carbon Monoxide (lbs.)								-1.45146		
Fluoride (lbs.)										
Hydrocarbons (lbs.)								- .26997		
Domestic Water (gals.)	128.02219									
Cooling Water (gals.)	125.04492		.21083							
Process Water (gals.)	44.65831		1.36497		.18348	.19568	.16471	.16948	.24674	.35340
Water Intake (gals.)	297.72542		1.57580		.18348	.19568	.16471	.16948	.24674	.35340
Water Discharge (gals.)	-253.26125		-1.57580		- .14678	- .15654	- .13177	- .13558	- .19739	- .28272
5-Day BOD (lbs.)	-.50894		- .00464							
Suspended Solids (lbs.)	- .53793		- .00223							
Organic Nitrogen (lbs.)			- .00100							
Solid Waste (lbs.)			- .64685	-53.83572	-4.31892	-3.10503	-3.68860	-3.57702		
Solid Waste (cu. yds.)	- .41819									

(Continued on next page)

Table 1. (Continued)

	Professional Services	Financial	Construction	Products	Services	Education	County Roads	Law Enforcement	Health Dept.	Welfare
Particulates (lbs.)										
Carbon Monoxide (lbs.)										
Fluoride (lbs.)										
Hydrocarbons (lbs.)										
Domestic Water (gals.)										
Cooling Water (gals.)										
Process Water (gals.)	.19194	.20285	.48082	1.16911	.41813					
Water Intake (gals.)	.19194	.20285	.48082	1.16911	.41813					
Water Discharge (gals.)	-.15355	-.16228	-.38466	- .93529	- .33450					
5-Day BOD (lbs.)										
Suspended Solids (lbs.)										
Organic Nitrogen (lbs.)										
Solid Waste (lbs.)				- .51967	-1.45294					
Solid Waste (cu. yds.)										

(Continued on next page)

Table 1. (Continued)

	Port Authority	General Fund	Astoria	Warrenton	Hammond	Gearhart	Seaside	Cannon Beach	Aluminum	Households
Particulates (lbs.)	-.60960								- .01820	
Carbon Monoxide (lbs.)										
Fluoride (lbs.)									- .00560	
Hydrocarbons (lbs.)										
Domestic Water (gals.)			28.29814	40.87534	68.15551	36.35790	41.11428	26.83976		9.54620
Cooling Water (gals.)									3.40000	
Process Water (gals.)									30.60000	
Water Intake (gals.)			28.29814	40.87534	68.15551	36.35790	41.11428	26.83976	34.00000	9.54620
Water Discharge (gals.)			-22.63851	-32.70027	-54.52441	-29.08632	-32.89142	-21.47181	-34.00000	-7.63696
5-Day BOD (lbs.)										
Suspended Solids (lbs.)										- .24131
Organic Nitrogen (lbs.)										
Solid Waste (lbs.)			- 3.22077	- 3.22077	- 3.22077	- 3.22077	- 3.22077	- 3.22077		- .66823
Solid Waste (cu. yds.)										

were drawn from secondary sources. Air and water quality studies and solid waste management studies are often conducted on an industry basis to facilitate development of long-run management plans. The presence of blanks does not imply that the data source revealed no direct input or residual existed for a sector. While this is known to be the case in some sectors, the blanks should be interpreted as evidence of data inadequacies, not zero linkages. The absence of entries in the DIM can serve to guide future research. However, there remains a need for additional research directed toward the improvement of non-zero element estimates being utilized. Reliance on the DIM to identify appropriate research is also constrained by its very construction. Rows are inserted on the basis of previous research findings and "a priori" consideration. The possibility of adding (deleting) rows should not be overlooked if service to basic and applied research is desired.

Development of the DIM initially proceeded on the premise that inputs and residuals would be related to the responsible economic sector, data permitting. A departure from the format was justified in situations involving obvious abuse of the model's linearity assumption. One sizable linkage prompted consideration of allocating the residual involved to the sector thought to be most linearly related via sales, not generation of the residual. Combustion engine powered transportation is a well documented source of particulate, hydrocarbon, and carbon monoxide residuals in any economy. To relate these rows to the most responsible sector would identify the sector as Households. Clatsop County transportation is predominately provided on an individual basis by members of households. However, conformity with the linearity assumption prevailed as opposed to selecting households on the basis of responsibility. Particulate, hydrocarbon, and carbon monoxide emissions were in turn related to the service station sector. Gasoline sales were thought to be more nearly a linear function of Service Station sales than that of Households. The service station sector was also attractive due to its low level of aggregation.

Non-zero elements are indicated in Table 1 for private and public sectors. Due to the inclusion of the local government revenue collecting units in the endogenous portion of the input-output matrix, public sectors could be linked to the generation of residuals. Port Authority is shown to be responsible for generation of particulates in its storage and shipping complex. Two rows relating to solid waste are included in the DIM but only one refers to the public sector of Clatsop County. Cubic yards are the units of the second solid waste row while pounds are the units of the row related to public sectors. Availability of data and unsatisfactory conversion estimates required the two-row approach for one residual.

The elements of the DIM used in the Clatsop County study were collected from a number of secondary sources. Use of secondary sources has cost advantages but elements can also be developed in varying manners and at three possible levels. The variation in residuals estimation is of primary concern in the latter respect. Residuals of production processes can be reported as "before treatment" (raw), "after treatment, " or at the level specified in federal, state, or local environmental regulations. To the purist the first approach may be the most logical. All residuals of a productive process would be counted whether or not a method of controlling or treating the residual was utilized. This is tantamount to constructing a DIM on the basis of the law of conservation of matter. Since matter is neither created nor destroyed in the productive process allowance would be made for the residuals generated before application of any type of control or treatment technology. The raw residuals approach is not completely dissimilar to that suggested by Leontief (1970). Recall that mention was made previously of Leontief's desire to include "pollution" and "anti-pollution" sectors in the conventional input-output transaction table. Leontief's method allows for pollution (residuals) effects of the "anti-pollution" sector and consequently recognition of the possibility that even with an "anti-pollution" sector the pollution problem may be only marginally affected. The implication of the "before treatment" method is that Table 1 contain non-zero elements in nearly all cells. There is one row in Table 1 that represents the "before treatment" method of computing cell values. The solid waste attributed to the lumber sector is derived primarily from the stump, trim, and brush waste of timber harvesting. The residuals of the harvesting process are reported in measurable solid waste form rather than a secondary form such as particulates, BOD, etc.

With the exception of the one row mentioned above, Table 1 was developed from engineering and economic data related to "after treatment" residual levels. Elements of the lumber, seafood processing, and aluminum sectors are the most accurate due to the numerous studies of the input and residual levels associated with these major Pacific Northwest industries. Estimates are based on existing in-place technology common to the economic endeavors of firms located in the region. Precise information on waste water requirements in Clatsop County were obtained in the heavily water oriented lumber and seafood processing sectors. Water quality and discharge elements of the seafood processing sector were obtained from Oregon State University Food Science and Technology researchers (Soderquist, 1972) conducting an Environmental Protection Agency funded analysis of seafood processing industry wastes. Analysis of the research results revealed that the development of a DIM at low levels of economic sector aggregation is necessary for suitable cell estimates but not sufficient. The reason was a variation in residual levels as product mix of the seafood firms changed with seasons. Canning, smoking, freezing, and fresh preparation of seafood products produced residuals variation as did the species being processed. Crab, tuna, salmon, shrimp, and bottom fish produced differing residuals that required utilization of a weighting process. Elements of the lumber sector would be altered as well if data were available to reveal the fluctuation of residuals in paper production as paper strength and brightness change even though the plants in Clatsop County are Kraft-process operations identical to those from which the engineering data were collected.

A final method for development of DIM elements is provided by public agency resource management efforts. Water, air, and land utilization are partially, though increasingly, controlled in the public interest. In a region with well outlined statutory guidelines for emissions, effluents, or uses, economic sectors identified by the regulations can be assumed to be in accordance. Elements of a DIM can then be drawn from publicly approved legal residuals constraints. Hite and Laurent (1971a) have cautioned against this approach on the basis that changes in regulations result in changes in the purchasing patterns of firms. Consequently, the input-output matrix would be in need of alteration if suitable results were to be maintained. The author agrees with the basic philosophy of Hite and Laurent but wishes to distinguish between the effects on local versus regional input-output models. A small economy would likely import the technology and operating materials rather than purchase it locally. With most expenditures for control equipment of a sunk or lump nature, the local economy may feel little monetary change. Models based on regions, however, may change as a result of the appearance and growth of a pollution abatement industry within the study area.

Economic and Environmental Systems Combined

The data to be analyzed and presented in this section represent a descriptive link between economic and environmental systems. It must be recalled, however, that the basis for what is to be revealed lies in the identification process outlined in the previous section. Carrying out the combination of the systems does not make factors appear that were not identified previously. The direct environmental linkages require thoughtful development so as to prevent specification errors from yielding iterative results that are descriptively inaccurate. Due to the interative process involved, a specification error has ramifications beyond those enumerated in Table 1. A thorough review of literature and familiarity with the Clatsop County economy provided the opportunity to restrict environmental variables. Thus, every effort was made to limit the model's specification errors to those of excluded variables.

Purchasing pattern data revealed some sectors of the Clatsop County economy to be completely independent, i. e. , no direct economic relationship existed. One-way dependence existed between other sectors, e. g., Table 2 shows that the commercial fishing sector did not purchase from the seafood processing sector while seafood processing made large purchases from commercial fishermen. The majority of the sectors exhibited a one-way relationship (see Table 2). Allowance for first, second, third, etc., round effects via the Leontief inverse revealed near complete economic interdependence (see Appendix Table 2). An important distinction between the entries in Table 2 and Appendix Table 2 is worthy of note prior to introducing the environmentally linked system. The Leontief inverse shows an interdependent economy without revealing how far removed groups of sectors actually are from an interdependent situation. Table 2 offers a comparison of product oriented sectors (sectors 1-5, 29) to service oriented (sectors 6-15) and public oriented (sectors 16-28). Complete independence predominates the direct relationships among product sectors while one-way dependence on the service and public sectors exists. Service sectors follow hypothesized "a priori" complete direct interdependence within the service and public sector groups. The contents of Table 2 can be used in the above manner to specify the underlying source of environmental linkages, i. e., the Leontief inverse reveals magnitude of relationship information not source of the multi-round relationships. The latter provides valuable insight in understanding and applying the results of the linkage process, e. g., a simple alteration of the export-import balance may be possible to shift environmental problems to other economies with minimal change in the economy's structure.

Table 2. Transaction Matrix Showing Interindustry Flows of Dollars, Clatsop County, Oregon, 1968.

	Lumber	Commercial Fishing	Fish Processing	Agric. & Fur	Manufac.	Lodging	Cafes & Taverns	Service Stations	Auto Sales & Service	Communic. & Transp.
1. Lumber	4617162	0	0	0	0	0	0	0	0	174880
2. Commercial Fishing	0	10156	2617590	0	0	0	0	0	0	0
3. Fish Processing	0	0	25000	0	6000	0	0	0	0	0
4. Agriculture & Fur	0	0	0	45271	909770	0	0	0	0	0
5. Manufacturing	0	0	3711720	0	0	0	0	0	0	0
6. Lodging	0	0	0	0	0	0	0	0	0	0
7. Cafes & Taverns	0	0	0	0	0	0	0	0	0	0
8. Service Stations	429434	200261	0	129360	96244	0	0	72504	18000	84866
9. Auto Sales & Service	85383	83330	95525	14461	103096	23000	1860	44002	31327	77364
10. Communic. & Transp.	1856093	146248	1623350	1047275	744919	696770	154162	189524	293938	209899
11. Professional Services	1124122	128876	11536	4429	3989	2327	27172	7142	6531	2327
12. Financial	652525	10788	432385	137390	163360	12354	5226	6176	571802	0
13. Construction	27717	4104	102525	14948	57425	27203	332884	13298	42299	38855
14. Products	2207448	173952	699316	648787	345476	665111	706348	1122969	269489	198520
15. Services	416242	314684	216923	170083	42148	864959	340374	143069	162928	21209
16. Education	1303402	17107	70021	63573	25030	207785	30516	9499	16186	320663
17. County Roads	60823	731	2992	2717	1069	8878	1304	406	692	13702
18. Law Enforcement	74263	892	3653	3317	1306	10840	1592	495	844	16729
19. Health Dept.	28057	337	1380	1253	493	4095	602	187	319	6321
20. Welfare	186903	2245	9194	8347	3286	27282	4007	1247	2125	42105
21. Port Authority	35558	427	1749	1588	625	5190	762	237	404	22152
22. General Fund	167465	2012	8238	7479	2945	24444	3590	1117	1904	37726
23. Astoria	12000	0	25000	0	15000	61000	5000	14500	7000	15000
24. Warrenton	0	0	5000	200	0	700	2800	1000	0	2000
25. Hammond	0	0	4515	0	0	40	100	100	0	60
26. Gearhart	0	0	0	0	0	10500	0	300	0	150
27. Seaside	0	100	200	0	500	6000	1000	6000	3000	6000
28. Cannon Beach	0	0	0	0	0	18000	40	450	0	300
29. Aluminum	0	0	0	0	0	0	0	0	0	0
30. Households	8828465	1494506	3485000	675000	435000	1789328	1884569	740807	1479507	2858248
31. Government	6142377	281579	1599635	142784	34125	237574	257420	152321	230458	1424974
32. Imports	25470265	4803355	24505429	224902	3377441	1773673	2424226	3939563	6333679	6792413
33. Depreciation	6838748	213615	528955	456311	755098	1066261	200802	127930	107889	1355849
34. Total inputs	60564452	3566305	39786831	3799475	7124345	7597314	6395356	6594843	9580321	13722312

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Table 2. (Continued)

	Professional Services	Financial	Construction	Products	Services	Education	County Roads	Law Enforcement
1. Lumber	0	0	119579	0	0	0	0	0
2. Commercial Fishing	0	0	0	0	0	0	0	0
3. Fish Processing	0	2500	0	53000	0	0	0	0
4. Agriculture & Fur	0	0	0	0	0	0	0	0
5. Manufacturing	0	0	0	0	68666	0	0	0
6. Lodging	0	5429	0	0	85000	0	0	0
7. Cafes & Taverns	0	0	0	0	0	18	0	219
8. Service Stations	17530	0	32099	26742	26786	55280	17418	1052
9. Auto Sales & Service	76670	15334	128189	41994	41978	64291	49169	0
10. Communic. & Transp.	130964	154442	169048	603752	189329	37992	0	4058
11. Professional Services	38788	26977	13574	22184	20082	20681	18889	5599
12. Financial	6176	33882	192863	99788	165995	0	0	0
13. Construction	100614	78981	830757	71867	47492	137668	104259	161
14. Products	216843	180915	347569	1359571	167679	422757	32065	11230
15. Services	257154	68941	136919	1129938	248334	110385	6441	5180
16. Education	14901	24064	37603	389589	115174	70383	0	0
17. County Roads	637	1028	1607	16647	4921	0	0	0
18. Law Enforcement	777	1255	1962	20326	6009	0	0	0
19. Health Dept.	294	474	741	7679	2270	0	0	0
20. Welfare	1957	3160	4938	51156	15123	0	0	0
21. Port Authority	372	9920	939	9732	2877	0	0	0
22. General Fund	1753	12184	4424	45836	13550	0	0	0
23. Astoria	7200	3600	3500	147648	26597	0	0	0
24. Warrenton	50	600	100	35068	5500	0	0	0
25. Hammond	0	0	50	1100	100	0	0	0
26. Gearhart	50	0	0	3000	300	0	0	0
27. Seaside	3000	3120	1600	70000	12000	0	0	0
28. Cannon Beach	100	0	100	7400	200	0	0	0
29. Aluminum	0	0	0	0	0	0	0	0
30. Households	3105940	1416209	4847974	7771713	6473845	3370333	196760	176929
31. Government	781251	542571	738480	1647535	751585	0	17643	350
32. Imports	2529936	5224503	10461891	30384030	7175960	722929	0	25064
33. Depreciation	159183	66484	592948	1378085	568593	0	0	0
34. Total inputs	7452140	7876573	18669454	45394380	16235945	4012717	442644	229842

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Table 2. (Continued)

	Health Department	Welfare	Port Authority	General Fund	Astoria	Warrenton	Hammond	Gearhart
1. Lumber	0	0	4174	0	135	174	0	48
2. Commercial Fishing	0	0	0	0	20	0	0	0
3. Fish Processing	0	0	2344	0	446	0	0	0
4. Agriculture & Fur	0	0	0	0	0	0	0	0
5. Manufacturing	0	0	1590	0	897	4034	0	0
6. Lodging	0	0	0	57	23018	0	0	0
7. Cafes & Taverns	0	0	1283	77	3210	0	19	0
8. Service Stations	1398	0	9271	3641	10929	1795	0	1452
9. Auto Sales & Services	0	0	5521	321	8296	5365	0	1769
10. Communic. & Transp.	1573	2258	1547	25911	9859	1461	0	974
11. Professional Services	0	209583	18424	11450	14078	4099	100	1950
12. Financial	0	0	7324	0	0	0	0	75
13. Construction	76	0	104663	5840	67680	53246	11903	17296
14. Products	4159	16761	40295	36595	93446	14507	3228	9437
15. Services	0	38425	2772	10977	75883	6433	724	2575
16. Education	0	0	0	38	2360	708	0	0
17. County Roads	0	0	0	0	0	0	0	0
18. Law Enforcement	0	0	0	0	5	0	0	0
19. Health Dept.	0	0	0	0	25	0	0	0
20. Welfare	0	0	0	0	0	0	0	0
21. Port Authority	0	0	0	0	211	0	0	0
22. General Fund	0	0	7195	1859	0	12	0	49
23. Astoria	0	0	2738	0	57349	0	0	0
24. Warrenton	0	0	3083	0	415	0	273	6761
25. Hammond	0	0	0	0	0	0	0	0
26. Gearhart	0	0	0	0	0	0	0	0
27. Seaside	0	0	0	0	0	0	0	0
28. Cannon Beach	0	0	0	0	0	0	0	0
29. Aluminum	0	0	0	0	0	0	0	0
30. Households	73522	498750	451838	338156	664663	59203	6971	26841
31. Government	5569	0	0	17030	17644	906	512	385
32. Imports	0	0	391949	82219	270740	11022	3047	13612
33. Depreciation	0	0	0	0	0	0	0	0
34. Total Inputs	86297	765777	1065011	534166	1321309	162965	26777	83224

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Table 2. (Continued)

	Seaside	Cannon Beach	Aluminum	Households	Government	Exports	Capital formation & inventory	Total output
1. Lumber	0	0	0	43538	851636	54654735	98391	60564452
2. Commercial Fishing	0	0	0	16896	0	921643	0	3566305
3. Fish Processing	0	0	0	392800	3080000	35889000	335741	39786831
4. Agriculture & Fur	0	0	0	125850	0	2651016	67568	3799475
5. Manufacturing	0	0	0	360900	0	2933940	42598	7124345
6. Lodging	0	164	0	7275523	0	203167	4956	7597314
7. Cafes & Taverns	277	19	0	6284390	0	0	105844	6395356
8. Service Stations	3659	516	100000	5154461	47400	57317	95428	6594843
9. Auto Sales & Service	9153	2265	5000	7510378	161876	351207	547197	9580321
10. Communic. & Transp.	2217	155	0	3764132	245564	1394554	20344	13722312
11. Professional Services	30648	3395	50000	3166537	374974	2105943	25734	7452140
12. Financial	0	1218	0	2790055	0	2583077	4114	7876573
13. Construction	25899	55703	0	3173407	442206	11828228	850250	18669454
14. Products	34604	5722	6564000	24801633	547711	9240657	769585	45394380
15. Services	10612	122	0	10711458	168339	482767	68947	16235945
16. Education	0	0	957060	1256401	1037714	0	0	5012717
17. County Roads	0	0	40896	82119	242372	0	0	442645
18. Law Enforcement	139	0	49933	85438	0	0	0	229842
19. Health Dept.	0	0	18865	31770	0	0	0	86297
20. Welfare	0	0	125669	164975	237727	0	0	765777
21. Port Authority	0	0	1523908	31386	0	931882	0	1056011
22. General Fund	329	219	112601	147813	0	42023	0	534166
23. Astoria	0	0	0	761401	156776	0	0	1321309
24. Warrenton	0	0	120605	73259	27156	0	0	162965
25. Hammond	0	0	0	5141	7534	8037	0	26777
26. Gearhart	0	0	0	5200	6005	57719	0	83224
27. Seaside	0	0	0	111178	57519	46579	0	390796
28. Cannon Beach	0	1968	0	69166	8214	0	0	105938
29. Aluminum	0	0	0	0	0	60000000	0	60000000
30. Households	217498	12734	6000000	200000	20529000	1533853	339543	89787205
31. Government	1242	0	3000000	11190000	0	0	0	26215950
32. Imports	54519	21738	41286463	0	0	0	1259010	145285115
33. Depreciation	0	0	0	0	0	0	0	14416751
34. Total Inputs	390796	105938	60000000	89787205	28229723	201721844	15966250	354365715

Source: Collin (1970)

The result of post-multiplying the environmental matrix (Table 1) by the Clatsop County model's Leontief inverse (Appendix Table 2) is presented in Table 3. Interpretation of the elements is similar to that of a Leontief inverse; each element indicates the direct and indirect resource requirement or residual discharge per dollar of delivery to final demand by the sector specified at the top of the column. Final demand sectors of the Clatsop County model include Government, Exports, and Inventories. Households were originally included in the final demand sectors but Haroldsen incorporated the sector into the endogenous part of the matrix in 1971.

The interdependencies existing in Clatsop County are specified more clearly as a result of the matrix multiplication. Most sectors are shown to have a relationship with the environment due to economic activity. Comparison of Tables 1 and 3 reveals the latter to have entries where none previously existed and larger values of the previously specified non-zero elements. Both factors indicate the presence of indirect environmental linkages. The presence of some indirect linkage was in essence guaranteed by inclusion of the Leontief inverse in the model. Thus, a sector may not be identified as environmentally important by the casual observer but its sales may have environmental repercussions because of purchases from environmentally linked sectors. The linkages and magnitudes can stand alone for identification of resource users and residuals producers.

Table 3. Direct and Indirect Linkages per Dollar Delivery to Final Demand: Clatsop County, Oregon.

	Lumber	Commercial Fishing	Fish Processing	Agric. & Fur	Manufac.	Lodging	Cafes & Taverns	Service Stations	Auto Sales & Service	Communic. & Transp.
Particulates (lbs.)	.023009	.001330	.000371	.001452	.000698	.001050	.000605	.009133	.000419	.001693
Carbon Monoxide (lbs.)	.037448	.143985	.027142	.093474	.046737	.045140	.044124	1.488330	.025691	.038899
Fluoride (lbs.)										
Hydrocarbons (lbs.)	.006965	.026781	.005048	.017386	.008693	.008396	.008207	.276827	.004778	.007235
Domestic Water (gals.)	141.656	7.25195	2.34332	5.2362	2.58009	5.96772	5.36631	2.59128	2.77934	5.2873
Cooling Water (gals.)	135.499	.238302	.361263	.600722	.313034	.28813	.213103	.112815	.125319	1.8385
Process Water (gals.)	48.6376	.637298	1.62980	.843618	.590595	.786157	.723803	.580341	.512665	1.23493
Water Intake (gals.)	325.793	8.12755	4.33438	6.68054	3.48372	7.04201	6.30322	3.28444	3.41732	8.36073
Water Discharge (gals.)	276.976	6.53177	3.80134	5.41758	2.82530	5.66907	5.06900	2.64153	2.74935	6.91078
5-Day BOD (lbs.)	.551494	.000983	.005259	.002454	.001282	.001182	.000877	.000464	.000515	.007489
Suspended Solids (lbs.)	.652643	.168161	.054279	.111780	.053183	.119991	.120996	.056181	.062920	.087978
Organic Nitrogen (lbs.)	.000001	.000003	.001002	.000002	.000002	.000003	.000003	.000001	.000001	.000002
Solid Waste (lbs.)	.570218	1.58048	2.12952	55.5852	11.7938	4.26263	4.71044	4.16639	.501177	.618392
Solid Waste (cu. yds.)	.453151	.000795	.000502	.002007	.001046	.000962	.000711	.000376	.000418	.006147

(Continued on next page)

Table 3. (Continued)

	Professional Services	Financial	Construction	Products	Services	Education	County Roads	Law Enforcement	Health Dept.	Welfare
Particulates (lbs.)	.000678	.001078	.000631	.000411	.000707	.001080	.001194	.001142	.001292	.001102
Carbon Monoxide (lbs.)	.057042	.024239	.036867	.025401	.052833	.101747	.127148	.101457	.125842	.095216
Fluoride (lbs.)										
Hydrocarbons (lbs.)	.010610	.00451	.006857	.004724	.009827	.018925	.023649	.018871	.023406	.017710
Domestic Water (gals.)	6.39382	2.92059	4.97237	3.07275	6.02346	10.1225	8.32065	11.221	12.0994	11.1617
Cooling Water (gals.)	.1882	.112899	1.01326	.088059	.150644	.263606	.400945	.276195	.30131	.263691
Process Water (gals.)	.677942	.448903	1.12445	1.41702	.833402	.791878	.873558	.801121	.845854	.830496
Water Intake (gals.)	7.25997	3.48240	7.11008	4.57783	7.00751	11.1780	9.59515	12.2983	13.2466	12.25589
Water Discharge (gals.)	5.83154	2.8003	5.81083	3.67360	5.62498	8.97556	7.72558	9.87346	10.6353	9.83799
5-Day BOD (lbs.)	.000777	.000466	.004131	.000368	.000624	.001091	.001646	.001144	.001247	.001093
Suspended Solids (lbs.)	.148109	.066710	.098352	.066935	.131000	.236707	.190483	.263041	.283685	.261635
Organic Nitrogen (lbs.)	.000003	.000002	.000002	.000003	.000003	.000005	.000004	.000005	.000006	.000005
Solid Waste (lbs.)	1.13914	.509798	.703114	1.07824	2.55735	1.80898	1.57697	1.95757	2.10270	1.97514
Solid Waste (cu. yds.)	.000627	.000376	.003387	.000293	.000502	.000878	.001338	.000920	.001004	.000878

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Table 3. (Continued)

	Port Authority	General Fund	Astoria	Warrenton	Hammond	Gearhart	Seaside	Cannon Beach	Aluminum	Households
Particulates (lbs.)	.610456	.001021	.001033	.000948	.000710	.000894	.001015	.000618	.033943	.0013
Carbon Monoxide (lbs.)	.070686	.090861	.083749	.079540	.052398	.084765	.090571	.046011	.021191	.116988
Fluoride (lbs.)									.005600	
Hydrocarbons (lbs.)	.013148	.016900	.015577	.014794	.097459	.015766	.016846	.008558	.003942	.021760
Domestic Water (gals.)	7.60213	9.60973	38.0571	48.6398	75.0269	46.7542	50.2304	32.2451	2.23944	13.86033
Cooling Water (gals.)	.776417	.301057	.263501	.638467	.550809	.488371	.276005	.600658	3.462775	.301457
Process Water (gals.)	.770488	.758455	.721935	.966174	.933039	.862091	.786926	.834861	30.8816	.872261
Water Intake (gals.)	9.14904	10.6692	39.0425	50.2444	76.5108	48.1047	51.2933	33.6806	36.583815	15.034
Water Discharge (gals.)	7.41443	8.57300	31.2671	40.2736	61.2759	38.5435	41.0692	27.0174	36.583815	12.0655
5-Day BOD (lbs.)	.003181	.001242	.001089	.002612	.002253	.002000	.001140	.002453	.000260	.001251
Suspended Solids (lbs.)	.161647	.223644	.196431	.172344	.142840	.158909	.212194	.104564	.049813	.326133
Organic Nitrogen (lbs.)	.000005	.000005	.000004	.000004	.000003	.000003	.000004	.000002	.000001	.000006
Solid Waste (lbs.)	1.24156	1.68918	5.01628	4.88694	4.39511	4.82904	4.86796	4.09313	.436503	2.31657
Solid Waste (cu. yds.)	.002593	.001004	.000898	.002133	.001840	.001631	.000920	.002007	.000209	.001004

The inclusion of the Leontief inverse in the modification of the input-output model reveals environmental linkages often overlooked. Decisions in Clatsop County regarding changes in the level of economic activity involve impact considerations as well as linkages though. The former require that emphasis be given to linkage magnitudes shown in Table 3.

Atmospheric Emissions

Environmental impact through atmospheric emission of particulates, fluorides, carbon monoxide, and hydrocarbons appears to be a potential of economic activity in most sectors of the Clatsop County economy (see Table 3). On the basis of the measure used in Table 3 the operations of the port authority result in the largest emission of particulates: .610456 pounds of particulate matter per dollar delivery to final demand. Aluminum and Lumber deliveries to final demand account for .033943 lbs. and .023009 lbs, respectively. Among those sectors for which no direct particulate linkage could be estimated (see Table 1) Communications-Transportation and Agriculture-Fur showed the largest indirect linkage. Reference to the transactions matrix (Table 2) indicates the indirect link for the former sector arises from purchases made from Lumber, Service Stations, and Port Authority, while the latter's results from large service station sector purchases.

Carbon Monoxide emissions were allocated to but one sector, Service Stations. From an engineering viewpoint, Communications-Transportation should also have a carbon monoxide link. Partial allowance for this deficiency was made by inclusion of Oregon Motor Vehicles Division (1972) bus and truck data in the service station sector's carbon monoxide figure. Bus and truck annual mileage was estimated at the level assigned to the 16, 651 passenger cars registered in Clatsop County. Mileage was estimated at 5, 000 in-county miles per year. Due to the assignment of personal and commercial use motor vehicle emissions to Service Stations, the sector showed the largest linkage in Table 3. Public firms are again shown to have residual linkages higher than many private firms, e. g. , County Roads and Health Department.

Gaseous and solid fluoride result from primary aluminum production plants like that proposed in Clatsop County. The proposed plant uses the vertical stud Soderberg (VSS) reduction process. Iversen (1972) has demonstrated that the best available primary <u>and</u> secondary residual treatment process for the VSS process will keep fluoride emissions to approximately 2. 8 pounds per ton of aluminum. When related to aluminum prices and deliveries to final demand an emission of . 0056 pounds fluoride would be anticipated (see Table 3). Note that the fluoride residual appears in but one column and the value is identical in Tables 1 and 3. The blanks are a result of zero purchases of locally produced aluminum by Clatsop County firms (see Table 2). The fluoride residual identity also flows from this unique purchasing pattern.

Hydrocarbon emissions were accounted for in a manner identical to carbon monoxide. Public firms were again demonstrated to be leading contributors to generation of atmospheric pollutants. The city of Hammond, County Roads, and Health Department were estimated to be responsible for .052398, .023649 and .023406 pounds, respectively, per final demand dollar (see Table 3).

Solid Waste

The disposal of solid wastes has increasingly become the responsibility of public agencies. A trend toward private disposal companies operating in municipalities is not contrary to this observation. Public input regarding rates, disposal methods, and disposal sites will be no less frequent regardless of which type of firm handles the physical transport of wastes.

Historically, the disposal of solid waste has been managed in a manner yielding secondary problems. For example, the filling of tidelands and marshes with solid waste has reduced the supply of such parcels in San Francisco Bay so as to have generated a new institution to manage the whole estuary not solely the solid waste disposal sites.

Elements of Table 3 reveal responsibility for generation of solid waste (lbs.) among all private and public firms depicted in Clatsop County. It is worthwhile to recall that the figures represent "raw" waste in that no firm treats solid waste to reduce poundage before disposal. On occasion effort is expended among firms in the products sector to reduce the volume of waste when related to disposal charges. Agriculture and Fur (55.5852 lbs.) rank first in solid waste generation, though disposal as such remains at the production site. Manufacturing (11.7938 lbs.) and the County's municipalities are a distant third and fourth respectively. Municipalities generate solid waste in relation to provision of public services. The municipality coefficients are based on two linearity assumptions: 1) an assumed linear relationship between population and municipal solid waste, 2) an assumed linear relationship between municipality final demand expenditures and population. The assumptions though made explicit do not make the municipality estimates less tenuous.

The semi-enclosed characteristic of estuaries tests the ingenuity of public resource managers charged with dredge spoil disposal. Disposal of dredge spoil resulting from maintenance dredging of turning basins, dock areas, and channels is the responsibility of the port authority. A direct linkage coefficient for the solid waste produced by Port Authority's dredging operation could not be developed due to lack of suitable data and the lack of annual need for dredging. Port Authority is, however, still hard pressed in Clatsop County to meet its charge of locating feasible spoil disposal sites. The likelihood of additional future emphasis on environmental impact statements and the paucity of sites will require that coastal zone researchers devote resources to the subject. A possible approach to inclusion of a spoil coefficient in the method of analysis used in the Clatsop County study would be consideration of land use requirements. For example, a conversion factor for estimating marsh or tideland acreage to be eliminated by disposal of spoil on the land surface could serve experimentally as a proxy.

Water Directed Emissions

The mention of saline and fresh water components is common to all definitions of the coastal zone. Emission of residuals into this major component of the coastal zone as a result of coastal economic activity consequently requires analysis. Three specific residuals of productive processes--Bio-Chemical Oxygen Demand (BOD), Suspended Solids, and Organic Nitrogen--were estimated as well as the quasi-residual "Water Discharge."

Public concern for the present and future quality of water resources is based on man's personal and industrial needs and frequently on the aesthetics of preserved aquatic life. A single parameter (BOD) has on occasion been used to monitor changes in water quality. In instances involving use of more than one parameter BOD remains a key target of scientific measurement and public concern. In spite of the impressive amount of recent research on BOD loadings resulting from industrial and municipal water use, the data available matched only two economic sectors as defined in the Clatsop County model--Lumber (-, 50894 lbs.) and Fish Processing (-. 00464 lbs.) (see Table 1). Direct and indirect linkages shown in Table 3, however, are present in each cell of the BOD row. Lumber produces by far the largest BOD loading of any sector. The reason for the top ranking is the predominence of pulp and paper production in the lumber sector. Lumber BOD is an "after treatment" residual contrary to Fish Processing's "before treatment." At the time of the analysis fish processors in the county were having their wastewater monitored to determine the magnitude of certain residuals of concern to the Environmental Protection Agency. A striking element of the BOD row in Table 3 is the second place rank of Communication-Transportation (. 007489 lbs.) as opposed to Fish Processing, third place (. 005259 lbs.). The ordering of the former is attributable to purchases from Lumber as was the case with particulate emissions.

Direct suspended solids linkages were developed for three sectors; Lumber, Fish Processing, and Households. Indirect linkages were shown to be numerous since all sectors have entries in the suspended solids row. The total residuals shown in Table 3 reveal that Lumber (. 652643 lbs.) and Households (. 326133 lbs.) are major dischargers of suspended solids. Once again a sector, fish processing, credited with direct residual discharge drops in the ranking of dischargers after allowance for indirect residual generation. An explanation is the numerous sectors without direct linkage that are tied monetarily to Lumber and Households.

Organic nitrogen discharges have received widespread media coverage directed at general audiences as well as subject matter professionals since the mid-1960's. Eutrophication and other aquatic biomass growth problems are the potential result of uncontrolled disposal of nitrogenous residuals. The former is a natural process capable of acceleration with the ultimate collapse of aquatic systems. In the latter case aquatic plant growth may proceed to the point of limiting recreational or other uses of water resources. Data inadequacies prohibited the development of direct linkages for sectors other than fish processing. The disposal of blood, scales, and some viscera by the sector in water discharges is linked indirectly to Households (.000006 lbs.) and Health Department (.000006 lbs.).

Water Inputs

The Clatsop County economy includes sectors utilizing municipally and privately provided water inputs. Key sectors such as lumber and aluminum draw practically all water from the Columbia River without assistance from municipalities or special water districts.

The nature of productive processes in Fish Processing require municipally provided potable water. Therefore, one key water using sector obtains rights to water inputs via a quasi-market while others appropriate water without the use of any market. Regardless of the method of acquisition, as available data permitted water inputs were divided into domestic, cooling, and process.

Domestic water is the first of the water inputs in Table 3. The term is somewhat of a misnomer in that it connotes potable water. The connotation is valid in each direct link identified in Table 1 with the exception of Lumber. Lumber's boiler water needs were allocated to Domestic Water. The boiler water was separated from Process Water for Lumber on the premise that such a coefficient would be more stable in time due to more stable boiler technology as opposed to process technology. Lumber (141.656 gals.) and Hammond (75.0269 gals.) rank at the top of domestic water using sectors. The remaining municipalities rank toward the top as compared to private firm users.

Water use for cooling of productive process machinery was estimated to be directly linked to Lumber, Fish Processing, and Aluminum. Lumber (135.499 gals.) retains top rank among cooling water users after allowance for indirect use by all sectors. Communications-Transportation (1.8385 gals.) and Construction (1.01326 gals.) once again had larger indirect requirements than the total cooling water needs of Fish Processing and Aluminum, sectors with estimated direct coefficients.

The process water coefficient in Tables 1 and 3 yielded the same ranking of top three sectors. Table 3 coefficients were Lumber (48.6376 gals.), Aluminum (30.8816 gals.), Fish Processing (1.6298 gals.). The process water coefficients are subject to becoming dated. The speed of the change in process water utilization will be dependent in part on industry initiated changes in technology and process changes imposed by water resource managers.

Allowance for consumptive use of water inputs was estimated when sector data permitted. Development of this "quantity" factor adds information to the "quality" orientation of water directed emissions. Consumptive use of water will likely not be a problem in the Clatsop County economy though the factor deserves research consideration in low fresh water flow estuaries.

Water intake coefficients were developed on the basis of the actual intake of water. Coefficients would be inflated if calculated on the basis of recirculated water since in the representation of a sector in operation, water intake exclusive of recirculation practices is the relevant index. Water for recirculation purposes is actually needed only to prime the productive process and should not be included in daily water intake estimates of a plant in operation. Lumber (325.793 gals.) and the municipalities were shown to be top ranked in the water intake row. Consumptive use of water was largest in Lumber (48.817 gals.). Pulp and paper manufacturing firms in the lumber sector were calculated to have a 15 percent consumptive use while plywood establishments consumed 9 percent of water intake.

Direct Links and Planning

The previous discourse on coefficients found in Table 3 confirmed a contention set forth in Chapter II. It was stated there that national level coastal zone and estuarine management studies place undue emphasis on first-round and readily observable potential sources of conflict among economic pursuits in drafting management plans. On two occasions in Table 3, BOD and Suspended Solids, first-round relationships among economic sectors were shown to provide unsatisfactory information for planning purposes. For example, fish processing was one of three sectors with a direct suspended solids link yet ranked twenty-eighth when direct and indirect links were developed. A similar situation was evident for BOD. In this instance decision makers acting on direct link information would not have considered Communications-Transportation as a vital sector to monitor when protecting sectors sensitive to BOD loadings. Communications-Transportation ranked second in BOD loadings per dollar delivery to final demand. The transactions matrix (Table 2) retains significance in evaluating environmental linkages by facilitating isolation of the sources of the indirect links.

Supply Prices

Individuals and agencies charged with management of coastal zone resources are inevitably involved in decisions affecting a locality's welfare. Rising demand for greater quantities of both the market goods of economic growth and the non-market services of environmental goods must be weighed against the decision maker's assessment of community needs and supply capacities. The emergence of additional agency permit requirements, minimum damage planning, environmental impact statements, and other checks on unilateral economic activity have been part of society's answer to the sizable information requirements of policy decisions in the coastal zone. Economists have a framework for developing and communicating information of value in optimizing various objective functions. Castle and Stoevener make no distinction between private and public firms when they say:

> Even though the market is rejected as a means of allocating certain goods and services, it may still provide data and criteria of value in dealing with extra-market problems. The role of the market in generating relevant information for decision-makers has not been given the explicit treatment it deserves. The generation and communication of information is an automatic function of the market. When the market is displaced, some substitute for the choice indicator--i. e., price--must be provided (1970, p. 544).

The discourse in Chapter I was descriptive of the extra-market problems inherent in coastal zone and estuarine resource allocations. If the modified input-output procedure presented in the Clatsop County model is to surmount extra-market problems, a choice indicator is needed. The coefficients in Table 3 offer a surrogate for price--supply price. A supply price will identify the minimum opportunity cost of securing a good. In essence, a trade-off is specified. An example would be the amount of net business income a firm will forgo to maximize sales as opposed to profit. Supply price is not a perfect substitute for the traditional choice indicator. Prices are established by combined demand and supply forces while supply prices provide no measure of sacrifice (demand) for goods.

Viewing the coefficients of Table 3 as supply prices of the specified environmental goods permits an answer to the following general questions: 1) If sector Z proceeds to grow rapidly, what will be the effect on environmental good Y?, 2) Which sectors should be encouraged to expand in relation to minimum environmental impact planning?, 3) How much impact on the local economy will result from an increase of X units of environmental good Y by restricting economic sector Z sales? An example of an answer to (1) would be a ranking of sectors having large Table 3 coefficients such as presented in Table 4. Lumber ranks high in most of the environmental goods relationships. For each dollar increase in delivery to final demand Lumber uses .551494 pounds of the surrounding water's BOD loading capacity. Sectors to be encouraged to expand (2) would depend upon statement of the specific environmental goods subject to minimum impact planning.

Table 4. Economic Sectors Exhibiting Relatively Large Direct and Indirect Relationships to Selected Environmental Goods: Clatsop County, Oregon.

	Rank (1-10)									
	1	2	3	4	5	6	7	8	9	10
Particulates (lbs)	Port Authority	Aluminum	Lumber	Service Stations	Comm. & Transp.	Agric. & Fur	Commercial Fishing	Households	Health Dept.	County Roads
Carbon Monoxide (lbs.)	Service Stations	Commercial Fishing	County Roads	Health Dept.	Households	Education	Law Enforcement	Agric. & Fur	Welfare	General Fund
Fluoride (lbs.)	Aluminum									
Hydrocarbons (lbs)	Service Stations	Hammond	Commercial Fishing	County Roads	Health Dept.	Household	Education	Law Enforcement	Welfare	Agric. & Fur
Domestic Water (gals.)	Lumber	Hammond	Seaside	Warrenton	Gearhart	Astoria	Cannon Beach	Households	Health Dept.	Law Enforcement
Cooling Water (gals.)	Lumber	Aluminum	Comm. & Trans.	Construction	Port Authority	Warrenton	Agric. & Fur	Cannon Beach	Hammond	Gearhart
Process Water (gals.)	Lumber	Aluminum	Fish Processing	Products	Comm. & Trans.	Construction	Warrenton	Hammond	County Roads	Households
Water Intake (gals.)	Lumber	Hammond	Seaside	Warrenton	Gearhart	Aluminum	Cannon Beach	Households	Health Dept.	Law Enforcement
Water Discharge (gals.)	Lumber	Hammond	Seaside	Warrenton	Aluminum	Astoria	Cannon Beach	Households	Health Dept.	Law Enforcement
5-Day BOD (lbs.)	Lumber	Comm. & Trans.	Fish Processing	Construction	Port Authority	Warrenton	Agric. & Fur	Cannon Beach	Hammond	Gearhart
Suspended Solids (lbs.)	Lumber	Households	Health Dept.	Law Enforcement	Welfare	Education	General Fund	Seaside	Astoria	County Roads
Organic Nitrogen (lbs.)	Fish Processing	[Households &	Health Dept.]	[Education &	Law Enforcement &	Welfare &	Port Authority &	General Fund]	[County Roads &	Others]
Solid Waste (lbs.)	Agric. & Fur	Manufac.	Astoria	Warrenton	Seaside	Gearhart	Cafes & Taverns	Hammond	Lodging	Service Stations
Solid Waste (cu. yds.)	Lumber	Comm. & Trans.	Construction	Port Authority	Warrenton	[Agric. & Fur &	Cannon Beach]	Hammond	Gearhart	County Roads

Low coefficients in Table 3 for the corresponding environmental goods of concern would be the choice indicator. Additional emphasis will be devoted to development of choice indicators related to (2) and (3) in the next chapter when economic growth and minimum impact planning are considered at length.

CHAPTER IV

GROWTH PERSPECTIVES OF THE MODEL

The expansion of the input-output model of Clatsop County, Oregon, to include environmental goods allowed a representation of the county's economy through a direct and indirect linkage matrix (Table 3). The insight gained from the matrix as to the source(s) of environmental linkages, the corresponding magnitudes, and a proxy monetary choice indicator-supply price(s) can be utilized in examining the resource use imperfections delineated in Chapter I and faced by those entrusted with revealing the characteristics of alternative solutions. Chapter IV will be devoted to extension of the modified model's latent ability to represent resource use conflicts and furnish input for further study of the conceptual roots of growth[14] complexities in estuarine economies. Multiplier analysis and growth projections for Clatsop County to 1980 will be applied to the former and linear programming of constrained economic growth to the latter.

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[14] The word "growth" is used in a manner inclusive of development considerations as expressed by Bromley and Stoevener (1968). Basically, they depict changes to a region's fixed resources (human and/or natural) as "growth" while "development" refers to internal and external relationships of a region, i. e., economic structure is the focal point of "development." Use of "growth" in the inclusive manner herein is consistent with the orientation of prior sections dealing with the structure and resource base of Clatsop County's income stream.

Business and Environmental Income Multipliers

Whether expanded business activity originates from public or private investment, the associated income multiplier effects are a focal point of interest. A national accounting stance would frequently disallow incorporation of such secondary benefits when a decision involves public investment. Localities and regions, however, view secondary benefits of public project construction and operation as external income generating growth. In previous chapters a predilection toward monetary indices alone was shown to be an incomplete analysis of coastal zone economic activity. Youmans and Coppedge (1970) demonstrated falacious methods of calculating multipliers thus adding accuracy considerations to those of applicability to a situation. Accurate multipliers specify the amount of business or household income increase as a result of an expenditure and not the value-added to products or the number of times a dollar turns over before an economy loses it to leakages.

Input-output models provide a means of computing multipliers for the various sectors comprising an economy. The Leontief inverse (Appendix Table 1) represents direct and indirect purchases of sectors across the top from left-hand-side sectors for each dollar of sales to final demand. Computing income multipliers reduces to the simple task of summing endogenous columns of the Clatsop County Leontief inverse (Table 5). The multipliers can be related to the

Table 5. Business Income Multipliers by Sector for the Clatsop County, Oregon, Economy.

Sector	Multiplier	Sector	Multiplier
Lumber	1.8454	Education	3.1849
Commercial Fishing	2.7556	County Roads	3.173
Fish Processing	1.7511	Law Enforcement	3.332
Agriculture	2.6028	Health Dept.	3.4659
Manufacturing	1.9059	Welfare	3.5789
Lodging	2.4045	Port Authority	2.5597
Cafes & Taverns	2.2916	General Fund	3.0694
Service Stations	1.7448	Astoria	2.9661
Auto Sales & Service	1.689	Warrenton	3.0662
Communic. & Transp.	1.7847	Hammond	2.8632
Professional Services	2.3664	Gearhart	2.9311
Financial	1.6462	Seaside	3.1098
Construction	1.9116	Cannon Beach	2.627
Products	1.6646	Aluminum	1.6022
Services	2.2532	Households	2.3512

elements of Table 3 for insight to the environmental impact per dollar of income generated. The procedure offers another index for measurement of trade-offs. It is conceivable that a sector exhibiting a large environmental impact would also have a large income multiplier. Ranking of sectors on the basis of an environmental income multiplier provides a measure of returns to non-market resources valuable for growth analysis and descriptive information on the structure of market and non-market activities for development purposes.

Performing the desired division of Table 3 elements by the respective multipliers yields environmental linkages per dollar of income generated (Table 6). The ranking of major air residuals sectors remained in line with that of Table 4. However, a general decline in the rank of public service sectors and a higher rank for Households (3) was noticeable for both Carbon Monoxide and Hydrocarbons. Aluminum maintains the highest rank among private sector particulate emitters. The remaining environmental links are dominated by Lumber. Aluminum remains low in most environmental links among the private sectors in spite of having the lowest multiplier. Relative to public and private sector linkages, establishment of Aluminum in Clatsop County would, in general, have minimal environmental linkage. Two exceptions to this generality are notable--Particulates and Process Water. The delaying influence public opinion has had on construction plans for the aluminum plant indicates that all

Table 6. Direct and Indirect Linkages per Dollar of Income Generated, Clatsop County, Oregon.

	Lumber	Commercial Fishing	Fish Processing	Agric. & Fur	Manufac.	Lodging	Cafes & Taverns	Service Stations	Auto Sales & Services	Communic. & Transp.
Particulates (lbs.)	.012469	.000483	.000212	.000558	.000366	.000437	.000264	.005234	.000248	.000949
Carbon Monoxide (lbs.)	.020293	.052252	.0155	.035913	.024522	.018773	.019255	.853009	.015211	.021796
Fluoride (lbs.)										
Hydrocarbons (lbs.)	.003774	.009719	.002883	.00668	.004561	.003492	.003581	.158658	.002829	.004054
Domestic Water (gals.)	76.761677	2.631714	1.338199	2.011757	1.353738	2.481896	2.341731	1.485144	1.645554	2.96257
Cooling Water (gals.)	73.425273	.086479	.206306	.230798	.164245	.119829	.092993	.064658	.074197	1.030145
Process Water (gals.)	26.356129	.231274	.930729	.324119	.309877	.326952	.31585	.332612	.303532	.691954
Water Intake (gals.)	176.543296	2.949467	2.475233	2.566674	1.827861	2.92868	2.750576	1.88416	2.02328	4.68467
Water Discharge (gals.)	150.089953	2.370362	2.170830	2.081443	1.482397	2.357692	2.211992	1.513944	1.627798	3.87236
5-Day BOD (lbs.)	.298848	.000357	.003003	.000943	.000673	.000492	.000383	.000266	.000305	.004196
Suspended Solids (lbs.)	.353659	.061025	.030997	.042946	.027904	.049903	.0528	.032199	.037253	.049296
Organic Nitrogen (lbs.)	.000001	.000001	.000572	.000001	.000001	.000001	.000001	.000001	.000001	.000001
Solid Waste (lbs.)	.308994	.573552	1.216104	21.355924	6.188048	1.772772	2.055525	2.38789	.29673	.346496
Solid Waste (cu. yds.)	.245557	.000289	.000287	.000771	.000549	.0004	.000310	.000216	.000275	.003444

(Continued on next page)

Table 6. (Continued)

	Professional Services	Financial	Construction	Products	Services	Education	County Roads	Law Enforcement	Health Dept.	Welfare
Particulates (lbs.)	.000287	.000655	.00033	.000247	.000314	.000339	.000376	.000343	.000373	.000308
Carbon Monoxide (lbs.)	.024105	.014724	.019286	.01526	.023448	.031947	.040072	.030449	.036309	.026605
Fluoride (lbs.)										
Hydrocarbons (lbs.)	.004484	.00274	.003587	.002838	.004361	.005942	.007453	.005664	.006753	.004948
Domestic Water (gals.)	2.701919	1.77414	2.601156	1.845939	2.673291	3.178279	2.622329	3.367647	3.490984	3.118752
Cooling Water (gals.)	.07953	.068582	.530059	.052901	.066858	.082767	.126362	.082892	.086936	.073679
Process Water (gals.)	.286487	.272609	.588225	.851268	.369875	.248635	.27531	.240433	.24405	.232053
Water Intake (gals.)	3.067939	2.115417	3.719439	2.750108	3.110026	3.509686	3.023999	3.690966	3.82198	3.424485
Water Discharge (gals.)	2.464309	1.701069	2.710206	2.206897	2.496441	2.818161	2.434787	2.963223	3.068554	2.748887
5-Day BOD (lbs.)	.000328	.000283	.00216	.000221	.000277	.000343	.000519	.000343	.00036	.000305
Suspended Solids (lbs.)	.062588	.040524	.05145	.040211	.05814	.074322	.060032	.078944	.08185	.073105
Organic Nitrogen (lbs.)	.000001	.000001	.000001	.000002	.000001	.000002	.000001	.000002	.000002	.000001
Solid Waste (lbs.)	.481381	.309682	.367814	.647747	1.134986	.567986	.496997	.587506	.606682	.551885
Solid Waste (cu. yds.)	.000265	.000228	.001772	.000176	.000223	.000276	.000422	.000276	.00029	.000245

(Continued on next page)

Table 6. (Continued)

	Port Authority	General Fund	Astoria	Warrenton	Hammond	Gearhart	Seaside	Cannon Beach	Aluminum	Households
Particulates (lbs.)	.238487	.000333	.000348	.000309	.000248	.000305	.000326	.000235	.021185	.000553
Carbon Monoxide (lbs.)	.027615	.029602	.028235	.025941	.018301	.028919	.029124	.017515	.013226	.049757
Fluoride (lbs.)									.003495	
Hydrocarbons (lbs.)	.005137	.005506	.005252	.004825	.034039	.005379	.005417	.003258	.00246	.009255
Domestic Water (gals.)	2.96993	3.130817	12.830687	15.863218	26.203863	15.951076	16.152293	12.274496	1.397728	5.895003
Cooling Water (gals.)	.303323	.098083	.088838	.208227	.192375	.166617	.088753	.228648	2.161263	.128214
Process Water (gals.)	.301007	.247102	.243395	.315105	.325873	.294119	.253047	.3178	19.274498	.370985
Water Intake (gals.)	3.574263	3.475989	13.162908	16.386537	26.722129	16.411825	16.494083	12.820936	22.83349	6.394182
Water Discharge (gals.)	2.896601	2.793054	10.541485	13.134694	21.401194	13.149841	13.20638	10.284507	22.83349	5.131635
5-Day BOD (lbs.)	.001243	.000405	.000367	.000852	.000787	.000682	.000367	.000934	.000162	.000532
Suspended Solids (lbs.)	.06315	.072862	.066225	.056208	.049888	.054215	.068234	.039804	.03109	.138709
Organic Nitrogen (lbs.)	.000002	.000002	.000001	.000001	.000001	.000001	.000001	.000001	.000001	.000003
Solid Waste (lbs.)	.485041	.550329	1.691204	1.59381	1.535034	1.647518	1.565361	1.558101	.27244	.985271
Solid Waste (cu. yds.)	.001013	.000327	.000303	.000696	.000643	.000556	.000296	.000764	.00013	.000427

environmental goods except Particulates and Process Water are being purchased at higher prices than necessary.

Toward 1980: Business and Environmental Projections

The initial Clatsop County input-output analysis was conducted to estimate the economic impact of an operating aluminum plant. Private business sectors were expected to experience an $8,000,000 increase in business activity. Public sectors were to gain over $1,000,000 in annual tax revenue in addition to $1,500,000 of increased Port Authority business. Though monetary benefits have been well specified, individual and group response has in no way approached consensus. The result has been a period of additional study by aluminum plant representatives and those entrusted with the public aspects of the possible options. Further insight to the environmental aspects of choices and long-run growth in the economy has been sought to convert choices involving uncertainty to those involving risk.[15]

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[15] The movement from uncertainty to a risk situation is an iterative process. A lack of information as to the outcomes, and frequency of outcomes, of decisions is indicative of public decision in Clatsop County. The analysis provides a portion of the desired information. Additional information is provided in the form of actual decision results. Continued iterations involving use of information revealed from uncertainty decisions narrows the expected outcomes. Ideally the process proceeds to the point of a risk situation, i.e., one involving probability statements of decision outcomes.

Information permitting delineation of results from hypothetical decisions was developed from secondary data. The Bureau of Economic Analysis of the U. S. Department of Commerce (DeGraff, 1972) provided data useful for estimating business activity by sectors for Clatsop County in 1980. The estimates involve two conditions worth being explicitly noted: 1) projections in 1980 are in terms of 1968 dollars, 2) the proportion of each sector's total sales delivered to final demand remains constant between 1968 and 1980. Deliveries to final demand are indicated in Table 7 for the private sector and Port Authority. Total business income can be derived from Table 7 by use of the multipliers found in Table 5. A decision maker can relate the data from Table 7 to that of Table 4 to assess possible environmental damages of growth trends or, conversely, the income losses associated with stringent controls on environmentally important sectors. The use of information from Tables 4 and 7 allows a projection of environmental impact for the economic magnitudes projected for 1980. However, the environmental projections cannot be made in the absence of restrictive assumptions. Projections based on Tables 4 and 7 require: 1) the production <u>and</u> waste treatment technology in Clatsop County in 1980 does not differ from that of 1968, 2) purchasing patterns in Clatsop County will remain the same as those estimated for 1968.

Summing the figures generated from Tables 4 and 7 by

Table 7. Projected Deliveries to Final Demand for Selected Sectors of the Clatsop County Economy, 1980.

	Dollar deliveries to final demand		Percent change (%)
	1968 (000 $)	1980 (000 $)	
Lumber	55,605	85,130	53.09
Commercial Fishing	922	1,307	41.88
Fish Processing	39,305	55,774	41.90
Agriculture & Fur	2,719	3,034	11.59
Manufacturing	2,977	5,185	74.20
Lodging	208	350	68.13
Cafes & Taverns	106	NA[a]	NA
Service Stations	200	350	74.91
Auto Sales	1,060	NA	NA
Communications & Transportation	1,660	2,511	51.19
Professional	2,507	5,064	102.02
Financial	2,587	4,350	68.11
Construction	13,121	22,279	69.80
Products	10,558	19,365	83.41
Services	720	1,260	75.00
Port Authority	932	1,966	111.01
Aluminum	60,000	85,560	42.60
Households	35,867	65,940	83.84

[a]NA = Not Available

environmental good rather than economic sector yields the total environmental goods projections in Table 8. The implications surrounding addition of a new sector, aluminum, to the area's fixed resource base and those of relationships among all sectors are more evident when attention is focused on market and non-market growth rates. Service oriented sectors were estimated to have the largest growth potential, e.g., Professional. The growth potential of sales for Lumber, Commercial Fishing, Fish Processing, and Aluminum was estimated to be below average. Sectors can be singled out for estimation of trade-offs indicating the percentage of specific environmental goods increases required by those sectors contributing the largest percentages of increased economic activity. For example, Lumber, Port Authority, and Aluminum account for 43 percent of the sales increase between 1968 and 1980 while contributing 97 percent of the increase in Particulates. Similarly, Lumber, Fish Processing, and Aluminum account for 55 percent of increased sales while requiring 99 percent of increased cooling water demands. Lumber sales account for 23 percent of the sales increase and 99 percent of the BOD increase. Aluminum was projected to account for: 1) 20 percent of increased sales in Clatsop County, 2) 37 percent of Particulate increases, 3) less than one percent each of the Cooling Water and BOD increases. The aluminum sector thus shows a relatively high income trade-off for environmental goods. It should be

Table 8. Projected Generation of Environmental Goods in 1980 Based on 1968 Linkage Coefficients, Clatsop County, Oregon. [a]

	Total environmental goods		Percent change
	1968 (000)	1980 (000)	(%)
Particulates (lbs.)	3,988	6,221	56.39
Carbon Monoxide (lbs.)	10,802	17,756	64.37
Fluoride (lbs.)	336	479	42.60
Hydrocarbons (lbs.)	2,015	3,306	64.04
Domestic Water (gals.)	7,879,447	13,627,293	72.90
Cooling Water (gals.)	7,606,042	11,646,375	53.10
Process Water (gals.)	4,695,766	7,004,193	49.10
Water Intake (gals.)	20,181,254	32,277,861	53.00
Water Discharge (gals.)	18,185,684	27,570,495	51.60
5-day BOD (lbs.)	31,023	47,497	53.10
Suspended Solids (lbs.)	57,209	91,085	59.21
Organic Nitrogen (lbs.)	40	57	42.22
Solid Waste (lbs.)	448,556	651,754	45.30
Solid Waste (cu. yds.)	25,340	38,811	53.16

[a] Estimates include the environmental goods effects of public sector expenditures.

recalled that the trade-off was based on an increase in aluminum sales as if the plant were originally operating with $60,000,000 sales. A linear programming optimum will be the subject of a following section to provide additional information pertaining to the total feasibility of locating an aluminum plant in Clatsop County.

For purposes of demonstration the model has facilitated the identification of trade-offs in 1968 and those associated with growth toward 1980. The estimates generated from the analytical framework within the outlined assumptions provide at a minimum a fuller representation of coastal zone economic relationships and insight to the direction public choice should take given the values of those represented. However, analysis of similar coastal economies would ideally include a data base suitable for determination of the need for making a choice. That is, a decision maker would benefit from an index such as an environmental goods inventory or assimilative capacities of the environment in order to determine <u>when</u> public choice is required from a resource standpoint.

Linear Programming of Business and Environment

The analysis to this point has utilized a model that permits consideration of general equilibrium forces in the Clatsop County economy. However, the trade-offs have been formulated for single environmental goods rather than simultaneous consideration of groups such as "air" or "water." It seems plausible that simultaneous consideration of several environmental goods may suggest business income effects of environmental regulation distinct from the one good case. For example, turbidity is often of major public concern in estuaries. Overt restriction of suspended solids disposition by altering the magnitude or direction of certain economic activities may be unnecessary if consideration is given to maximizing business sales subject to given levels of suspended solids and BOD. The latter may reach maximum permissible levels prior to the former thus emphasizing BOD not suspended solids to be the relevant constraint to providing a desired mix of market and non-market goods. As Stevens and Youmans (1969) have stated, income generation and the resource barrier, natural or self-imposed, are the pith of local economy growth:

> The essence of economic growth pertains to increasing income streams for a defined region. Further, we might hypothesize that the natural resource endowment in a region is nearly neutral in the process of development, i. e., the problem of development is precisely to break through the natural resource restriction, if, indeed, one exists. If we accept such as the essence of growth, then degrading our natural resource environment is an attempt to push back a felt restriction. Conversely, if a choice can be made to enhance the natural resource environment, this act would tend to extend the frontier of the restriction, but according to our hypothesis our restriction may not be a severe one with respect to our potentials for growth (1969, p. 2).

A linear programming model of business and environmental aspects of the Clatsop County economy can proceed along either of two routes: 1) minimize (maximize) selected environmental good levels subject to given constraints on levels of sales by economic sectors, 2) maximization of economic sector sales given constraints on environmental goods. Information produced from the preceding modified input-output analysis assures the feasibility of both approaches. The former involves an objective function with direct and indirect environmental links (elements of Table 3) as coefficients and deliveries to final demand as the unknowns. Unknowns are constrained singly and/or in combination to specific levels. Method two involves business income multipliers as coefficients in the objective function and deliveries to final demand as unknowns. Unknowns when multiplied by direct and indirect environmental links are constrained to specific levels of total environmental goods. The order of events common to most coastal zone growth problems and the previously stated desire to include analyses of groups of environmental goods favors method two.

A model formulated on the method one format proved unsatisfactory. The equation system in general terms is:

$$\text{minimize } \phi = \alpha_1 X_1 + \alpha_2 X_2 + \ldots \alpha_n X_n \quad (4.1)$$

subject to:

$$X_1 \geq k_1$$
$$X_2 \geq k_2$$
$$\vdots \qquad (4.1a)$$
$$X_n \geq k_n$$

$$X_1 + X_2 + \ldots + X_n = (1+\lambda) \sum_{i=1}^{n} X_i \qquad (4.1b)$$

where:

ϕ = an environmental good, e.g., BOD

α_i = direct and indirect environmental coefficient of sector i, i=1, ..., n

X_i = sales to final demand by sector i, i=1, ..., n

k_i = the current level of sector i sales to final demand, i=1, ..., n

λ = a projected growth rate for final demand deliveries

Minimization of an environmental good is to be achieved by maintenance of existing sales for each sector and allowance for increased economic activity (4.1a and b). Hite and others (1972) employed the procedure to "reveal" what should have been evident. Elements of Table 3 are available to indicate into which sector the economy's growth should be directed given the desire to minimize an environmental good. The linear programming model simply reproduces the obvious. All growth is directed to the sector with the smallest direct and indirect coefficient for the environmental good in question. Due to the trivial nature of the solutions flowing from method one and the previously cited desire to examine grouped environmental goods in a linear programming model, method two was adopted for the analysis.

Subset and Total Linear Programming Models

Business income multipliers, sales to final demand, absolute environmental goods levels and direct and indirect environmental linkages were utilized to develop linear programming optimums for selected subsets of economic sectors and environmental goods. A problem representing total economic sector activity and several environmental goods using the same general format can be stated as:

$$\text{maximize} \quad \theta = \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n \qquad (4.2)$$

subject to:

$$\begin{aligned} k_1 &\le X_1 \le a_1 \\ k_2 &\le X_2 \le a_2 \\ &\vdots \\ k_n &\le X_n \le a_n \end{aligned} \qquad (4.2a)$$

$$\sum_{i=1}^{n} e_{fi} X_i \le Z_f \qquad f = 1, \ldots, g \qquad (4.2b)$$

where:

θ = total business sector sales

β_i = business multiplier for economic sector i, $i = 1, \ldots, n$

X_i = sales to final demand for economic sector i, $i = 1, \ldots, n$

k_i = 1968 level of sales to final demand for economic sector i, i=1, . . . , n

a_i = maximum sales to final demand for economic sector i, i=1, . . . , n

e_{fi} = direct and indirect environmental linkages of environmental good f, f=1, . . . , g per dollar of sales to final demand for economic sectors i=1, . . . , n

Z_f = maximum permissible level of environmental good f, f=1, . . . , g

The objective function (4.2) was maximized subject to the constraint that; 1) no economic sector's sales be diminished below k_i and no sector's sales be permitted to balloon above level a_i, 2) the total level of each environmental good not exceed a specified amount, Z. Applied to the Clatsop County data the first constraint was formulated to permit k_i to slip no lower than the levels experienced in 1968 and a_i could be no larger than twice the projection of sales for 1980. The latter was required in order to prevent ballooning of figures above those that could be realistically expected. If Clatsop County chose to pursue economic growth of a specific sector (s), it was assumed that realistic attainment would be exclusive of sales being more than double the 1980 projection even though a deliberate public effort was applied with gusto.

Air Residual Considerations

Particulates, Carbon Monoxide, and Hydrocarbons were grouped as constraints to the maximum of sales function for economic sectors exemplifying air residual relationships and major economic impact. Seven key sectors were identified as having significant residual and economic impact effects: Lumber, Fish Processing, Service Stations, Construction, Products, Port Authority, and Aluminum. Three variations of the basic air residual objective function (4. 3) were performed The results are to be presented in tabular format following explanation of the initial system of bounds and constraints.

$$\text{maximize } \theta = 1.8454\, X_{Lum} + 1.7511\, X_{FP} + 1.7448\, X_{SS} + 1.9116\, X_{Con} + 1.6646\, X_{Pro} + 2.5597\, X_{PA} + 1.6022\, X_{Al} \quad (4.3)$$

subject to:

$$\$55,604,762 \le X_{Lum}$$

$$\$39,304,741 \le X_{FP} \le \$111,548,754$$

$$\$200,145 \le X_{SS} \le \$700,182$$

$$\$13,120,684 \le X_{Con} \le \$44,558,550$$

$$\$10,557,953 \le X_{Pro} \le \$38,729,432$$

$$\$931,882 \le X_{PA} \le \$3,932,744$$

$$0 \le X_{Al} \le \$60,000,000 \quad (4.3a)$$

$$.023009\, X_{Lum} + .000371\, X_{FP} + .009133\, X_{SS} + .000631\, X_{Con} + .000411\, X_{Pro} + .610456\, X_{PA} + .033943\, X_{Al} \leq 6,105,000 \text{ lbs. Particulates} \quad (4.3b)$$

$$.037448\, X_{Lum} + .027142\, X_{FP} + 1.48833\, X_{SS} + .036867\, X_{Con} + .025401\, X_{Pro} + .070686\, X_{PA} + .021191\, X_{Al} \leq 8,483,000 \text{ lbs. Carbon Monoxide} \quad (4.3c)$$

$$.006965\, X_{Lum} + .005048\, X_{FP} + .276827\, X_{SS} + .006857\, X_{Con} + .004724\, X_{Pro} + .013148\, X_{PA} + .003942\, X_{Al} \leq 1,573,000 \text{ lbs. Hydrocarbons} \quad (4.3d)$$

where: X coefficients are business income multipliers

X_{Lum} = Lumber sales to final demand

X_{FP} = Fish Processing sales to final demand

X_{SS} = Service Stations sales to final demand

X_{Con} = Construction sales to final demand

X_{Pro} = Products sales to final demand

X_{PA} = Port Authority sales to final demand

X_{Al} = Aluminum sales to final demand

Lower limit bounds of (4.3a) are 1968 sales to final demand and indicate the sound assumption that the range of public choice does not include designed deflating of economic sectors below 1968 levels. No upper limit was imposed throughout the study on Lumber to determine if this environmentally connected sector would show a tendency to increase. The bounds on Aluminum run from zero to the projected level of sales for an operating plant ($60, 000, 000) in order to allow for the possibility that the economy's total income may be higher without the plant given constraints (4. 3b through d). Coefficients of (4. 3b through d) are direct and indirect environmental linkages (see Table 3). The magnitude of the Particulate, Carbon Monoxide, and Hydrocrabon constraints represent the amounts expected from the seven sectors included in the objective function due to economic activity projected in 1980. Thus, the objective function was designed to answer the question: Can total income from the selected sectors be increased over that estimated by the Bureau of Economic Analysis in 1980 if the corresponding levels of environmental goods are reallocated in a manner consistent with the goal of the objective function? In essence, within the assumption framework outlined for the environmental goods projections, the environmental goods levels will be experienced as an inevitable result of increased economic activity. The initial and subsequent air residual linear programming runs attempt to estimate alternative growth strategies for the coastal economy.

Runs one and two involve environmental goods constraints ($Z_{3,b}$, $Z_{3,c}$, $Z_{3,d}$) computed "as if" Aluminum had been a functioning part of the economy in 1980 with sales of $85, 560, 000 as provided by the Bureau of Economic Analysis. Environmental goods constraint magnitudes for runs three and four were estimated on the premise that if no aluminum plant existed in the 1980 economy to contribute to residual levels, projected residual levels (Particulates 3,201,000 lbs.; Carbon Monoxide 6,670,000 lbs.; Hydrocarbons 1,236,000 lbs.) could possibly be redistributed to any existing or potential sector, including Aluminum, in a manner increasing total business income.

Comparison of the air residuals runs is possible from Table 9.[16] Run one yields three sectors operating at maximum limits in the 1980 economy (Fish Processing, Products, Aluminum). Lumber, Service Stations, and Port Authority are included at the minimum allowable levels. Construction activity falls toward the lower end of the specified bounds and slightly under the 1980 projection. Total business income from run one was estimated to be $500,392,000 or an increase of approximately six percent over that originally projected. Another factor evident from run one is that the additional business income can be attained with 35 percent less particulate matter. The second run involves only a slight modification of the first. Since Aluminum was included in the solution at the maximum bound of run one the upper bound was increased for run two to that projected for 1980 ($85,560,000). The impact of the change was substantial. Fish

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[16] For brevity and conciseness a tabular format was developed to portray the various linear programming problem formulations. The format and accompanying comments are presented in Appendix B.

Table 9. Comparison of Air Residuals Linear Programming Runs for Clatsop County, Oregon.

	Run			
	1 (000)	2 (000)	3 (000)	4 (000)
Sales to final demand ($)				
Lumber	55, 605	55, 605	55, 605	55, 605
Fish Processing	111, 549	101, 596	71, 661	71, 661
Service Stations	200	200	200	200
Construction	20, 460	13, 121	13, 121	13, 121
Products	38, 730	38, 730	38, 730	38, 730
Port Authority	932	932	932	932
Aluminum	60, 000	85, 560	38, 300	38, 300
Total business income ($)	500, 392	509, 815	381, 750	381, 750
Constraint level				
Particulates (lbs.)	3, 957	4, 815	3, 201	3, 201
Carbon Monoxide (lbs.)	8, 483	8, 483	6, 670	6, 670
Hydrocarbons (lbs.)	1, 573	1, 573	1, 236	1, 236

Processing and Construction decreased thus permitting Aluminum to increase to the limit. Total business income increased eight percent above that projected while the majority of the Particulate surplus was preserved. Runs three and four were performed as indicated previously. Major changes are to be noticed in Fish Processing and Aluminum. The level of sales permitted Aluminum is below the anticipated level for the scale of plant originally proposed. The feasibility of plant operation on the scale indicated remains to be determined. All environmental good constraints are fully utilized in return for an estimated increase in total business income of 14 percent over that possible without the entry of Aluminum. An obvious element of all runs is the unvarying results: 1) Lumber--limit to the 1968 level, 2) Service Stations--limit to the 1968 level, 3) Products--expand to double the 1980 projection, 4) Port Authority--limit to the 1968 level.

BOD and Suspended Solids Consideration

Application of the double requirement of environmental and economic impact in selection of sectors for a water effluent linear programming analysis resulted in minor adjustment of equation (4. 3). The Communications and Transportation sector was added and Service Stations deleted from the objective function and constraints. The initial system of bounds and constraints, on which three additional runs were based, is represented below:

$$\text{maximize } \theta = 1.8454\, X_{Lum} + 1.7511\, X_{FP} + 1.7847\, X_{CT} + 1.9116\, X_{Con} + 1.6646\, X_{Pro} + 2.5597\, X_{PA} + 1.6022\, X_{Al} \qquad (4.4)$$

subject to:

$$\$55,604,762 \leq X_{Lum}$$

$$\$39,304,741 \leq X_{FP} \leq \$111,548,751$$

$$\$1,660,462 \leq X_{CT} \leq \$5,022,048$$

$$\$13,120,684 \leq X_{Con} \leq \$44,558,550$$

$$\$10,557,953 \leq X_{Pro} \leq \$38,729,432$$

$$\$931,882 \leq X_{PA} \leq \$3,932,744$$

$$0 \leq X_{Al} \leq \$60,000,000 \qquad (4.4a)$$

$$.551494\, X_{Lum} + .005259\, X_{FP} + .007489\, X_{CT} + .004131\, X_{Con} + .000368\, X_{Pro} + .003181\, X_{PA} + .0026\, X_{Al} \leq 47,388,000 \text{ lbs. BOD} \qquad (4.4b)$$

$$.652643\, X_{Lum} + .054279\, X_{FP} + .087978\, X_{CT} + .098352\, X_{Con} + .066935\, X_{Pro} + .161647\, X_{PA} + .049813\, X_{Al} \leq 66,872,000 \text{ lbs. Suspended Solids} \qquad (4.4c)$$

where:

X_{CT} = Communications and Transportation sales to final demand

Upper and lower bounds of (4.4a) follow the explanation of the previous section. Direct and indirect environmental linkages similarly serve as coefficients in (4.4b through c). BOD and Suspended Solids magnitudes were developed identically to the environmental constraints of (4.3b through d), i.e., the magnitudes are estimates of those expected at the 1980 level of economic activity for the seven specified sectors. Given the system of equations, the initial run yields total business income of $600,885,000 as compared to $476,187,190 projected from Bureau of Economic Analysis information (see Table 10). Aluminum appears at the upper bound level as was the case in the air residuals run. Lumber increases to $76,269,000 as contrasted to its static behavior in run one of "air residuals." All other sectors appear at upper bound values to contribute to the 26 percent increase in total business income. The linear programming optimum of run one was achieved with 91 and 100 percent, respectively, of the BOD and Suspended Solids constraint levels. Total business income of run two was estimated to be 34 percent larger than that originally expected from the seven sectors in 1980. Increasing the upper bound on Aluminum (run two) to the level indicated in Table 7 resulted in inclusion of the sector at the new bound value at the expense of Lumber. Not only was the total business income shown to increase, but BOD generation amounted to 88 percent of the constraint level.

Runs three and four followed the design of the corresponding runs for the air residuals problem. Once more viewing Table 10 it becomes

Table 10. Comparison of BOD and Suspended Solids Linear Programming Runs for Clatsop County, Oregon.

	Run			
	1 (000)	2 (000)	3 (000)	4 (000)
Sales to final demand ($)				
Lumber	76,269	74,318	69,743	67,792
Fish Processing	111,549	111,549	111,549	111,549
Communications & Transportation	5,022	5,022	5,022	5,022
Construction	44,559	44,559	44,559	44,559
Products	38,730	38,730	38,730	38,730
Port Authority	3,933	3,933	3,933	3,933
Aluminum	60,000	85,560	60,000	85,560
Total business income ($)	600,885	638,237	588,842	626,194
Constraint level				
BOD (lbs.)	42,913	41,843	39,313	38,244
Suspended Solids (lbs.)	66,872	66,872	62,613	62,613

evident that Aluminum remains a preferred sector given the content of the equation system. Recall that runs three and four have environmental goods constraints ($Z_{4,b}$, $Z_{4,c}$ of Appendix Table 4) calculated in the absence of Aluminum residuals. Total permissible residual constraints were designed to reflect the public's lack of acceptance of Aluminum residuals by excluding said residuals from the constraints. Table 10 contains evidence that total business income would be higher with an aluminum sector without a corresponding increase in BOD and Suspended Solids loadings. In fact, run three reveals a 74 percent increase in 1980 business income with 83 percent of the BOD levels projected in the absence of an aluminum plant. Run four reveals similar aspects; income increases 85 percent with 81 percent of BOD levels. All four runs indicated in Table 10 demonstrate that additional business income and lower than anticipated BOD levels are possible if Lumber growth were traded for Aluminum growth. A decision maker entrusted with responsibility to encourage maximum growth giving due respect to BOD factors would be purchasing BOD at exorbitantly high costs if he failed to give consideration to the above change.

Residuals and Economic Sectors *En Masse*

The air and water effluent linear programming problems reveal a disparity in potential business income. Optimums between air and water effluents also differ as to the distribution of economic activity among sectors common to both. Results concerning the sector under closest scrutiny were inconclusive even though all solutions included sizable Aluminum sales. Two of the eight solutions involved sales below those intended by the aluminum company. A determination as to whether the lower value should be interpreted as an infeasible solution could not be made.

The disparity cited above and the potential discontinuity interpretation of the Aluminum findings raises the question of possible trade-off insight to be gained from simultaneous consideration of numerous environmental goods constraints and economic sectors. A system of equations comprising ten economic sectors and five environmental goods incorporating air, water, and solid residuals as well as water intake constraints was constructed as follows:

$$\begin{aligned} \text{maximize} \quad \theta = {} & 1.8454\, X_{Lum} + 1.7511\, X_{FP} + 2.6028\, X_{Ag} \\ & + 1.9059\, X_{Mfg} + 1.7448\, X_{SS} + 1.7847\, X_{CT} \\ & + 1.9116\, X_{Con} + 1.6646\, X_{Pro} \\ & + 2.5597\, X_{PA} + 1.6022\, X_{Al} \end{aligned} \tag{4.5}$$

subject to:

$$\$55,605,000 \le X_{Lum}$$

$$\$39,305,000 \le X_{FP}$$

$$\$\ 2,720,000 \le X_{Ag} \le \$6,070,000$$

$$\$\ 2,980,000 \le X_{Mfg} \le \$10,400,000$$

$$\$200,000 \le X_{SS} \le \$1,400,000$$

$$\$\,1,660,000 \le X_{CT} \le \$5,022,000$$

$$\$13,120,000 \le X_{Con} \le \$44,560,000$$

$$\$10,560,000 \le X_{Pro} \le \$38,700,000$$

$$\$930,000 \le X_{PA} \le \$3,930,000$$

$$0 \le X_{Al} \le \$60,000,000 \qquad (4.5a)$$

$$\begin{aligned}&.023009\, X_{Lum} + .000371\, X_{FP} + .001452\, X_{Ag}\\ &+ .000698\, X_{Mfg} + .00913\, X_{SS} + .00169\, X_{CT}\\ &+ .000631\, X_{Con} + .000411\, X_{Pro} + .610456\, X_{PA}\\ &+ .033943\, X_{Al} \le 6,117,000 \text{ lbs. Particulates} \qquad (4.5b)\end{aligned}$$

$$\begin{aligned}&135.499\, X_{Lum} + .361263\, X_{FP} + .600722\, X_{Ag}\\ &+ .313034\, X_{Mfg} + .112815\, X_{SS} + 1.8385\, X_{CT}\\ &+ 1.01326\, X_{Con} + .088059\, X_{Pro}\\ &+ .776417\, X_{PA} + 3.462775\, X_{Al}\\ &\le 11,613,253,000 \text{ gals. Cooling Water} \qquad (4.5c)\end{aligned}$$

$$\begin{aligned}&48.6376\, X_{Lum} + 1.6298\, X_{FP} + .843618\, X_{Ag}\\ &+ .590595\, X_{Mfg} + 1.580341\, X_{SS} + .23493\, X_{CT}\\ &+ 1.12445\, X_{Con} + 1.41702\, X_{Pro}\\ &+ .770488\, X_{PA} + 30.8816\, X_{Al}\\ &\le 5,721,600,000 \text{ gals. Process Water} \qquad (4.5d)\end{aligned}$$

$$.551494\, X_{Lum} + .005259\, X_{FP} + .002454\, X_{Ag} + .001282\, X_{Mfg} + .000464\, X_{SS} + .007489\, X_{CT} + .004131\, X_{Con} + .000368\, X_{Pro} + .003181\, X_{PA} + .000260\, X_{Al} \leq 47,396,000 \text{ lbs. BOD} \quad (4.5e)$$

$$.570218\, X_{Lum} + 2.12952\, X_{FP} + 55.5852\, X_{Ag} + 11.7938\, X_{Mfg} + 4.16639\, X_{SS} + .618392\, X_{CT} + .703114\, X_{Con} + 1.07824\, X_{Pro} + 1.24156\, X_{PA} + .43650\, X_{Al} \leq 465,243,000 \text{ lbs. Solid Waste} \quad (4.5f)$$

where:

X_{Ag} = Agriculture sales to final demand

X_{Mfg} = Manufacturing sales to final demand

Results of the initial run and subsequent runs similar to those performed previously are shown in Table 11. Aluminum enters solutions one and two at upper limit levels. The trade-off involving higher levels of Aluminum and decreases in Lumber established in previous problems was reaffirmed in runs one and two. Fish Processing retains levels near those estimated by optimization of separated residual groups. The second run suggests that Aluminum growth to the projected level in 1980 would be at the expense of sales from Lumber and Port Authority. However, the value of the maximized objective function would be 30 percent larger than the $494,576,975 estimated

Table 11. Comparison of Particulates, Cooling Water, Process Water, BOD, and Solid Waste Linear Programming Runs for Clatsop County, Oregon.

	Run			
	1 (000)	2 (000)	3 (000)	4 (000)
Sales to final demand ($)				
Lumber	81,655	63,584	55,605	55,605
Fish Processing	111,701	111,647	111,622	111,625
Agriculture & Fur	2,720	2,720	2,720	2,720
Manufacturing	10,400	10,400	10,400	10,400
Service Stations	1,400	1,400	1,400	1,400
Communications & Transportation	5,022	5,022	5,022	5,022
Construction	44,560	44,560	44,560	44,560
Products	38,700	38,700	38,700	38,700
Port Authority	3,417	2,679	2,328	2,328
Aluminum	60,000	85,560	12,140	12,140
Total business income ($)	639,425	645,047	510,648	510,655
Constraint level				
Particulates (lbs.)	6,117	6,117	3,216	3,216
Cooling Water (gals.)	11,377,706	9,016,875	7,562,360	7,562,360
Process Water (gals.)	5,721,600	5,721,600	3,079,500	3,079,500
BOD (lbs.)	45,895	35,932	31,179	31,179
Solid Waste (lbs.)	465,243	465,243	427,896	427,896

from the Bureau of Economic Analysis data. Realization of run two would involve limit usage of Particulates, Process Water, BOD, and Solid Waste. BOD and Cooling Water prove to be unrestrictive as but 75 and 76 percent, respectively, of constrained levels are met.

The possibility of a discontinuity was not reduced by performance of runs three and four. Aluminum sales of twelve million dollars remain below plant management desires. In all probability the disparity is large enough to discourage construction. Thus, recalling the basis of runs three and four, an objective function excluding Aluminum would be a plausible alternative. Optimization of the system revealed a potential increase of 30 percent in total business income. Thus, Aluminum does not involve a choice of growth versus stagnation to Clatsop County. Incentives for economic activity to proceed in alternate directions remains a viable choice for public sector inputs to the growth process.

CHAPTER V

SUMMARY AND IMPLICATIONS

Summary

The general end to which the study was directed was a description of economic and resource relationships in the light of growth considerations for Clatsop County, Oregon. Specific objectives were: 1) to delineate economic characteristics of estuary resource allocation problems (Chapter I), 2) to uncover economic-ecologic linkages of key sectors in the Clatsop economy (Chapter III), 3) to predict the residuals generation and non-market good requirements of a proposed aluminum plant (Chapter III), and 4) to evaluate possible trade-offs associated with public choice related to aluminum production (Chapter IV). The procedure incorporated modification of a standard input-output model to include environmental factors pertinent to public decisions in Clatsop County with a linear programming analysis utilizing environmental constraint functions extracted from the input-output model.

Fulfillment of the first objective involved examination of physical, economic, and institutional factors judged to be relevant to coastal zone management in general. Multiple use was represented as fact in relation to physical and economic factors present in estuarine resource utilization. Reference to institutional factors related to the conceptual errors caused by strict adherence to multiple use as an objective of public estuarine management. Public management of estuarine resources generally involves conflict over gaining desired shares of resources and their services. Multiple use as an applied objective, however, has given unwarranted emphasis to matters of resource access. Share considerations are involved closely with matters of economic efficiency, perhaps more so than those of access. When access to the resource base is the relevant issue, local management efforts need to envision multiple use as inclusive of restricting access to but a single endeavor. Thus, the critique of multiple use rests on the undue emphasis given to resource access and, when access matters surface, the possibility that the multiple use concept may impede the movement of resources toward a single use.

Multiple use as a national objective was also analyzed. Basic criticism centered on the infeasible task facing resource managers assigned to attain multiple use. Agency statements of the multiple use objective have exhibited elements of both a maximization and minimization problem. The operational probability of maximizing economic growth and minimizing environmental impact is understandably low.

Phase-space diagrams depicted dynamic productive relationships between hypothetical firms as an alternative means of viewing production possibilities from resource utilization. Arguments then focused on the theoretical implications of estuarine resource utilization to lend credence to the hypothesis that the pervasive influence of common property resources, external diseconomies, and poorly delineated jurisdictions among responsible agencies can perhaps lead too frequently to extra-market intervention.

Armed with a more general perspective of resource utilization as a result of the theoretical investigation, economic and environmental relationships surrounding economic growth in Clatsop County, Oregon, were analyzed. The analysis was built on the foundation of a 1970 Clatsop County study dealing with the monetary impact of a new industry, aluminum. A more complete analysis for public decisions associated with the change was sought by means of a modified input-output model and linear programming. The former provided a supply-price approach in the absence of stated community goals to analyze possible trade-offs. The linear programming analysis was based on a perceived community goal (objective function), and yielded both community business income and environmental goods trade-offs.

The results of the modified input-output model approach are compared to those of the original input-output analysis in Table 12. The business sectors (1-15) could experience approximately $20, 100, 000 in additional sales annually as a result of the operation of the aluminum plant. The products sector ($10, 980, 000) and the

Table 12. Direct and Indirect Changes in Total Output and Associated Environmental Goods as a Result of a Proposed Aluminum Plant in the Clatsop County, Oregon, Economy, 1968.

Sectors	Direct & indirect change in total output ($)	Environmental goods magnitudes associated with increased economic activity				
		Particulates (lbs.)	Cooling water (1,000 gals.)	Process water (1,000 gals.)	5-Day BOD (lbs.)	Suspended solids (lbs.)
1. Lumber	30,000	690	4,065.0	1,459.1	17	19,579
2. Commercial Fishing	6,000	8	1.5	3.8	6	1,010
3. Fish Processing	72,000	27	26.0	117.4	379	3,908
4. Agriculture and Fur	24,000	35	14.0	20.3	59	2,827
5. Manufacturing	72,000	50	22.5	42.5	92	3,829
6. Lodging	1,014,000	1,065	292.2	797.2	1,199	121,671
7. Cafes and Taverns	864,000	523	184.1	625.4	758	104,541
8. Service Stations	876,000	8,001	98.9	508.4	407	49,215
9. Auto Sales and Service	1,170,000	490	146.6	598.8	603	73,616
10. Communic. & Transp.	948,000	1,605	1,742.9	1,170.7	7,100	83,403
11. Professional Services	600,000	407	112.9	406.8	466	88,865
12. Financial	528,000	569	59.6	237.0	246	35,223
13. Construction	840,000	530	851.1	944.5	3,470	82,616
14. Products	10,980,000	4,513	966.9	15,558.9	4,041	734,946
15. Services	2,076,000	1,468	312.7	1,730.1	1,295	271,956
16. Education	1,320,000	1,426	347.9	1,045.3	1,440	312,453
17. County Roads	60,000	72	24.1	52.4	99	11,429
18. Law Enforcement	72,000	82	19.9	57.7	82	18,939
19. Health Dept.	24,000	31	7.2	20.3	30	6,808
20. Welfare	168,000	185	44.3	139.5	184	43,955

(Continued on next page)

Table 12. (Continued)

Sectors	Direct & indirect change in total output ($)	Environmental goods magnitudes associated with increased economic activity				
		Particulates (lbs.)	Cooling water (1,000 gals.)	Process water (1,000 gals.)	5-day BOD (lbs.)	Suspended solids (lbs.)
21. Port Authority	1,536,000	937,660	1,192.6	1,183.5	4,886	248,290
22. General Fund	162,000	165	48.8	122.9	201	36,230
23. Astoria	168,000	174	44.3	121.3	183	33,000
24. Warrenton	144,000	137	91.9	139.1	376	24,818
25. Hammond	a	-	-	-	-	-
26. Gearhart	a	-	-	-	-	-
27. Seaside	48,000	49	13.2	37.8	55	10,185
28. Cannon Beach	12,000	7	7.2	10.0	29	1,255
29. Aluminum	b	-	-	-	-	-
30. Households	12,318,000	16,013	3,713.3	10,744.5	15,410	4,017,306
Total	36,132,000	975,982	14,451.5	37,895.2	42,113	6,441,873

[a] Less than $6,000

[b] All aluminum production is exported.

services sector ($2, 076, 000) receive the majority of the increase. Expenditures for gas and electricity are the major components of the products sector increase.

Additional monetary impact would be experienced by public sectors. Given the 1968 tax structure, annual revenue gains were estimated to be $3, 714, 000. Expansion of the tax base most directly affects education sector revenues. Education revenues could increase $1, 320, 000 annually. The other public sector receiving a major portion of the $3, 714, 000 increase is the port authority. Approximately $1, 536, 000 of port services associated with ore handling could be anticipated. Astoria ($168, 000) and Warrenton ($144, 000) are estimated to be the primary municipality beneficiaries.

Payments to the households sector ($12, 318, 000) involve a direct aluminum sector payroll of $6, 000, 000 and indirect household payments of $6, 318, 000.

The relationship of aluminum sector sales and the induced economic activity to residuals generation and resource requirements is also delineated in Table 12. Aluminum has direct and indirect linkages with particulates, cooling water, and process water and indirect links only with BOD and suspended solids.

The level of particulates was estimated to be 1, 909, 919 pounds in 1968 without the aluminum sector. Fluoride particulate emissions associated with $60, 000, 000 aluminum production were estimated to be 1,092,000 pounds. Release of particulates resulting from indirect monetary impact amounted to an additional 975,982 pounds. Virtually all of the indirect release comes from Port Authority ore handling operations. The combination of direct and indirect linkages was estimated to increase particulates by slightly more than 100 percent.

The estimates (Table 12) of water inputs for cooling and processing purposes reveal a varied impact of aluminum sector operation. Although indirect requirements (14,451,500 gals.) for cooling water were not largely different from direct needs (20,400,000 gals.), combined requirements were estimated to be less than a one percent increase over a non-aluminum economy. Process water needs of aluminum production could increase total use in the economy by nearly two billion gallons annually. Indirect effects are comparatively small (43,113,000 gals.). The products sector and households sector are important indirect users contributing to a 66 percent increase in total process water requirements.

The production of aluminum could not be directly related to BOD and suspended solids residuals. Both water-borne residuals are associated indirectly with aluminum production. The primary sectors of the indirect relationships are similar--households, products, services, and the port authority. The total BOD increase was estimated to be less than one percent of that experienced in a non-aluminum economy. Suspended solids estimates sum to 6,441,873 pounds, an increase of approximately 13 percent.

The development and application of modifications to the Clatsop County input-output model has yielded estimates of environmental factors associated with economic activity. Tables 3, 6, and 8 were presented to specify various choice indicators to the trade-offs possible in policy decisions in Clatsop County: 1) Table 3 represents environmental goods as related to final demand deliveries, 2) Table 6 represents environmental goods aspects of income generation, 3) environmental goods are related to growth considerations in Table 8. Data inadequacies, primarily those of omission, and stringent model assumptions lead to the observation that the analysis, though including multiple round effects, represents but a first round appraisal of economic and environmental factors relevant to the Clatsop economy. The model employed was one representing static relationships but improvement of the model via polishing of pertinent economic concepts, development of desired data, and repeated applications will be a dynamic process.

In the absence of an environmental inventory for Clatsop County and a delineation of relationships within the natural resource system to provide insight to the impact of residuals and non-market input utilization, alternative strategies for economic activity were developed from linear programming models based on the author's perception of community goals. Business income multipliers were the objective function's coefficients and deliveries to final demand were the unknowns.

Constraints included maximum and minimum values for the unknowns and maximum allowable use of selected environmental goods. Three linear programming problems were designed to reveal trade-offs involving: 1) air quality considerations and economic growth, 2) water-borne residuals generation and economic growth, 3) combined air quality, water input, water-borne residuals, and solid waste considerations and economic growth. The analysis involved four runs for each problem. Runs one and two involved environmental good constraints computed as if the aluminum sector had been a functioning part of the economy in 1980. Run one differed from the second only in the maximum upper bound placed on the aluminum unknown. The third and fourth runs included environmental goods constraint magnitudes simulating the non-existence of an aluminum plant in 1980 to contribute to residual levels. Run four differed from the third in a manner identical to that of runs one and two.

Aluminum production appeared in the solution to runs one and two of the air quality problem at the maximum constraint level. Proxies for air quality included particulates, hydrocarbons, and carbon monoxide. The latter two reached maximum constraint levels in runs one and two. However, the particulate level consistent with maximization of business income was far below the constraint. All three air quality proxies reached full constraint levels in runs three and four. However, total business income was but 77 percent of that for runs one and two. Aluminum production of $38, 300, 000 was included in the estimates of the objective function unknowns. The sales are far below those proposed by the aluminum company, thus possibly representing an infeasible level of production.

BOD and suspended solids sectors served as water-borne residuals constraints. The value of the objective function was largest for run two, followed by runs four, one, and three. Only the suspended solids level specified actually proved to be a constraint. BOD did not reach the maximum permissible levels. Aluminum reached the maximum allowable sales level in all cases. As aluminum sales increased between runs one and two and three and four lumber sector sales declined. Thus, even though BOD did not prove to be a constraint when associated with suspended solids, increased aluminum sector sales were traded for lower lumber sector sales.

Simultaneous consideration of numerous environmental goods in the third problem resulted in particulates, process water, and solid waste reaching constraint levels. The value of the aluminum sector sales unknown corresponded with those of runs one and two of the previous problems--maximum permissible. Runs three and four reveal a fate for aluminum production identical to that of the first problem. If the aluminum sector were facing an agency with broad responsibility for environmental goods management, or even well coordinated action among several agencies, aluminum production would likely not be feasible.

Table 13 indicates the objective function values for the three problems. Among the sectors with large economic impact lumber and aluminum compete vigorously for the constrained environmental goods, as the aluminum sector increases lumber sector sales decline. The reverse of the relationship did not occur. When aluminum sector sales decreased in runs three and four to infeasible levels, lumber sector sales entered the solution at the minimum allowable levels. Lumber and aluminum processing appear to exemplify supplementary and competitive relationships. Fish processing exhibits supplementary relationships to both lumber and aluminum processing with the exception of a minor indication of competition with the aluminum sector for "air" environmental goods.

Implications

Aluminum Revisited

Coastal zone literature of technical and lay nature contains conspicuous common elements. An awareness of alternate levels of consuming coastal zone resources can be cited. Recent national, state, and local coastal zone planning efforts include emphasis on abandonment of final consumption attitudes directed toward the relevant resources. The task of organizing public management to facilitate inclusion of intermediate goods values remains a central issue in improved decision making.

Table 13. Summary of Linear Programming Problems: Estimated Objective Function, Lumber, Fish Processing, and Aluminum Values.

	Runs			
	1 (000 $)	2 (000 $)	3 (000 $)	4 (000 $)
Problem 1				
Total business income	500, 392	509, 815	381, 750	381, 750
Lumber	55, 605	55, 605	55, 605	55, 605
Fish Processing	111, 549	101, 596	71, 661	71, 661
Aluminum	60, 000	85, 560	38, 300	38, 300
Problem 2				
Total business income	600, 885	638, 237	588, 842	626, 194
Lumber	76, 269	74, 318	69, 743	67, 792
Fish Processing	111, 549	111, 549	111, 549	111, 549
Aluminum	60, 000	85, 560	60, 000	85, 560
Problem 3				
Total business income	639, 425	645, 047	510, 648	510, 655
Lumber	81, 655	63, 584	55, 605	55, 605
Fish Processing	111, 701	111, 647	111, 622	111, 625
Aluminum	60, 000	85, 560	12, 140	12, 140

The implication of the methods employed in the revisit of the aluminum decision in Clatsop County evolves from the model's versatility. Previously revealed interdependencies were given a new dimension via the linkage process. The process enables an intermediate-good viewpoint of identified coastal zone resources. Aluminum as the proposed growth impetus and existing economic pursuits were included in the study. This factor is desirable if historical sector growth and resource usage are not to be allowed preferential treatment. Pursuit of a "last settler" syndrome would permit little opportunity for correction of established final consumption utilization of resources. Due consideration was given to analyzing the aluminum sector as an insider and a "squatter." Consequently the analysis was decidedly more decision oriented than that of Collin. As an established economic pursuit the production of aluminum retained appeal to the economic goal specified for the county. However, viewing the aluminum sector as an outsider looking in with constraints to economic growth purposely constructed to reflect intermediate goods attitudes of county residents yielded low levels of sales. Sales may in fact be low enough to represent a discontinuity, making aluminum production infeasible.

Resource Conflict Representation

The search for a means to represent resource use conflicts in the coastal zone to decision makers entrusted with public choices has been persistent. Consultants acting as resources to public decision makers have attacked with passion the problem of conveying their analyses in an understandable format that encourages use. Academic institutions have been no less persistent. Results range from empirically founded matrices to those including perceived effects only. The former invariably include portrayal of first round or direct effects of resource usage rather than focus on complete linkages based in the economic sector as utilized in the preceding analysis. The latter method does little more than formalize what may be ill conceived views of problems.

The implication of the linkage analysis to the representation of conflicts should be clear but no less worthy of emphasis. Reciprocity is overwhelmingly evident in utilization of common pool resources in Clatsop County. Without explicit reference to a well developed statement of county goals definitive conflict matrices[17] are not possible. In the absence of goal specification, conflict matrices and the like do little more than describe existing resource problems. This latter factor was the basis for evaluation of market effects of alternative environmental goods distribution in Clatsop County. The linear programming analysis necessitated explicit reference to the

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[17] For example see: National Estuary Study and Peter Harrison of the University of Washington.

community's "wants," i. e., an objective function including bounded monetary variables and specific levels of positive and negative environmental goods.

The allowance for community goals in the analysis also suggests that conflict representations can be formulated on a resource and/or monetary basis. Preferably both factors should be present in any representation if the previous comments concerning intermediate goods have any credence to the topic of competition versus conflict in the coastal zone.

A resource inventory was mentioned early in the analysis as a desirable input to the coastal zone public decision process. The basis for the value can be found in the assistance it can render in determining when reciprocal economic forces are bordering a transfer from resource competition to conflict.

Environmental Linkages, Growth, and Institutional Metamorphosis

The basis of realized and potential multiple use conflicts was delineated in Chapter I. With accompanying emphasis on a modified input-output model, coastal zone resource use conflicts were depicted as competition directed through common pool resources rather than markets. Conflict prevention and alteration mechanisms were approached in the analysis from a trade-off stance. This does not imply information as to issues, and related magnitudes, to be the sole requirement for improved returns from coastal zone resource utilization. The analysis was, however, focused on disclosure of the simultaneous presence of competitive and complementary relationships between sectors of the Clatsop economy. That is, the input-output model inverse reveals complementarity of trade activity among sectors while the environmental linkage matrix suggests competitive use of common pool resources. Incorporation of the separate systems into a linear programming model permits inspection of competitive and complementary aspects of economic activity. The researcher can insert perceived relevant levels of environmental goods as constraints and purchased input needs from sample data in the model to reveal impact of alternatives on the locality's surrogate for well being, e. g., maximum business income. For example, the production of aluminum was found to be inconsistent with perceived attitudes in Clatsop County in but four of the 12 linear programming problems. It is worthy of note that all four occasions involved problems assuming that county residents did not wish to experience larger residuals levels in 1980 than would be experienced from normal growth of sectors comprising the 1968 economy.

The procedure followed in the Clatsop analysis reveals competitive and complementary information that could ideally be applied to relieve the duress placed on public decisions due to a proliferation of coastal zone management agencies. Public choice of alternative resource allocations involves trade-offs. Economic theory of resource allocation suggests that substitution of one economic activity for another (or level of one for level of another) will in many instances not be voluntary. The task of institutions is to foster willing substitution and, failing such, to impose measures to channel economic activity in desired directions. Institutional design is a topic worthy of an in-depth analysis. However, elementary principles of improved institutional management are evident from the Clatsop analysis.

Approximately three dozen federal, state, and local agencies are responsible for overseeing Oregon's coastal resources (Wick, 1969). The cost of reaching public decisions (see Buchanan and Tullock) has received little consideration from traditionally problem oriented agencies. Elementary principles flowing from the Clatsop County analysis relevant to cost considerations of institutional design include:

1) Parties to conflicts, and potential conflicts, involving common pool resources are more clearly specified as a result of the input-output and environmental linkage attributes of the model. Composition of citizens groups, task forces, and the like may therefore portray low cost means of reaching a decision.

2) The environmental linkage format focused attention on the consumptive and assimilative uses of resources. Institutions

designed to reflect consumptive considerations as well as a traditional production orientation may be of merit.

3) Estimates of the magnitude of relevant variables to a problem under investigation have the potential of serving as inputs to the appropriateness and scale of institutional change.

4) Supply prices provide a source of information as to those individuals or special interests receiving benefits from designated courses of action. Distribution of disbenefits is also identifiable. Public resource managers can provide the information to the parties involved in the hope of stimulating a bargained solution. However, the choice may include realignment of institutions to encourage individual incentives to produce desired outcomes.

5) The combined input-output and linear programming analysis offers the insight that environmental goods and natural resources may be utilized at levels above, below, or equal to perceived maximum limits. The three linear programming problems indicate higher values for the objective function are obtainable with simultaneous consideration of "air" and "water" constraints. The example suggests that in relation to the hypothetical objective function, institutions be arranged along macro or systems lines. That is, a local institution

responsible for numerous resources rather than a one resource-one agency framework may be appropriate.

Further Research

The combined economic and environmental data requirements of the model utilized in the study and others to follow place immediate stress on the researcher. A call for more biological science and engineering research, is necessary for improved estimates, but not sufficient. The nature of the model necessitates a well conceived and conducted study which is the responsibility of the economist. Particular emphasis directed toward low level aggregation of sectors key to major economic activity and/or common pool resource usage will aid the development of a sound foundation to base detailed linkage analysis. The potential of standardizing certain coefficients in the input-output model's inverse offers added opportunity to concentrate academic and budget resources on key economic sectors.[18]

The important role previously cited for definition of community goals needs elaboration. National objectives and priorities have been extensively expressed in the studies cited in Chapter I. Few parallel statements are found at the state level and such statements are minimal at the local level. Goal and priority specification are perhaps more

[18] Research on the subject was conducted in 1972 at Oregon State University by Gary Vieth and Dr. Herbert H. Stoevener of the Agricultural Economics Department.

valuable at the secondary and tertiary level in view of the immediacy of improved decision making. The regional goods aspects of coastal zone decisions are pervasive thus making state level input desirable.

A procedure to assess goal and priority proxies would ideally precede studies of resource allocation problems in the coastal zone. In the absence of such information the nature of an optimum is not readily apparent. Delphi analysis of state and local goals and priorities for the coastal zone may offer insight to the desired components of an optimum. Parties to which the end result of the applied research may prove valuable would be consulted thus encouraging appreciation of the alternative uses of coastal resources. The rapid pace of specialization of economic and recreational pursuits may necessitate single use of resources particular to a site in dispute.[19] It is plausible that such choices involving abandonment of the venerable multiple use philosophy may be more palatable if a central point of the analysis were well stated goals and priorities developed by those assigned decision responsibilities.

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[19] The frequency of changes in personal and group values and the discovery of new information concerning public choices make the development of long-run plans of dubious value. Similar comments can be directed at efforts designed to yield definitive statements of goals and priorities. However, the appeal of such an effort lies in the addition of political feasibility considerations to those of economic feasibility. Just as the analysis of the Clatsop economy has focused on revelation of the nature and operation of the economic system, a study of goals and priorities provides insight to the nature and operation of the system of public decision making.

The frequency of public choice in coastal matters will likely not diminish in the near future. The possibility of directly estimating values of an objective function needs consideration for budgetary reasons. Estimation of a performance function that relates values of structural parameters and decision variables to objective function values may prove valuable for extending the policy recommending life of a model. In terms of the Clatsop County analysis the performance function could be utilized to reveal the combination of structural parameters (e. g. business multipliers and environmental linkages) and decision variables (e. g. economic sector activity and environmental goods constraints) associated with desired levels of the objective function.

Elements of the economic framework of the coastal zone stressed in Chapter I and recognition of the complexity that historical use, vested interests, and jurisdictional disputes attribute to the topic lead the author to suggest that researchers will come to broaden their view of the components of acceptable analysis of public policy matters in the coastal zone.

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APPENDICES

APPENDIX A

PUBLIC GOODS AND INPUT-OUTPUT IDENTITIES

Public Goods and Input-Output Identities

Public goods represent a conceptual problem for the specification of economic systems with input-output identities. Deliveries to final demand in public goods sectors do not follow the equational format of system 2.1 (Chapter II). Interindustry and exogenous demands for a public good need not be summed to obtain total output. Each endogenous sector can require and receive the total public good output. Given a three sector economy where sector three yields a public good, the consumption of three can be related to the other sectors by a state of equality not summation. An alteration of 2.1 to represent the result is shown in system A.1. Due to the possibility of equal consumption

$$X_1 = a_{11}X_1 + a_{12}X_2 + a_{13}X_3 + D_1$$

$$X_2 = a_{21}X_1 + a_{22}X_2 + a_{23}X_3 + D_2$$

$$X_3 = a_{31}X_1 + a_{32}X_2 + a_{33}X_3 + D_3 \qquad \text{(A. 1)}$$

where: $\sum_{j=1}^{3} a_{3j}$ can be > 1

of the public good, X_3, without diminishing the total level of the sector's output, the delivery to final demand can be equally large. The attempt to incorporate non-market factors in the input-output framework by this method violates an input-output identity crucial to deriving a solution. The identity is termed the Hawkins-Simon condition and requires that to produce one unit of a good, the first round interindustry input requirements for the good be less than or equal to one. By the properties of a public good, sector 3 violates the Hawkins-Simon condition since there are no bounds on a_{ij}. It is possible for $\sum_{j=1}^{n} a_{ij}$ to be less than, equal, or greater than one.

The adjustments to input-output system identities suggested represent a conceptual approach to alterations of a model developed to measure economic implications of market good transactions. The adjustments suggest a short-circuiting of the proxy for a functioning economy, an input-output model. Consideration of the source of the short-circuiting offers insight to the informational inadequacies of market-oriented models.

APPENDIX B

Appendix Table 1. Aggregation of Private and Public Sectors of Clatsop County, Oregon.

Sector no.	Sector	Business types
1	Lumber & lumber products	Logging, log hauling, lumber mills, plywood mills, timber dealers, shingle manufacturing, logging contractors, paper and pulp plants
2	Commercial fishing	Trollers, otter trawlers, gill-netters, commercial clammers, commercial crabbers
3	Fish processing & products	Fish and seafoods dealers, fish packing and processing, fish packing cooperatives, crab companies, clam and shrimp processors
4	Agriculture & fur	All farms and ranches which derive at least one-half of the gross receipts from the sale of agriculture and fur products
5	Manufacturing	Food processors (other than seafoods), soft drink bottling companies, meat and poultry processors, creameries, machine manufacturing, stone and clay processors, glass products, box products, electric sauna manufacturers, manufacturers of sporting goods, canvas products, metal cans, bio-products, ice cream, bakers, and foundries
6	Lodging	Hotels, motels, trailer parks, apartments, boarding houses, rooming houses
7	Cafes and taverns	Restaurants, cafes, taverns, drive-ins and short order eating places, and ice cream parlors

(Continued on next page)

Appendix Table 1. (Continued)

Sector no.	Sector	Business types
8	Service stations & bulk plants	All service stations and wholesale gasoline distributors
9	Automotive sales & service	New and used auto and trailer sales, tire stores, parts and accessories, auto repair shops, towing, automotive body and paint shops, tire stores, auto upholstery, boat dealers, trailer towing, tire recapping and farm tractor dealers
10	Communications & Transportation	Trucking, railroads, airlines, buses, radio and television stations, telephone company, telegraph, newspapers, television cable company, taxicabs, auto leasing, moving vans, trailer rentals, tugs and barge service
11	Professional services	Doctors, dentists, lawyers, accountants, bookkeepers, chiropractors, architects, surveyors, engineers, medical and dental laboratories, optometrists, veterinarians, ambulance service, nursing homes, and appraisers
12	Financial	Banks, savings and loan associations, stock brokers, financial companies and credit bureaus
13	Construction	Firms that contract for building, electrical, plumbing, road and highway, painting, heating, roofing, flooring, and ship builders, sand and gravel operations, carpenters, asphalt paving companies, concrete manufacturers, excavators, land levelers, masonries, well drillers, cabinet makers, tile layers, sheet metal firms,

(Continued on next page)

Appendix Table 1. (Continued)

Sector no.	Sector	Business types
		plasterers, electrical and hardware stores, steel and pipe dealers, retail lumber yards, salvage companies, and commercial refrigeration contractors
14	Product oriented (wholesale-retail)	Natural gas companies, fuel oil dealers, electric utilities, bottled gas suppliers, clothing stores, shoe stores, department stores, variety stores, furniture and appliance stores, jewelry stores, beer distributors, drug stores, office supply stores, milliners, state-owned liquor stores, music stores, and flower shops, camera shops, paint stores, news stands, gift shops, fisherman's supply stores, printing companies, cold storage and ice dealers, wholesale-retail groceries and super markets, and all wholesale dealers supplying the above stores if located in Clatsop County
15	Service oriented (wholesale-retail)	Privately owned kindergartens and child nurseries, photo studios, theaters and other recreational facilities, laundries and cleaners, tailors, barbers and beauty shops, upholstery, funeral homes, machine and welding shops, car wash, private business schools, music teachers, repair shops, unions, lodges, and service organizations, building rental services, garbage collectors, insurance and real estate, churches, vending machine operators, private parking lots, trading stamp companies, private employment agencies, janitorial

(Continued on next page)

Appendix Table 1. (Continued)

Sector no.	Sector	Business types
		service, credit services, telephone answering service, security police
16	Education	Includes all six school districts, intermediate education district (I. E. D.), Clatsop Community College, and the county superintendent of schools
17	County roads	Includes all transactions involved in construction and maintenance of county roads
18	Law enforcement	Includes all transactions concerning the county sheriff's office including tax collection, all justices of the peace and district court
19	Health department	Includes all transactions of the county health department
20	Welfare	All funds administered by the county welfare department, including federal, state, and local; also salaries, office supplies of employees of county welfare department
21	Port authority	All transations of the Port of Astoria as recorded by the county port authority
22	General fund	All transactions of the following county departments: assessor, treasurer, county commissioners, elections, county clerk, county surveyor, courthouse maintenance, planning commission, land agent, humane officer and department, veterans service and current expense account

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Appendix Table 1. (Continued)

Sector no.	Sector	Business types
23	Astoria	All transactions conducted by the city government, includes all departments and divisions
24	Warrenton	All transactions conducted by the City of Warrenton
25	Hammond	All transactions conducted by the town of Hammond
26	Gearhart	All transactions conducted by the City of Gearhart
27	Seaside	All transactions conducted by the City of Seaside
28	Cannon Beach	All transactions conducted by the City of Cannon Beach
29	Aluminum	All transactions of primary aluminum production
30	Households	All economic activity associated with individuals and family units

Appendix Table 2. Leontief Inverse of the 1968 Clatsop County, Oregon, Economy.

	Lumber	Commercial Fishing	Fish Processing	Agric. & Fur	Manufac.	Lodging	Cafes & Taverns	Service Stations	Auto Sales & Service	Communic. & Transp.
1. Lumber	1.0836	.0019	.0012	.0048	.0025	.0023	.0017	.0009	.0010	.0147
2. Commercial Fishing	.0001	1.0032	.0661	.0002	.0002	.0003	.0003	.0001	.0001	.0002
3. Fish Processing	.0014	.0034	1.0018	.0024	.0020	.0025	.0025	.0013	.0013	.0016
4. Agric. & Fur	.0006	.0015	.0125	1.0130	.1297	.0011	.0011	.0005	.0005	.0007
5. Manufacturing	.0015	.0040	.0945	.0026	1.0013	.0031	.0028	.0013	.0014	.0017
6. Lodging	.0238	.0573	.0176	.0375	.0178	1.0412	.0412	.0191	.0214	.0273
7. Cafes & Taverns	.0202	.0485	.0149	.0317	.0150	.0345	1.0348	.0162	.0181	.0232
8. Service Stations	.0258	.0992	.0187	.0644	.0322	.0311	.0304	1.0254	.0177	.0268
9. Auto Sales & Service	.0278	.0854	.0246	.0462	.0352	.0479	.0447	.0275	1.0264	.0353
10. Communic. & Transp.	.0550	.0932	.0731	.3194	.1600	.1298	.0607	.0481	.0505	1.0392
11. Professional Services	.0325	.0634	.0112	.0201	.0097	.0216	.0239	.0103	.0110	.0143
12. Financial	.0236	.0333	.0228	.0563	.0378	.0231	.0221	.0113	.0708	.0139
13. Construction	.0159	.0354	.0145	.0286	.0208	.0319	.0790	.0141	.0179	.0200
14. Products	.1401	.2892	.1005	.3404	.1508	.2581	.2783	.2542	.1159	.1274
15. Services	.0540	.1985	.0460	.1214	.0479	.1941	.1325	.0620	.0577	.0530
16. Education	.0317	.0234	.0094	.0368	.0152	.0432	.0185	.0094	.0091	.0323
17. County Roads	.0015	.0012	.0005	.0017	.0007	.0020	.0009	.0005	.0005	.0015
18. Law Enforcement	.0018	.0014	.0005	.0020	.0008	.0023	.0011	.0005	.0005	.0017
19. Health Dept.	.0007	.0005	.0002	.0008	.0003	.0009	.0004	.0002	.0002	.0007
20. Welfare	.0044	.0030	.0012	.0048	.0020	.0056	.0024	.0012	.0012	.0042
21. Port Authority	.0009	.0007	.0003	.0013	.0006	.0012	.0005	.0003	.0004	.0019
22. General Fund	.0040	.0028	.0011	.0044	.0018	.0051	.0022	.0011	.0011	.0038
23. Astoria	.0038	.0085	.0035	.0063	.0052	.0146	.0070	.0056	.0039	.0050
24. Warrenton	.0004	.0009	.0004	.0008	.0004	.0009	.0011	.0006	.0004	.0006
25. Hammond	.0000	.0001	.0001	.0000	.0000	.0000	.0001	.0000	.0000	.0000
26. Gearhart	.0001	.0001	.0000	.0001	.0001	.0015	.0001	.0001	.0001	.0001
27. Seaside	.0009	.0022	.0007	.0018	.0009	.0095	.0032	.0019	.0011	.0014
28. Cannon Beach	.0003	.0007	.0002	.0005	.0002	.0030	.0005	.0003	.0003	.0004
29. Aluminum	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
30. Households	.2890	.6926	.2130	.4525	.2148	.4921	.4976	.2308	.2585	.3318

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Appendix Table 2. (Continued)

	Professional Services	Financial	Construction	Products	Services	Education	County Roads	Law Enforcement	Health Dept.	Welfare
1. Lumber	.0015	.0009	.0081	.0007	.0012	.0021	.0032	.0022	.0024	.0021
2. Commercial Fishing	.0003	.0002	.0002	.0002	.0003	.0005	.0004	.0006	.0006	.0005
3. Fish Processing	.0030	.0017	.0019	.0025	.0028	.0048	.0038	.0052	.0057	.0052
4. Agric. & Fur	.0013	.0006	.0008	.0006	.0018	.0020	.0016	.0023	.0024	.0023
5. Manufacturing	.0033	.0015	.0020	.0017	.0073	.0051	.0041	.0057	.0060	.0058
6. Lodging	.0503	.0233	.0320	.0228	.0524	.0802	.0643	.0892	.0960	.0889
7. Cafes & Taverns	.0427	.0192	.0273	.0193	.0402	.0684	.0548	.0769	.0819	.0756
8. Service Stations	.0393	.0167	.0254	.0175	.0364	.0701	.0876	.0699	.0867	.0656
9. Auto Sales & Service	.0640	.0263	.0414	.0255	.0531	.0988	.1824	.0952	.1024	.0973
10. Communic. & Transp.	.0600	.0392	.0367	.0330	.0520	.0753	.0615	.0916	.0974	.0809
11. Professional Services	1.0287	.0142	.0159	.0117	.0236	.0415	.0732	.0658	.0445	.3163
12. Financial	.0264	1.0157	.0270	.0137	.0336	.0404	.0410	.0436	.0467	.0441
13. Construction	.0433	.0240	1.0652	.0159	.0309	.0754	.2849	.0522	.0560	.0548
14. Products	.2298	.1142	.1478	1.1225	.1991	.4076	.3451	.4037	.4314	.3813
15. Services	.1278	.0512	.0670	.0681	1.1029	.1718	.1404	.1874	.1766	.2229
16. Education	.0171	.0103	.0118	.0159	.0212	1.0380	.0201	.0261	.0278	.0263
17. County Roads	.0009	.0005	.0006	.0008	.0011	.0013	1.0011	.0014	.0015	.0014
18. Law Enforcement	.0010	.0006	.0007	.0009	.0012	.0014	.0012	1.0016	.0017	.0016
19. Health Dept.	.0004	.0002	.0003	.0003	.0005	.0005	.0005	.0006	1.0006	.0006
20. Welfare	.0022	.0013	.0015	.0021	.0027	.0031	.0026	.0034	.0036	1.0034
21. Port Authority	.0005	.0015	.0004	.0004	.0006	.0007	.0006	.0008	.0008	.0008
22. General Fund	.0020	.0024	.0014	.0019	.0025	.0028	.0024	.0031	.0033	.0031
23. Astoria	.0081	.0037	.0047	.0067	.0084	.0115	.0095	.0126	.0135	.0127
24. Warrenton	.0008	.0004	.0005	.0011	.0010	.0012	.0010	.0013	.0014	.0013
25. Hammond	.0000	.0000	.0000	.0000	.0000	.0001	.0001	.0001	.0001	.0001
26. Gearhart	.0001	.0001	.0001	.0001	.0001	.0002	.0002	.0002	.0002	.0002
27. Seaside	.0022	.0012	.0012	.0024	.0024	.0029	.0024	.0031	.0033	.0032
28. Cannon Beach	.0007	.0003	.0004	.0005	.0006	.0010	.0008	.0011	.0012	.0011
29. Aluminum	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
30. Households	.6104	.2748	.3895	.2758	.5733	.9762	.7822	1.0851	1.1702	1.0795

(Continued on next page)

Appendix Table 2. (Continued)

	Port Authority	General Fund	Astoria	Warrenton	Hammond	Gearhart	Seaside	Cannon Beach	Aluminum	Households
1. Lumber	.0062	.0024	.0021	.0051	.0044	.0039	.0022	.0048	.0005	.0024
2. Commercial Fishing	.0005	.0005	.0005	.0004	.0003	.0003	.0004	.0002	.0001	.0007
3. Fish Processing	.0054	.0045	.0043	.0035	.0029	.0033	.0043	.0021	.0012	.0064
4. Agric. & Fur	.0016	.0019	.0018	.0047	.0013	.0016	.0018	.0009	.0004	.0028
5. Manufacturing	.0052	.0048	.0052	.0286	.0034	.0055	.0046	.0022	.0012	.0069
6. Lodging	.0539	.0758	.0850	.0579	.0480	.0535	.0719	.0363	.0169	.1104
7. Cafes & Taverns	.0472	.0647	.0592	.0492	.0415	.0455	.0619	.0298	.0144	.0943
8. Service Stations	.0487	.0626	.0577	.0548	.0361	.0584	.0624	.0317	.0146	.0806
9. Auto Sales & Service	.0637	.0818	.0782	.0979	.0547	.0832	.1014	.0632	.0195	.1174
10. Communic. & Transp.	.0486	.1127	.0668	.0668	.0459	.0628	.0688	.0382	.0158	.0892
11. Professional Services	.0430	.0568	.0423	.0527	.0268	.0509	.1124	.0497	.0100	.0511
12. Financial	.0348	.0373	.0342	.0352	.0290	.0317	.0376	.0363	.0088	.0535
13. Construction	.1363	.0555	.0952	.3764	.4967	.2770	.1121	.5817	.0140	.0630
14. Products	.2578	.3724	.3447	.3334	.3241	.3458	.3813	.2085	.1830	.4352
15. Services	.1042	.1617	.1876	.1528	.1223	.1391	.1648	.0727	.0346	.2010
16. Education	.0161	.0234	.0227	.0234	.0161	.0179	.0218	.0121	.0220	.0309
17. County Roads	.0009	.0013	.0011	.0010	.0009	.0009	.0012	.0006	.0010	.0017
18. Law Enforcement	.0010	.0014	.0013	.0011	.0010	.0010	.0017	.0007	.0012	.0019
19. Health Dept.	.0004	.0005	.0005	.0004	.0004	.0004	.0005	.0003	.0004	.0007
20. Welfare	.0021	.0030	.0027	.0025	.0021	.0023	.0028	.0016	.0028	.0040
21. Port Authority	1.0005	.0007	.0008	.0006	.0005	.0005	.0007	.0004	.0256	.0009
22. General Fund	.0088	1.0063	.0025	.0023	.0019	.0027	.0034	.0036	.0027	.0037
23. Astoria	.0104	.0108	1.0552	.0086	.0072	.0081	.0105	.0053	.0028	.0152
24. Warrenton	.0037	.0012	.0014	1.0009	.0110	.0821	.0011	.0006	.0024	.0016
25. Hammond	.0000	.0001	.0001	.0001	1.0000	.0000	.0001	.0000	.0000	.0001
26. Gearhart	.0001	.0002	.0002	.0001	.0001	1.0001	.0002	.0001	.0000	.0003
27. Seaside	.0019	.0027	.0026	.0022	.0019	.0021	1.0026	.0014	.0008	.0037
28. Cannon Beach	.0007	.0010	.0009	.0008	.0006	.0007	.0009	1.0194	.0002	.0014
29. Aluminum	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	1.0000	.0000
30. Households	.6560	.9214	.8093	.7028	.5821	.6498	.8744	.4226	.2053	1.3461

Addendum to Appendix Table 3

The seven sectors selected for inclusion in the air residuals equation system accounted for 77 percent of all 1968 sales to final demand.

The percentage of air residuals accounted for by the seven sectors was:

Particulates:	99 percent
Carbon Monoxide:	74 percent
Hydrocarbons:	73 percent

Appendix Table 3. Equation System Representing Linear Programming of Air Residuals, Runs 1-4: Clatsop County, Oregon.

	Sectors							Constraint levels (000)	
	X_{Lum}	X_{FP}	X_{SS}	X_{Con}	X_{Pro}	X_{PA}	X_{Al}	Runs 1 & 2	Runs 3 & 4
Objective function									
Multipliers	1.8454	1.7511	1.7448	1.9116	1.6646	2.5597	1.6022		
Constraints									
Particulates (lbs.)	.023009	.000371	.009133	.000631	.000411	.610456	.033943	≤ 6,105	≤ 3,201
Carbon Monixide (lbs.)	.037448	.027142	1.48833	.036867	.025401	.070686	.021191	≤ 8,483	≤ 6,670
Hydrocarbons (lbs.)	.006965	.005048	.276827	.006857	.004724	.013148	.003942	≤ 1,573	≤ 1,236
Bounds on X (000)									
Run 1									
Upper	∞	111,549	700	44,559	38,729	3,933	60,000		
Lower	55,605	39,305	200	13,121	10,558	932	0		
Run 2									
Upper	NC[a]	NC	NC	NC	NC	NC	85,560		
Lower	NC	NC	NC	NC	NC	NC	NC		
Run 3									
Upper	NC	NC	NC	NC	NC	NC	60,000		
Lower	NC	NC	NC	NC	NC	NC	NC		
Run 4									
Upper	NC	NC	NC	NC	NC	NC	85,560		
Lower	NC	NC	NC	NC	NC	NC	NC		

[a]No change

Addendum to Appendix Table 4

The seven sectors selected for inclusion in the water effluent equation system accounted for 78 percent of all 1968 sales to final demand.

The percentage of water effluent accounted for by the seven sectors was:

BOD:	99 percent
Suspended Solids:	73 percent

Appendix Table 4. Equation System Representing Linear Programming of Water Effluents, Runs 1-4: Clatsop County, Oregon.

	Sectors							Constraint levels (000)	
	X_{Lum}	X_{FP}	X_{CT}	X_{Con}	X_{Pro}	X_{PA}	X_{Al}	Runs 1 & 2	Runs 3 & 4
Objective function									
Multipliers	1.8454	1.7511	1.7847	1.9116	1.6646	2.5597	1.6022		
Constraints									
BOD (lbs.)	.551494	.005259	.007489	.004131	.000368	.003181	.00026	≤ 47,388	≤ 47,366
Suspended Solids (lbs.)	.652643	.054279	.087978	.098352	.066935	.161647	.049813	≤ 66,872	≤ 62,613
Bounds on X (000)									
Run 1									
Upper	∞	111,549	5,022	44,559	38,729	3,933	60,000		
Lower	55,605	39,305	1,660	13,121	10,558	932	0		
Run 2									
Upper	NC[a]	NC	NC	NC	NC	NC	85,560		
Lower	NC	NC	NC	NC	NC	NC	NC		
Run 3									
Upper	NC	NC	NC	NC	NC	NC	60,000		
Lower	NC	NC	NC	NC	NC	NC	NC		
Run 4									
Upper	NC	NC	NC	NC	NC	NC	85,560		
Lower	NC	NC	NC	NC	NC	NC	NC		

[a]No change

Addendum to Appendix Table 5

The ten sectors selected for inclusion in the equation system accounted for 80 percent of all 1968 sales to final demand.

The percentage of residuals and inputs accounted for by the ten sectors was:

Particulates:	99.8 percent
Cooling Water:	99.8 percent
Process Water:	61 percent
BOD:	99.8 percent
Solid Waste	73 percent

Appendix Table 5. Equation System Representing Linear Programming of Five Perceived Important Residuals, Runs 1-4: Clatsop County, Oregon.

	Sectors										Constraint levels (000)	
	X_{Lum}	X_{FP}	X_{Ag}	X_{Mfg}	X_{55}	X_{CT}	X_{Con}	X_{Pro}	X_{PA}	X_{Al}	Runs 1 & 2	Runs 3 & 4
Objective function												
Multipliers	1.8454	1.7511	2.6028	1.9059	1.7448	1.7847	1.9116	1.6646	2.5597	1.6022		
Constraints												
Particulates (lbs.)	.023009	.000371	.001452	.000698	.00913	.00169	.000631	.000411	.610456	.033943	≤ 6,117	≤ 3,216
Cooling Water (gals.)	135.499	.361263	.600722	.313034	.112815	1.8385	1.01326	.088059	.776417	3.462775	≤ 11,796,853	≤ 11,578,770
Process Water (gals.)	48.6376	1.6298	.843618	.590595	1.580341	.23493	1.12445	1.41702	.770488	30.8816	≤ 5,721,600	≤ 3,079,500
BOD (lbs.)	.551494	.005259	.002454	.001282	.000464	.007489	.004131	.000368	.003181	.000260	≤ 47,396	≤ 47,374
Solid Wastes (lbs.)	.570218	2.12952	55.5852	11.7938	4.16639	.618392	.703114	1.07824	1.24156	.43650	≤ 465,243	≤ 427,896
Bounds on X (000)												
Run 1												
Upper	∞	∞	6,070	10,400	1,400	5,022	44,560	38,700	3,930	60,000		
Lower	55,605	39,305	2,720	2,980	200	1,660	13,120	10,560	932	0		
Run 2												
Upper	NC[a]	NC	NC	NC	NC	NC	NC	NC	NC	85,560		
Lower	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC		
Run 3												
Upper	NC	NC	NC	NC	NC	NC	NC	NC	NC	60,000		
Lower	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC		
Run 4												
Upper	NC	NC	NC	NC	NC	NC	NC	NC	NC	85,560		
Lower	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC		

[a]No change