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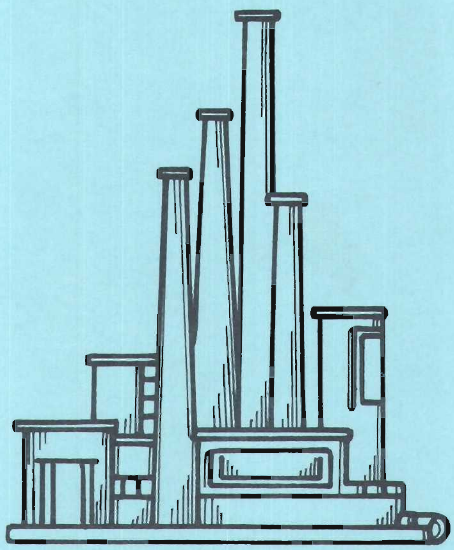
LINKAGES BETWEEN THE ECONOMY AND THE ENVIRONMENT:
an analysis of economic growth in
CLATSOP COUNTY, OREGON

Kenneth J. Roberts
R. Bruce Rettig



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AGRICULTURAL EXPERIMENT STATION

Station Bulletin no. 618

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abstract

This report analyzes some of the linkages between economic growth and environmental change in a rural community. Recently developed methodology for estimating induced as well as direct environmental change from a new industry is applied to a current development issue on the Oregon coast. Some extensions of the methodology were developed to assist in long-range planning. Linear programming was used to trace environmental consequences of alternative economic growth patterns. Total change from new industry (in this case, a new aluminum plant in Warrenton, Oregon) is shown to depend not only on the relation of the new industry to the environment but also on impact of the new industry on the local economy and the feedback from the local economy's total expansion back to the environment.

authors

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related publication

IMPACT OF A MAJOR ECONOMIC CHANGE ON A RURAL COASTAL ECONOMY: A LARGE ALUMINUM PLANT IN CLATSOP COUNTY, OREGON, by Theodore Collin, Russell Youmans and Herbert Stoevener. Publication no. T-73-001. 30 pp.

An attempt to measure distribution of the economic impacts of the addition of a large aluminum manufacturing plant to Clatsop County. The new industry's effects are determined on the basis of data collected for one year (1968-69). Measures applied, such as the business multiplier and the household income multiplier, are explained and analyzed.

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introduction

Growth in business activity has been a well accepted community goal. It remains so, but two elements of growth that were formerly treated as peripheral have become the focus of community concern: (1) How will various economic segments of the community be affected? (2) What will happen to the community's natural resources if growth occurs in certain businesses?

The first concern has been investigated by the business and academic community through economic research involving input-output analysis. Input-output analysis allows the researcher to estimate the total dollar impact of an economic change and to indicate the distribution of the impact among the sectors of an economy. The study being reported involves the use of input-output analysis to provide insight as to the natural resource impact of community growth prospects. The study examines the natural resource requirements, many of which involve free goods, as well as the wastes or by-products of certain economic activities. The economic and natural resource impacts are then combined to represent the possible choices of a community.

THE ECONOMY: CLATSOP COUNTY OREGON

This study is based on previous research of a major economic change in a coastal rural economy, Clatsop County, Oregon. Collin, Youmans, and Stoevener [1] described the economy and natural resources base of Clatsop County in a 1969 study of the economic impact of a large aluminum manufacturing plant.

The cool, moist climate of Clatsop County provides excellent conditions for timber growth in the mountainous regions. A portion of the county in the city of Astoria area is flat and thus conducive to development of waterfront-dependent businesses. Although roughly 90 percent of the land is in forests, 8 percent in farmland, and 2 percent in other uses, approximately 44 million dollars in 1968 sales occurred from businesses requiring minimal land resources, i.e., Commercial Fishing, Fish Processing, and the Port Authority. In terms of sales, Lumber and Fish Processing are the largest sectors in the economy.

The proposed plant with assumed value of $150 million would increase the 1968 assessed valuation in the county by approximately 48 percent. Clatsop County receives more than 80 percent of its ad valorem revenue from real property. Thus, county revenues would increase significantly with the aluminum plant.

An important aspect of the Collin study is that the analysis concerned the economic impact of the aluminum plant's annual operations, not construction. The operations were to result in annual expenditures of $8,288,000 for locally provided goods and services, $6 million in payrolls, and $1,427,000 in local taxes. Because a portion of direct expenditures are re-spent in the county, there would be an additional economic impact. This total effect of the aluminum plant's annual expenditures was estimated by Collin to be $11,183,000.

More than 87 percent of the plant's expenditures for local goods and services was for gas and electricity. Commercial Fishing income was found to be the least affected. The change in the Agriculture and Fur sector was also relatively small, a $958 income increase as a result of the aluminum plant's $60 million annual sales. The relationship of aluminum to fishery and 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. The relationship among sectors in such cases occurs through the environment. The magnitude of relationships developed via the environment and the related economic ramifications must be analyzed to more completely represent the market and non-market effects of interindustry economic activity. The present study focused on revealing the non-market (environmental) effects of economic activity by expanding the Clatsop County model to include environmental as well as monetary factors. The reader unfamiliar with the technique of input-output analysis is referred to the Collin study for a concise explanation.

ENVIRONMENTAL LINKS TO THE ECONOMY

An input-output model consists of a matrix with an equal number of rows and columns. The economic activity in the community is divided into sectors on the basis of similarity of characteristics, e.g., paper mills, plywood plants, and timber harvesting were placed in the Lumber sector of the Clatsop County model. The expenditures in the economy were allocated among the various sectors on the basis of a sample of both business and government. Each sector is recorded twice, once as a column and once in a row. Reading down a column reveals how the sector at the top made its purchases from those sectors listed to the left.

Since the input-output model divides the economic activity into sectors, the procedure for linking the environment to the economy also involves matrices. The environmental linkage matrix would have the same economic sectors from the input-output matrix as columns and links to the environment as rows. The matrix used to link the Clatsop County economy and environment appears in Appendix Table 1. Each row of the linkage matrix represents *either* a natural resource input used by economic sectors or a residual, waste, discharge, etc., resulting from the economic sectors. The former are inputs required by the community such as cooling water, water used in production processes, domestic water, etc. Inputs to the economic sectors listed at the top carry a positive sign and the residuals flowing from the economy are indicated by minuses. No connotation of "good" or "bad" should be inferred by the designation. An alternative to the designation would be to denote residuals as reductions in an existing inventory of the set of natural system components. Reference to waste water residuals as producing certain alterations in dissolved oxygen (DO) *after* release into waterways as opposed to specifying the bio-chemical oxygen demand *before* release is an example of a labeling change.

Information on environmental effects was drawn from published sources and on-going research. Air and water quality studies as well as solid waste management studies are often conducted on an industry basis to facilitate development of long-run management plans. However, Appendix Table 1 cannot be deemed to represent a complete linkage between environment and economy for two reasons: (1) blank spaces indicate either no linkage to the environment by the sector at the top or a lack of data when a linkage is known to exist, and (2) there are feedback mechanisms in the environment that come into play when the magnitude of inputs withdrawn or residuals absorbed by the environment alter its capability to provide inputs or receive residuals at previous levels. Improvement in the estimates for which data were available and improvements in filling the two previous data gaps are needed.

The actual linkage of the economic and natural systems can be illustrated prior to presentation of the actual linkage used for Clatsop County. Matrix F^{-1} in Figure 1 represents the Leontief inverse for an hypothetical four sector economy (W, X, Y, Z).[2] The matrix represents the *total* business transactions of an economy resulting from a dollar increase in sales to final demand by a particular sector.[2] Matrix A represents the environmental factors of interest: BOD[3], cooling water, and marshland. For example, column Z of matrix A indicates that each dollar of gross output of economic sector Z results in the release of 2 pounds of BOD, requires 2 gallons of water for cooling purposes, and necessitates use of 2 square feet of marsh. These are the direct effects only. The hypothetical figures

$$
\begin{array}{l}
\\ \text{BOD} \\ \text{Cooling water} \\ \text{Marsh}
\end{array}
\overset{A}{\begin{array}{cccc} W & X & Y & Z \end{array}}
\begin{bmatrix} -4 & -4 & -1 & -2 \\ 1 & 3 & 0 & 2 \\ 5 & 5 & 1 & 2 \end{bmatrix}
\quad
F^{-1} =
\begin{array}{cccc} W & X & Y & Z \end{array}
\begin{bmatrix} 1.2 & 0.1 & 0.0 & 0.1 \\ 0.1 & 1.2 & 0.0 & 0.1 \\ 0.1 & 0.2 & 1.1 & 0.3 \\ 0.1 & 0.1 & 0.2 & 1.3 \end{bmatrix}
$$

=

$$
E =
\begin{array}{l} \text{BOD} \\ \text{Cooling water} \\ \text{Marsh} \end{array}
\overset{\begin{array}{cccc} W & X & Y & Z \end{array}}{\begin{bmatrix} -5.5 & -5.6 & -1.5 & -3.7 \\ 1.7 & 3.9 & 0.4 & 3.0 \\ 6.8 & 6.9 & 1.5 & 3.9 \end{bmatrix}}
$$

Figure 1. Hypothetical Calculation of Direct and Indirect Economic-Ecologic Linkages

[1] F^{-1} is the Leontief inverse.

[2] The components of final demand include transfers of money to non-county government, sales to business and government outside the community, and local business depreciation and investment.

[3] Bio-chemical oxygen demand.

show that when the linkage matrix, A, is post-multiplied by the economic sector matrix, F^{-1}, the *total* environmental effect of each dollar increase in sales to final demand is revealed. The result of the process, matrix E, shows that the *total* effect of each dollar sales of sector Z is the release of 17 pounds of BOD, the use of 10 gallons of cooling water, and utilization of 19 square feet of marsh. The difference between the direct and total environmental effects is the result of increased sales throughout the community's economy generated by the additional one dollar of sales by sector Z. The remaining sectors of the community's economy are similarly interpreted.

Returning to the model of the Clatsop County economy to perform the multiplication of the environmental system's direct effect matrix by the economic system's total effect matrix yields Table 1. Interpretation of the elements is identical to that of E in Figure 1; each element indicates the *total* resource requirment or residual discharge per dollar of sales to final demand by the sector specified at the top of the column.

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 because of economic activity. Comparison of Appendix Table 1 and text Table 1 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. 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.

Consideration of both direct and indirect resource needs and residuals production 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 1.

Atmospheric Emissions

Environmental impact through atmospheric emission of particulates, fluoride, carbon monoxide, and hydrocarbons appears to be a potential of economic activity in most sectors of the Clatsop County economy (see Table 1). On the basis of the measure used in Table 1, 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 pounds per dollar and .023009 pounds per dollar, respectively. Among those sectors for which no direct particulate linkage could be estimated (see Appendix Table 1) Communications-Transportation and Agriculture-Fur showed the largest indirect linkage. 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 [15, p. 68].

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 emissions by motor vehicles in personal and commercial use to Service Stations, that sector showed the largest linkage in Table 1. Public firms are again shown to have residual linkages higher than many private firms, e.g., County Roads and Health Department.

Gaseous and solid fluorides result from primary aluminum production plants like that proposed in Clatsop County. The proposed plant was assumed to use the vertical stud Soderberg (VSS) reduction process. Iverson (1972) has demonstrated that the best available primary *and* 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 1). Note that the fluoride residual appears in but one column and the value is identical in Table 1 and Appendix Table 1. The blanks are a result of zero purchases of locally produced aluminum by Clatsop County firms. The fluoride residual identity also flows from this unique purchasing pattern.

Table 1. 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	.723603	.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 1. (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

(Continued on next page)

Table 1. (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

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 1).

Solid Waste

Historically, the disposal of solid waste has been managed in a manner yielding secondary problems. For example, tidelands and marshes in San Francisco Bay have been so reduced in size by filling with solid waste that a new institution has been generated to manage not just the solid waste disposal sites but the whole estuary.

Elements of Table 1 reveal responsibility for generation of solid waste (lbs.) among all private and public firms depicted in Clatsop County. 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 by provision of public services.[4]

Water Directed Emissions

The interfacing of saline and fresh water 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 Appendix Table 1). Direct and indirect linkages shown in Table 1, 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 predominance 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 1 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 linkages with suspended solids 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 1 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 that numerous sectors without direct linkage are tied monetarily to Lumber and Households.

Discharges of organic nitrogen have received widespread media coverage since the mid-1960s. Eutrophication and other aquatic biomass growth problems are the potential result of uncontrolled disposal of nitrogenous residuals. Eutrophication is a natural process capable of acceleration and the ultimate collapse of aquatic systems. Even without ultimate collapse, aquatic

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[4] The municipality coefficients are based on two linearity assumptions: (1) an assumed linear relationship between population and municipal solid waste, and (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.

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 needed water from the Columbia River without assistance from municipalities or special water districts. The nature of productive processes in Fish Processing requires 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, water inputs were divided into domestic, cooling, and process.[5]

Domestic water is the first of the water inputs in Table 2. The term is somewhat of a misnomer in that it connotes potable water. The connotation is valid in each direct link identified in Appendix 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, the only sectors with estimated direct coefficients.

The process water coefficient in Table 1 and Appendix Table 1 yielded the same ranking of top three sectors--Lumber (48.6376 gals.), Aluminum (30.8816 gals.), and Fish Processing (1.6298 gals.). The process water coefficients are subject to becoming outdated. 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 it 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 1 indicates that national level coastal zone and estuarine management studies may 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 1, 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

[5] Water used for household purposes such as cooking, drinking, washing, and sewage disposal is identified as "domestic" water in the study. Water used for cleaning equipment or machinery in industry and inclusion in products is identified as "process" water in the study.

Table 2. Economic Sectors Exhibiting Relatively Large Direct and Indirect Relationships to Selected Environmental Goods: Clatsop County, Oregon

	RANK (1-5)				
	1	2	3	4	5
Particulates (lbs.)	Port Authority	Aluminum	Lumber	Service Stations	Comm. & Transp.
Carbon Monoxide (lbs.)	Service Stations	Commercial Fishing	County Roads	Health Dept.	Households
Fluoride (lbs.)	Aluminum				
Hydrocarbons (lbs.)	Service Stations	Hammond	Commercial Fishing	County Roads	Health Dept.
Domestic Water (gals.)	Lumber	Hammond	Seaside	Warrenton	Gearhart
Cooling Water (gals.)	Lumber	Aluminum	Comm. & Transp.	Construction	Port Authority
Process Water (gals.)	Lumber	Aluminum	Fish Processing	Products	Comm & Transp.
Water Intake (gals.)	Lumber	Hammond	Seaside	Warrenton	Gearhart
Water Discharge (gals.)	Lumber	Hammond	Seaside	Warrenton	Aluminum
5-Day BOD (lbs.)	Lumber	Comm. & Transp.	Fish Processing	Construction	Port Authority
Suspended Solids (lbs.)	Lumber	Households	Health	Law Dept.	Welfare Enforcement
Organic Nitrogen (lbs.)	Fish Processing	Households &	Health Dept.	Education &	Law Enforcement
Solid Waste (lbs.)	Agric. & Fur	Manufac.	Astoria	Warrenton	Seaside
Solid Waste (cu. yds.)	Lumber	Comm. & Transp.	Construction	Port Authority	Warrenton

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 when protecting other sectors sensitive to BOD loadings. Communications-Transportation ranked second in BOD loadings per dollar delivery to final demand.

Supply Prices

Individuals and agencies charged with management of resources in the coastal zone 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 use the market as a framework for developing and communicating information of value in optimizing various objective functions. However, conflicts over alternative uses of coastal resources are often considered to be inadequately handled by the marketplace, particularly in bays and estuaries. The existence of imperfections in the market does not say anything meaningful about public action to be taken until an alternative is put forward. A second issue arises because of reliance on sweeping institutional and political action rather than incremental changes or market adjustments when action is needed. Both major changes and small alterations require substantial information concerning the ties between market and environmental goods. Castle and Stoevener emphasize the importance of the market to this problem 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 communications of information is [sic] 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].

If the modified input-output procedure presented in the Clatsop County model is to provide information on problems of growth and the environment, a choice indicator is needed. The coefficients in Table 1 offer a surrogate for the price that would exist in a market--supply price. A supply price will identify the minimum opportunity cost of securing a good. In essence, a trade-off is specified. 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 1 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 ranking of sectors having large Table 1 coefficients such as presented in Table 2. 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. Coefficients in Table 2 for the corresponding environmental goods of concern would be the choice indicators. Additional emphasis will be devoted to development of choice indicators related to (2) and (3) later when economic growth and minimum impact planning are considered.

A SCENARIO FOR FUTURE ENVIRONMENTAL EFFECTS

Communities planning for economic growth can use material developed in this report to examine two important questions: What changes will occur in the economy if we expand one or more of our industries? What changes will occur in our environment if we expand an industry?

The numbers displayed in Table 3 show the total change in business income in the community from a dollar change in a base industry.[6] For example, a one dollar

[6] A discussion of business multiplier can be found in the study by Collin and others [4, 1973] starting on page 13.

increase in the final demand for lumber will be associated with an increase in output of $1.84 by Clatsop County industry.

These multipliers can be related to the elements of Table 1 for insight to the environmental impact per dollar of income generated. This 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.

Dividing the numbers in Table 1 by the relevant multipliers from Table 3 yields environmental linkages per dollar of income generated (Table 4). The ranking of major air residuals sectors remained in line with that of Table 2. However, a general decline in the rank of public service sectors and a higher rank for Households (2) 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.

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. Though monetary benefits were well specified, individual and group response has in no way approached consensus. The result has been a period of additional study of the proposed plant and the future of the Clatsop County economy.

The Bureau of Economic Analysis of the U.S. Department of Commerce [6, 1972] provided data useful for estimating business activity by sectors for Clatsop County in 1980. The estimates involve two conditions: (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. Sales to final demand are indicated in Table 5 for the private sector and Port Authority. Total business income can be derived from Table 5 by use of the multipliers found in Table 3. A decision maker can relate the data from Table 5 to that of Appendix Table 1 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 Appendix Table 1 and text Table 5 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 Appendix Table 1 and text Table 5 require: (1) the production *and* 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.

The ecologic linkage coefficients of Table 1 can be multiplied by the appropriate 1980 final demand figures for each economic sector in Table 5 and summed by environmental goods, rather than by economic sector.[7] The public sectors such as Hammond, Education, County Roads, etc., are not listed in Table 5 but their effect has been included in Table 6. The resulting figures project total environmental goods useage and appear in Table 6. 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 (such as Professional) were estimated to have the largest growth potential. 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

[7] For example, the 6,221,000 poungs of particulates at the top of the second column in Table 6 results from multiplying each element of the particulates *row* in Table 1 by the predicted value of 1980 sales for the economic sectors (.023009)($85,130,000) + (.00133)($1,307,000) + ... + (.033943)($85,560,000) + (.0013)($65,940,000) = 6,221,000 lbs.

Table 3. 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

Table 4. Economic Sectors Exhibiting Relatively Large Direct and Indirect Linkages per Dollar of Income Generated, Clatsop County, Oregon

	RANK (1-5)				
	1	2	3	4	5
Particulates (lbs.)	Port Authority	Aluminum	Lumber	Financial	Households
Carbon Monoxide (lbs.)	Service Stations	Commercial Fishing	Households	County Roads	Health Dept.
Fluoride (lbs.)	Aluminum				
Hydrocarbons (lbs.)	Service Stations	Commercial Fishing	County Roads	Health Dept.	Agric. & Fur
Domestic Water (gals.)	Lumber	Hammond	Seaside	Gearhart	Warrenton
Cooling Water (gals.)	Lumber	Aluminum	Comm. & Transp.	Construction	Port Authority
Process Water (gals.)	Lumber	Aluminum	Fish Processing	Products	Comm. & Transp.
Water Intake (gals.)	Lumber	Hammond	Aluminum	Seaside	Gearhart
Water Discharge (gals.)	Lumber	Aluminum	Hammond	Gearhart	Warrenton
5-Day BOD (lbs.)	Lumber	Comm. & Transp.	Fish Processing	Financial	Port Authority
Suspended Solids (lbs.)	Lumber	Households	Health Dept.	Law Enforcement	Education
Organic Nitrogen (lbs.)	Fish Processing	Households			
Solid Waste (lbs.)	Agric. & Fur	Manufac.	Service Stations	Cafes & Taverns	Lodging
Solid Waste (cu. yds.)	Lumber	Construction	Port Authority	Agric. & Fur	Cannon Beach

Table 5. Projected Sales to Final Demand for Selected Sectors of the Clatsop County Economy, 1980

	Sales 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.

Source: [15]

Table 6. 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 effect of public sector expenditures.

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 recalled that the trade-off was based on an increase in Aluminum sales as if the plant were originally operating with $60 million sales.

For purposes of demonstration, the model has facilitated the identification of trade-offs in 1968 and those associated with growth toward 1980 ignoring new technology and alternative production techniques introduced in response to higher relative prices of natural resource inputs. 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 inventory of environmental goods or assimilative capacities of the environment) to determine *when* 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 different 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.

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. 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, and (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 goods constraints computed as if the Aluminum sector were a functioning part of the economy in 1980. That is, the magnitudes of the environmental goods used in the constraints were those predicted to exist in the county as a result of the economic activity predicted in Table 5. Run one differed from run two only in the maximum upper bound placed on the Aluminum unknown. Runs one and two of each problem were designed to explore the question, "Can the economy be realigned to realize a higher level of sales than predicted in 1980 without exceeding the levels of environmental goods predicted in Table 5?" 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. In runs three and four of each problem, the level of environmental goods required by the aluminum plant was not included in the environmental goods constraint magnitudes. Thus, runs three and four answered the question, "If the economy does not have an aluminum plant in 1968 *and* does not want to experience the increased environmental goods demands of an aluminum plant, would it be beneficial to community business sales to encourage aluminum production and discourage growth of other business sectors that require environmental goods?" 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 only 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 the management of environmental goods, or even well coordinated action among several agencies, aluminum production would likely not be feasible. The objective function values for total business income, Lumber income, Fish Processing income, and Aluminum income in 1980 for all three problems are shown in Table 7. 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 processing 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.

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 to uncover economic-ecologic linkages of key sectors in the Clatsop economy, to predict the residuals generation and non-market good requirements of a proposed aluminum plant, and to evaluate possible trade-offs associated with public choice related to aluminum production. 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. 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 8. 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 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

Table 7. Summary of Linear Programming Problems: Estimated Objective Function, Values for Total Business, Lumber, Fish Processing, and Aluminum Income in 1980

	Runs			
	1 (000 $)	2 (000 $)	3 (000 $)	4 (000 $)
<u>Problem 1</u>				
Total business income	500,392	509,815	381,750	381,750
Lumber income	55,605	55,605	55,605	55,605
Fish Processing income	111,549	101,596	71,661	71,661
Aluminum income	60,000	85,560	38,300	38,300
<u>Problem 2</u>				
Total business income	600,885	638,237	588,842	626,194
Lumber income	76,269	74,318	69,743	67,792
Fish Processing income	111,549	111,549	111,549	111,549
Aluminum income	60,000	85,560	60,000	85,560
<u>Problem 3</u>				
Total business income	639,425	645,047	519,648	510,655
Lumber income	81,655	63,584	55,605	55,605
Fish Processing income	111,701	111,647	111,622	111,625
Aluminum income	60,000	85,560	12,140	12,140

Table 8. Induced 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				
			Particu-lates (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 & 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 & 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 & 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
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.

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 million 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 8. There are five environmental goods listed in the table: particulates, cooling water, process water, BOD, and suspended solids. In previous tables, the Aluminum sector was shown to require the first three in its production process. All five of the environmental goods are required by other sectors of the economy as a result of induced economic activity brought about by the Aluminum sector becoming a part of the Clatsop economy. For example, Table 8 indicates that in addition to the particulates produced by the Aluminum sector, 975,982 pounds of particulates are produced by other sectors as a result of increased economic activity induced by the Aluminum sector's operation. Virtually all the induced release comes from Port Authority ore-handling operations. The Aluminum sector particulate emissions combined with emissions induced from the other sectors represent slightly more than a 100 percent increase in particulate levels over that which would have been experienced in a non-aluminum economy.

The estimates of water inputs for cooling and processing purposes reveal a different impact of Aluminum sector operation. The requirements for cooling water represent less than a 1 percent increase over the requirements for a non-aluminum economy. Increased economic activity from operation of the aluminum plant would induce use of 37,895,200 gallons of process water over the additional two billion gallons annually required by the aluminum plant. As evident in Table 8, the Products sector and Household sector are important users of additional induced process water demands.

The production of aluminum could not be directly related to BOD and suspended solids residuals. Both water-borne residuals are induced in other sectors from increased economic activity resulting from the Aluminum sector. The primary sector relationships are similar--Households, Products, Services, and the Port Authority. The induced BOD increase was estimated to be less than 1 percent of that experienced in a non-aluminum economy. Suspended solids estimates represent 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 1, 4, and 6 were presented to specify various choice indicators to the trade-offs possible in policy decisions in Clatsop County: (1) Table 1 represents environmental goods as related to final demand deliveries, (2) Table 4 represents environmental goods aspects of income generation, (3) environmental goods are related to growth considerations in Table 6. 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.

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Appendix Table 1. Direct Ecologic Linkages to the Clatsop County Economy: Resource Inputs and Waste Output 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)

Appendix 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)

Appendix 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.)										

ADDENDUM TO APPENDIX TABLE 1

Development of the environmental information initially proceeded on the assumption that inputs and residuals would be related to the economic sector generating the demand. In one case, a residual was allocated to the sector thought to be most directly 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. However, these emissions were related to the Service Station sector for reasons described in Roberts' thesis.

Non-zero elements are indicated in Appendix Table 1 for private and public sectors. 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, 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.

Environmental impact data in the Clatsop County study were collected from a number of secondary sources. Use of secondary sources has cost advantages but data can also be developed in varying manners. 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 a method of controlling or treating the residual was utilized or not. 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 implication of the "before treatment" method is that Table 1 contains non-zero elements in nearly all cells. There is one row in the table 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, Appendix 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 because of numerous studies of the input and residual levels associated with these major Pacific Northwest industries. Estimates are based on inplace technology common to the economic endeavors of firms located in the region. Precise information on waste water requirements in Clatsop County was 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. One problem encountered in estimating environmental effects for the table 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 environmental data is provided by the work public agencies engaged in resource management. Water, air, and land resources 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. Data can then be drawn from publicly approved legal residuals constraints.

DATA SOURCES FOR ECOLOGIC LINKAGES

Particulates

Lumber: reference 8, reference 20

Service Station: reference 9, reference 14, reference 20

Aluminum: reference 11

Carbon Monoxide

Service Stations: reference 9, reference 12, reference 20

Fluoride

Aluminum: reference 11

Hydrocarbons

Service Stations: reference 9, reference 14, reference 20

Domestic Water

Lumber, all municipalities, households: reference 5, reference 16, reference 19

Cooling Water

Lumber: reference 5, reference 16, reference 19

Fish Processing: reference 17, reference 18

Aluminum: reference 5, reference 16, reference 19

Process Water

Lumber: reference 5, reference 16, reference 19

Fish Processing: reference 17, reference 18

Aluminum: reference 5, reference 16, reference 19

Water Discharge

Lumber: reference 5, reference 16, reference 19

Fish Processing: reference 17, reference 18

Aluminum: reference 5, reference 16, reference 19

All other sectors: reference 5, reference 9, reference 16, reference 19 (those sources inconclusive, but pointed to fact that assuming 20 percent consumptive use would be conservative).

BOD

Lumber: reference 5, reference 16, reference 19

Fish Processing: reference 17, reference 18

Suspended Solids

Lumber: reference 5, reference 16, reference 19

Fish Processing: reference 17, reference 18

Organic Nitrogen

Fish Processing: reference 17, reference 18

Solid Waste (Lbs.)

Fish Processing: reference 17, reference 18

All other sectors: reference 13

Solid Waste (Cu. Yds.)

Lumber: reference 7