AN ABSTRACT OF THE THESIS OF

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Title: INTERRELATIONSHIPS BETWEEN ISSUES OF THE ENVIRONMENT AND ECONOMIC GROWTH: AN ECONOMIC-ECOLOGIC ANALYSIS OF TILLAMOOK COUNTY, OREGON

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The general objective of this study is to develop a systematic evaluation of the interrelationships between issues of the environment and economic growth for Tillamook County. In order to gain some appreciation for the complexities between environment and economic development; specific objectives were established 1) to identify relevant economic-ecologic linkage in Tillamook County and quantify these linkages for incorporation into the model, 2) to develop environmental impact business output and household income coefficients and 3) to indicate the use of the economic-ecologic model in environmental planning.

Local communities who are concerned with the development can utilize the essential information of economic-ecologic model for assisting local decisions. However, the decision is framed

in terms of trade-offs between changes in business outputs and/or household income and environmental consideration. For example, if biochemical oxygen demand (BOD) is a major environmental concern in the community then (BOD) produced per dollar of household income or business output is one criteria to be considered when evaluating potential expansion of business activity. If the community has options of influencing selection of wood processing; plywood mill, seafood processing or a salmon plant, the least BOD impact per dollar of output or income would be wood processing. If electricity is the major concern, wood processing uses the least electricity per dollar of business output but seafood processing uses the least electricity per dollar of household income. The community can see the need to clarify the goals. In general sense, the model provides alternative impacts for comparison when making local decisions concerned with development. By allowing comparisons, the locally most important trade-offs in environmental impact can be evaluated.

The economic-ecologic model is adequate to estimate the impact of proposed developments. For example, if we know the basic expenditure pattern of the proposed new plant and its specific demand on local resources from an environmental stand point the economic-ecologic trade-offs can be estimated. The basic expenditure of the proposed salmon aquaculture development would contribute increase local economic activity, a portion of which would be to

construction $13,000, to retail and wholesale sales $22,000, $6,000 in government taxes and payments to households of $65,000. Associated with this economic activity would be the following types of annual or local environmental loads: 780 pounds of particulates, 14,720 pounds of 5 Day BOD, 59 cubic yards of solid wastes and need for 1,148,010 gallons of water, and 307,260 kilowatt hours of electricity. The local challenge is how to evaluate the relative empacts and determine the preferred cause of development.

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INTERRELATIONSHIPS BETWEEN ISSUES OF THE ENVIRONMENT AND ECONOMIC GROWTH: AN ECONOMIC-ECOLOGIC ANALYSIS OF TILLAMOOK COUNTY, OREGON

I. INTRODUCTION

Due to recent developments, local people are becoming increasingly concerned about interrelationships between issues of environmental quality and economic growth. Local committees and officials are interested in examining economic alternatives which bring economic benefits and have minimal effect on environmental quality. Economists are challenged to look more closely at growth and environmental relationships in local economies to assist this social decision making (Collins, 1970, p. 1-2).

No longer can community or regional planning be primarily concerned with the economy and its development, but rather it must also be aware of the effect of economic development on the natural environment (Laurent and Hite, 1970, p. 1).

Unfortunately, many environmental considerations are not priced in economic markets. As a result, the information necessary to bring such considerations into traditional economic analysis is lacking. Therefore there is a strong need to develop economic tools which can incorporate environmental considerations into the regional planning process. Such methodology should account for all inputs

and outputs of an economic and environmental nature. Workable solutions to the problem of tradeoffs between regional economic and natural environmental quality lie in such methodology (Isard, 1968, pp. 85-96).

This study is an attempt to develop a general model, based on existing economic methodology, for the purpose of incorporating environmental as well as pecuniary values into management systems for natural resources. No attempt to simulate the internal 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 system will be analyzed without consideration of the natural system, safe minimum standards, finite resource supplies, regenerative processes, etc.

Objectives

The general objective of this study is to develop a systematic evaluation of the interrelationships between issues of the environment and economic growth in order to gain some appreciation for the complex relationships between the environment and economic development. It is the intention to draw those implications which would assist decision making by local committees interested in examining economic alternatives which bring economic benefits and identify the effects on environmental quality.

The specific objectives of this study are:

1. To identify relevant economic-ecologic linkages in Tillamook County and quantify these linkages for incorporation into the model.
2. To develop environmental impact business and household income coefficients, i.e., the environmental impact per dollar of business generated by the various sectors in the economic input-output table describing the Tillamook County economy.
3. To indicate the use of the economic-ecologic model in environmental planning.

Procedures

The economic and environmental relationships in this study are built around Leontief's input-output analysis. This modified input-output model follows the works of Laurent and Hite (1971) and Roberts (1973), and was a modification of the Isard economic-ecologic model.

Considering the Leontief system as a general theory of production, the environmental matrix was developed to fit within this modified input-output model. The environmental matrix shows the inflow from the environment and outflow to the environment associated with one dollar of gross sales. An economic input-output table or matrix was constructed for Tillamook County, Oregon by Ives (1977).

The linkage of the economic input-output matrix and environment involved post-multilying the environmental linkages matrix by the inverse matrix of the input-output model.

$$(S)\ (1-A)^{-1} = Z$$

where

S is an environmental linkage matrix.

$(1-A)^{-1}$ is the Leontief inverse matrix.

Z is a matrix of the direct and indirect environmental impact of each economic sector.

The completed model was used to quantify particular economic-ecologic linkages in Tillamook County, Oregon. Of particular interest are the direct and indirect environmental impacts which result from an increase in the output of the various industries of the county. These ecologic impacts are expressed in terms of: a) dollars of total business output, b) dollars of indirect business output (resulting from an increase in direct output) and c) dollars of direct and indirect household income (resulting in an increase in exports or additional business). These coefficients could then be used to indicate the direct and indirect impacts on both the economic and ecologic systems of various types of economic growth and management strategies.

II. AN ECONOMIC-ECOLOGIC MODEL: THE THEORY

The Tillamook County input-output model[1] (1973) is adapted to provide information relating the market and non-market aspects of the pecuniary forces in the economy. Generally, many environmental goods are not bought and sold in markets. This immensely complicates the difficulty of quantifying the tradeoffs between economic development and conservation or use of natural resources. If available, it would assist in wiser use of resources for the community under investigation.

A conceptual model of the economic-ecologic relationships will be developed for analyzing environmental resources and their roles with respect to an interrelated economic system. This task involves developing a model that will provide the necessary economic information as well as quantifying the economic-ecologic linkages. The conceptual base for the modified input-output used in this study is rooted in work done two centuries ago. The input-output analysis used here, was developed from the theory of economic equilibrium. The first publication relating to input-output analysis was published by Francois Quesnay in his Tableau Economique (1758). His focused attention on

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[1]The Tillamook County input-output model was developed by Ives (1977).

the circular flow of economic goods in a national economy. His work recognized the broad interrelationships within an economic system and was the forerunner of modern input-output analysis (Newman, 23, pp. 34-40). In other words, his work contributed to the understanding of the interdependent nature of economic activity in an ideally competitive economy. It showed graphically the different activities that increased the value of a product (Collin, p. 11).

The reference point for most modern general equilibrium analysis, however, is found with another Frenchman, Leon Walras. In 1874 Walras published the Elements d'Economie Politique Pure. His main interest was to determine all prices in an economy at the same time. He was one of the first to work with production coefficients, consumer income, and expenditures (Collin, p. 18). Walras was interested in the simultaneous answers which an economic system gives to such questions as: What is to be produced and how much is to be produced? He developed a general equilibrium model based on a series of simultaneous equations, each of which represented a good or service produced by the economy (Spiegal, pp. 581-591). 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 equation to determine aggregate demand (Roberts, pp. 40-41). Other early workers with equilibrium models included

Gustav Cassel of Sweden and Vilfredo Pareto of Italy (Collin p. 19).

However, until recently, the entire concept of the general equilibrium model was considered as strictly a theoretical device. The practical use of this analysis was not made until the 1930's by a Russian born economist, Wassily Leontief, who realized that these ideas were more than just a tool for the theoretician. He developed a theory of production based on the general equilibrium concept of economic interdependence. But he went several steps beyond theory and gave general equilibrium analysis an empirical tool. He published an input-output table for the United States economy in 1936 (Leontief, pp. 105-125). Thus, he was able to apply inter-industry analysis in a manner not available to Quesnay and Walras. The age of Quesnay was one of laissez-faire, an age in which government was viewed as having no economic role; while Walras viewed the general equilibrium approach as conceptually rich, but empirically impracticable (Roberts, p. 41). Since Leontief's contribution, the model has been used to study regional and local aspects of economic impacts. However, empirical applications of the model to natural resource problems have been relatively new and generally have been limited in scope.

In 1954 Professor S. C. Ciriaey-Wantrup (1954) showed that input-output model might be useful in developing a framework necessary for analyzing the effects of investments in water resource

projects. In 1957 Professor W. Folz concluded that such studies applied to comprehensive river basin studies, could be very useful in describing the expected pattern of growth of a region (Folz, p. 211).

A study on water was presented by Lofting and McGauhey (1963); they developed water use coefficients to be used in association with an input-output table representing the California economy. The model displayed the sectors of the economy which exercise demands for water, both directly and indirectly. Davis (1968) further expanded the above work. He developed a multiregional input-output model in an attempt to decide the economic interdependence between various Pacific and Mountain States and possible impacts of various water planning systems.

The suggestion for a general model to deal with the entire natural environment has also come recently. Most economists have been using partial equilibrium analysis to approach the examination of environmental quality. Solid waste, water and air pollution have been treated as separate problems. As Ayres and Kneese (1970) have stated, the partial equilibrium approach is both theoretically and empirically convenient, but it overlooks the possibility of important tradeoffs between the various forms in which residuals may be discharged back into the environment (Ayres and Kneese, pp. 284-285). A partial equilibrium approach may result in a reduction of certain types of environmental pollution but would increase the expense of the

other types (Laurent and Hite, 1971, p. 11). For example to quote:

> One can reduce water pollution by various types of treatment. However, in doing so, one creates sludge which must either be burned or buried. In this matter it is creating air pollution or solid waste for disposal. Therefore, comprehensive planning based on a series of partial equilibrium studies can be plagued by a "fallacy of composition" (Laurent and Hite, 1971, pp. 11-12).

In 1967 Rorham and associates (1967) studied and evaluated the economic impact of marine oriented activities on the Southern New England Maine Region. The study made extensive use of the input-output model to analyze the economic impact of commercial enterprises that depend upon the ocean environment for their business.

Fortunately, Boulding (1972), Ayres and Kneese (1970), and Isard (1969) have recognized the need for a general equilibrium economic model involving the environment to face with this problem. Kenneth Boulding, in his famous "Spaceship Earth" (1972) article first noted that man lives on earth in essentially a closed system (Boulding, 1972, p. 3-14). With the exception of energy from the sun and heat radiated out into space, there are no new inputs into or from man's ecosystem. Instead, there is a materials cycle which involves man removing basic raw materials from the environment, utilizing the services of these materials, and discharging the material substances of these materials back into the environment as waste.

Ayres and Kneese (1969) preceeded Boulding and took the logical step beyond Boulding's "Spaceship" presentation and conceived of

environmental pollution and its control as a materials balance problem for the entire economy (Ayres and Kneese, pp. 284-285). The essence of their discussion is that if man uses materials from the natural environment, he must return the residuals of those materials to the environment. The questions are how they shall be returned and in what form.

Closely paralleling the work of Ayres and Kneese, but somewhat different is the work of Professor Walter Isard (1967, p. 79-99). The basic idea is that man's economic system produces various exports into the environment. In turn, the ecologic system exports various products to economic system. It is through these exports and imports that the two systems (the economic and the ecologic) can be linked.

As briefly discussed above, Ayres and Kneese, Boulding and Isard have perceived the need for a general equilibrium model involving economics and the environment to surround this problem. The Leontief input-output system provides a base from which such a model can be built. Basically, the Leontief model divided the economy into exogenous and endogenous activities. The economy is broken into processing sectors, final demand, and a primary input sector. The decision as to what is classed as exogenous is based on one's preference and depends on the purpose of the study. For example, the model can be completely closed, as Boulding's "spaceship earth," or it can be very open. In a closed Leontief table, all elements are

endogenous; i.e., there are no imports and exports. If the table is very open, not only will exports and imports be excluded from the processing sector, but such semi-endogenous factors as households and government activities will be excluded (Laurent and Hite, pp. 11-13).

A general equilibrium approach would account for materials moving from the environment into the processing sector of the economy, changing form, and being deposited back into the environment. The ecologic system consists of a large number of interdependent activities involving as inputs and outputs of the many commodities utilized by the economic system. These commodities serve as inputs into the economic system and exports from the ecologic system (Isard, 1967, pp. 79-83). In other words, this materials flow can be seen as a special type of import-export activity or intersystem trading between economy and the environment. Laurent and Hite 1971) discussed this

> ...by including the environmental resources as just another element (source of inputs and receiver of output) within the framework of the Leontief general production model, the model can be expanded into a general model of economic-ecologic linkages (Laurent and Hite, 1971, p. 13)

Professor Walter Isard (1968) has developed such a model for analyzing the economic-ecologic linkup. The Isard model is a linear system utilizing the input-output model as its basic methodology (Isard, 1967), pp. 83-84). However, the inclusion of the natural system matrix adds a great degree of complexity. It is describing all of the

interrelated processes that take place within the ecosystem under consideration.[2] Though the disaggregation of environmental resources may be conceptually desirable, the Isard model requires vast amounts of quantitative environmental data. At the given state of understanding of the ecologic system, much of these data are not available. Moreover, in the Isard model, the relations described in the model are linear. Unfortunately, there are many ecologic relationships that do not show linearity.[3] The necessity to consider non-linear relationships outside the model restricts the model's capabilities as a tool for general equilibrium analysis. In this manner, the operational significance of the complete model will be minimal until the state of ecologic science improves.

In Figure 1[4] the Isard model of the economy is related directly

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[2]For example, in the Plymouth-Kington-Dixbury study, Isard found it necessary to attempt to quantify the various components of the chain food for winter flounder in order to develop inputs for commercial fisheries sector (Laurent and Hite, 1971, p. 14).

[3]Isard considered these non-linear process separately in Plymouth-Kington-Dixbury study. The quantities of white shrimp in any particular season are not directly related to the temperature as it takes a certain temperature range for them to exist at all (Isard, 1968, pp. 502-503).

[4]This section draws heavily on Roberts, 1973, pp. 41-48.

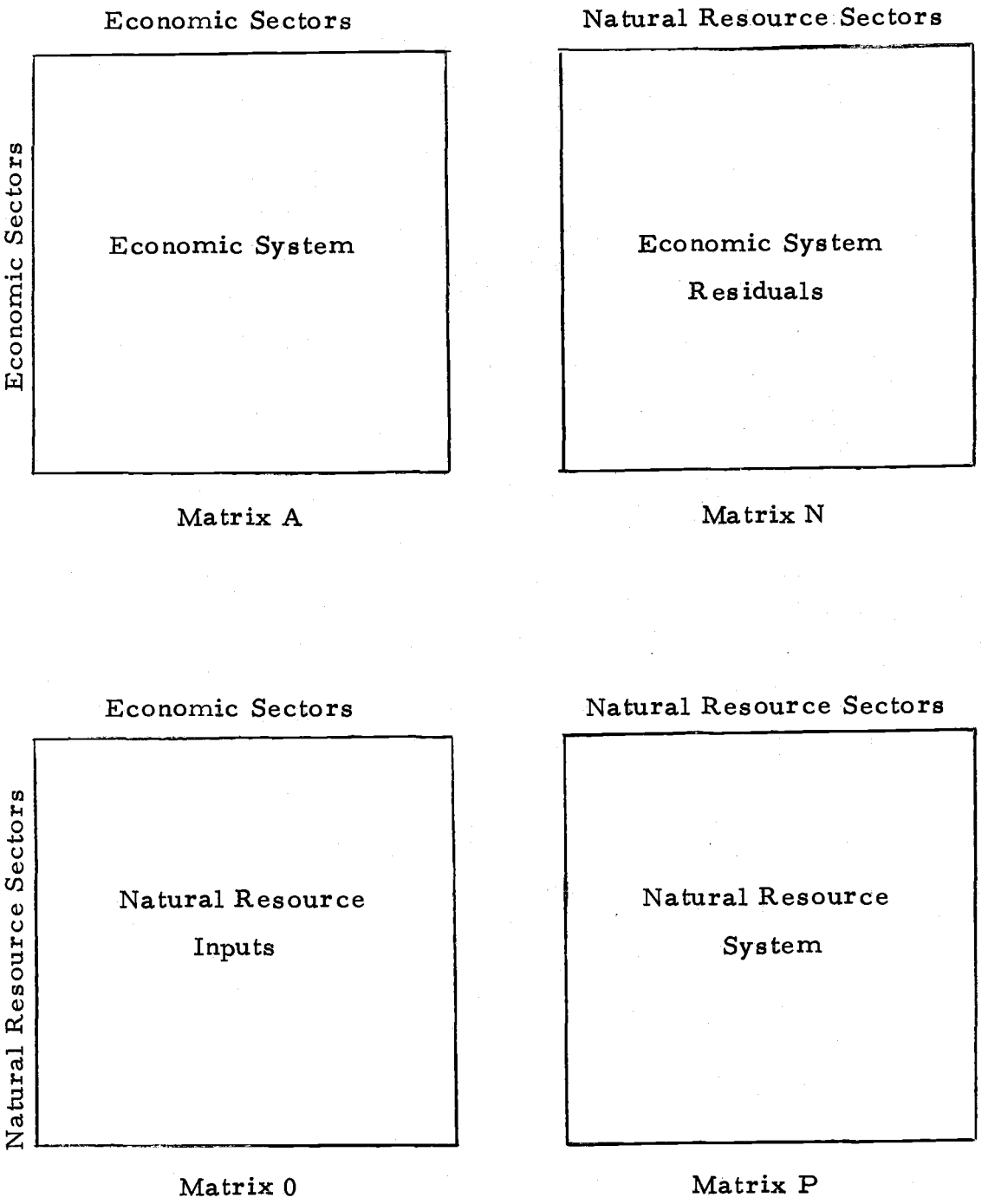

Figure 1. Hypothetical Matrix Representation of Economic and Natural Resource Systems.

to the natural resource base via input requirements (matrix 0) and emissions of non-market residuals (matrix N). The natural resource system is represented in conventional input-output format by matrix P. Entries in Matrix P are interpreted in the same manner (not the same units) as elements of a transaction table, A.

Laurent and Hite (1971) discussed some of the problems of the Isard model:

> ....many problems of the Isard model appear to stem from its all encompassing nature. Although ecologic inputs into the economic system can be viewed at many levels of aggregation (beach, hard march, soft march, etc.) the identification of economic-ecologic linkages does not require such a comprehensive model. The only ecologic processes of direct interest are involved in a state of affairs between the two systems. Consequently, a simplified version of the Isard model is adequate for empirical quantification of economic-ecologic linkages (Laurent and Hite, 1971, pp. 14-15).

Hite and Laurent (1971) and Roberts (1973) used an adaptation of the model in attempts 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.

Figure 2[5] represents a simplified version of these modified

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[5]This section draws heavily on Laurent and Hite, 1971, pp. 14-17.

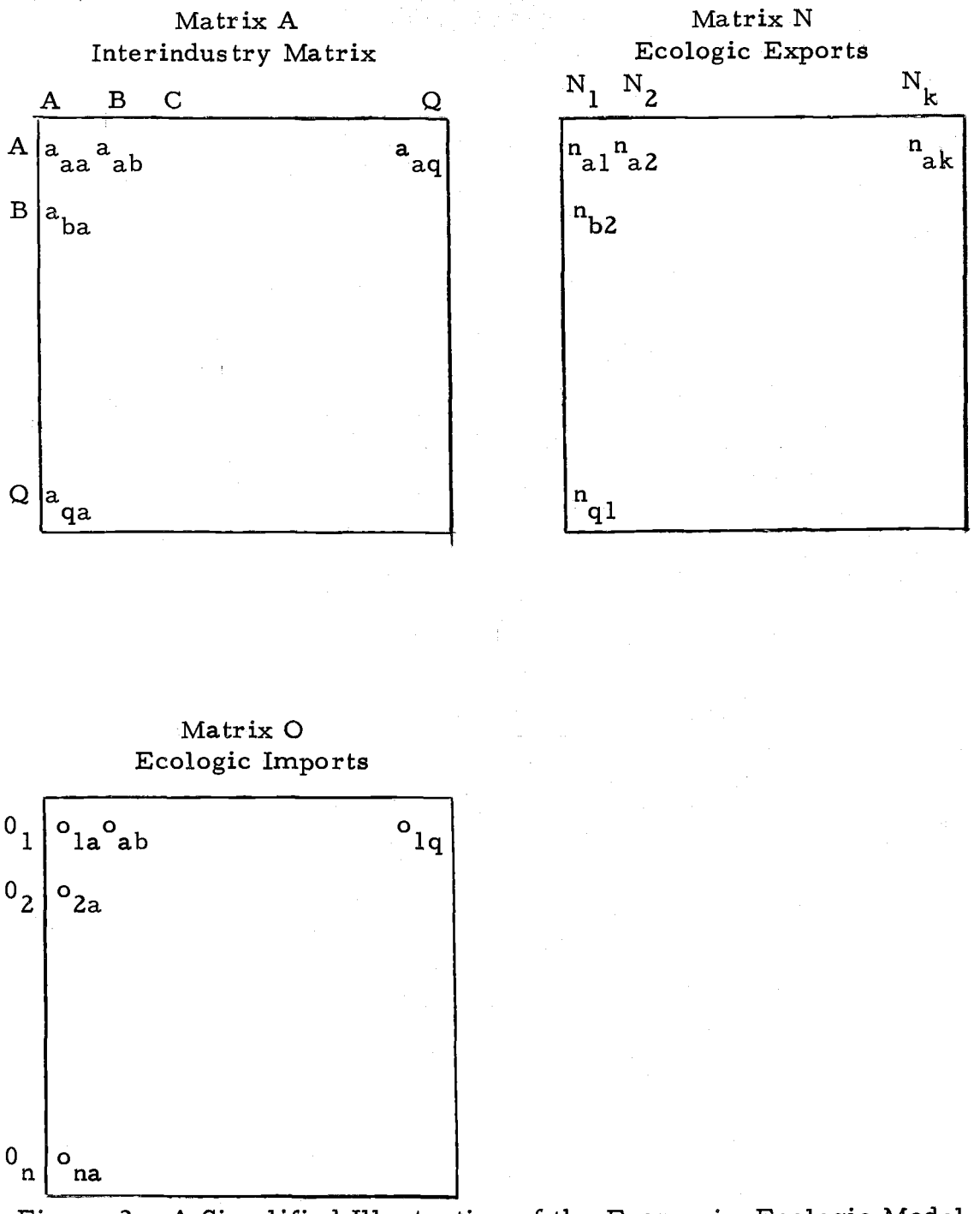

Figure 2. A Simplified Illustration of the Economic-Ecologic Model.

models. It assumes a linear system and constant coefficients. Matrix A is a standard economic inter-industry input-output matrix. Each cell contains the amount (measured in dollar values) of the output of the industries in each row required to produce one dollar's worth of gross output by the industry heading the column. Thus a_{qa} is the amount of output of A required to produce one dollar of gross output by Q; a_{qb} is the amount of output B required to produce one dollar of gross output of Q, etc. Below the matrix A is the 0 matrix. It shows the amount (in physical units) of various types of imports from the ecologic system required to produce one dollar of gross output by the industrial sectors in the matrix A. If 0_1 is the cooling water, then 0_{1a} is the amount of cooling water service required to produce one dollar of gross output by A, etc. Beside matrix A is the N matrix. The N matrix is similar to the matrix 0, except it shows exports to the environment from various industries in the A matrix. The matrix N is read in much the same way as the other two matrices. Thus if N_1 is the carbon monoxide, then N_{q1} is the amount of carbon monoxide associated with one dollar of gross output by sector Q, and so on.

The advantages of the input-output modified model are related to the size of the 0 and N matrix. One may have q number of industrial sectors in the A matrix, q number of environmental imports in the 0 matrix, and k number of environmental exports in the N matrix. These numbers are not expanded by the ecologic interprocess

matrix as proposed by Isard. In this manner, one can specify the economic-ecologic linkages at any level of aggregation desired.

Other important modifications have been made in the model by Hite and Laurent (1971) and Roberts (1973). Instead of constructing an N matrix which shows exports of pollutants and other materials into the environment from the economic system, one can consider such exports as negative imports. That is, the elements in the 0 matrix (representing such outputs as solid wastes, BOD, S_2O, etc.) are given a negative sign and included in the 0 matrix. The new matrix will be called the S matrix. Moreover, the modification suggested above does not eliminate the necessity of assuming constant coefficients (linear process). At the present time the modification makes the assumption easier to deal with.[6]

Conceptually the model is useful in this form as it fits within the Leontief system. The model, however, is not derived empirically in this manner as dollar values for environmental goods are difficult to obtain. Moreover, it is more useful to enter the environmental goods in a single matrix rather than two matrices. Therefore, the economic-ecologic linkages are actually quantified by

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[6]For example, it is more reasonable to assume that water use or BOD will vary proportionately with industrial output, instead of assuming that aquatic life will vary proportionately with BOD output (Laurent and Hite, 1971, pp. 28-30).

post-multiplying the environmental matrix by the inverse matrix of the input-output model.

S is the ecologic matrix and

$(1 - A)^{-1} = R^1$ is the inverse Leontief input-output matrix.

Then

$$S \times R^1 = Z$$

$$\begin{bmatrix} s_{11}s_{12} & s_{1q} \\ s_{21} & \\ & \\ s_{k1} & s_{kq} \end{bmatrix} \times \begin{bmatrix} r^1_{11}r^1_{12} & r^1_{1q} \\ r^1_{21} & \\ & \\ r^1_{q1} & r^1_{qq} \end{bmatrix} = \begin{bmatrix} z_{11}z_{12} & z_{1q} \\ z_{21} & \\ & \\ z_{k1} & z_{kq} \end{bmatrix}$$

S $\qquad$ R^1 $\qquad$ Z

Figure 3.[7] (Roberts, pp. 49-50). Hypothetic figures show post multiplying the environmental matrix by the inverse matrix of the input-output model.

S_{ij} represents the amount of ecologic import, i = 1, 2....k, required to produce one dollar of gross output by economic sector j, j = 1, 2.....q.

Each element of R^1 includes direct and indirect requirements per dollar of final demand.

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[7] This section draws heavily on Roberts, pp. 48-50.

Z_{ij} then represents the first, second, third, and subsequent round, environmental requirements per dollar of final demand in each sector.

Consider an example of a five sector economy, A, B, C, D, E, with four ecologic factors of interest, positive need for cooling water, and a negative index of CO, BOD, and solid waste. Assume the following coefficients for S and R^1.

$$S \qquad R^1 = Z$$

$$\begin{array}{c} \\ \text{Cooling} \\ \\ \\ \\ \end{array} \begin{array}{c} \begin{array}{ccccc} A & B & C & D & E \end{array} \\ \begin{bmatrix} -2 & -1 & -3 & -1 & -2 \\ 5 & 2 & 1 & 4 & 2 \\ -3 & -1 & -1 & -2 & -1 \\ -1 & -3 & -2 & -1 & -4 \end{bmatrix} \end{array} \begin{array}{c} \begin{array}{ccccc} A & B & C & D & E \end{array} \\ \begin{bmatrix} 1 & 3 & 2 & 0 & 1 \\ 2 & 3 & 1 & 4 & 2 \\ 5 & 2 & 1 & 0 & 1 \\ 0 & 3 & 2 & 1 & 0 \\ 3 & 2 & 1 & 0 & 1 \end{bmatrix} \end{array} = \begin{array}{c} \begin{array}{ccccc} A & B & C & D & E \end{array} \\ \begin{bmatrix} -25 & -22 & -12 & -5 & -9 \\ 20 & 39 & 23 & 12 & 12 \\ -13 & -22 & -13 & -6 & -7 \\ -29 & 27 & -13 & -13 & -13 \end{bmatrix} \end{array}$$

Figure 4. Hypothetic figures show economic-ecologic linkages.

These hypothetic figures show that for each dollar increase in output of final demand by sector A there is use of 20 gallons of cooling water, a release of 25 pounds of carbon monoxide, 13 pounds of BOD and 29 pounds of solid waste into the environment.

III. THE TILLAMOOK COUNTY ECONOMIC MODEL

The input-output model of Tillamook County was developed by Ives (1977). He conducted a business firm survey to acquire data to complete the Tillamook input-output model. The data were collected from a sample drawn from a list of all firms and agencies in the Tillamook County economy. Household data was not directly acquired, even though one sector of the model was households. These data were collected from businesses estimates of their sales to households.

About 130 different types of firms were found to exist in the county. The total number of the firms was slightly over 1200. Twenty-four sectors were defined for the model, 22 business sectors, one local household and one local government sector. The definition of sectors, in terms of types of businesses included, population sizes, sample sizes of all sectors and strata are presented in Appendix A.

Ives (1977) developed the model around data of purchases made by each sector, the sectors were defined as groups of firms with similar business or production processes. Moreover, some stratification by firm size was done to reduce the variance of the estimated total output and estimated sales to firms exogenous to the model.

Technical or Direct Coefficients

Table 1 of technical coefficients presents the direct purchases

Table 1. Estimated direct input coefficients and leakage coefficients for Tillamook County, Oregon, base year 1973.

	Sector	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	Silviculture	.00126	.00143	.18176	.04944	.00000	.00000	.00000	.00000
(2)	Logging & log hauling	.01263	.06902	.01806	.04604	.00000	.00000	.00000	.00000
(3)	Sawmills	.00002	.00000	.02052	.00011	.00000	.00000	.00000	.00000
(4)	Other wood processing	.00000	.00000	.00000	.00666	.00000	.00000	.00000	.00000
(5)	Commercial agriculture	.00000	.00000	.00000	.00001	.00000	.00000	.00000	.00000
(6)	Commercial fisherman	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.42574
(7)	Oyster aquaculture	.00000	.00000	.00000	.00000	.00000	.00000	.00569	.00467
(8)	Seafood processing	.00000	.00000	.00000	.00000	.00000	.01571	.00000	.01555
(9)	Formal tourist lodging	.00000	.00022	.00000	.00000	.00000	.00000	.00000	.00000
(10)	Informal tourist lodging	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
(11)	Sport fishing and marinas	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
(12)	Cafes and taverns	.00033	.00035	.00005	*	.00000	.00149	.00000	.00156
(13)	Service stations	.00018	.00682	.00159	.00442	.00793	.03307	.01501	.00467
(14)	Auto and farm implements	.00151	.01818	.00389	.00134	.04488	.02808	.00575	.00000
(15)	Manufacturers	.00000	.00098	.00038	.00000	.17320	.01098	.00000	.00109
(16)	Construction	.04550	.00002	.00094	.00070	.01719	.00894	.00000	.00669
(17)	Retail and wholesale sales	.00319	.05833	.02700	.00595	.11221	.11382	.03683	.00467
(18)	Transportation	.00057	.00084	.00052	.00042	.01939	.00000	.00000	.02955
(19)	Medical services	.00004	.00000	.00010	.00003	.00291	.00685	.00000	.00156
(20)	Other professional services	.00000	.00843	.00063	.00021	.02671	.00440	.01298	.01166
(21)	Financial services	.00000	.00703	*	.00003	.02609	.01457	.00000	.00311
(22)	Retail services	.00304	.01625	.02166	.00636	.04068	.01204	.05085	.01555
(23)	Local government	.11734	.00686	.00673	.00467	.02684	.01162	.02890	.00327
(24)	Households	.11444	.43833	.19161	.18577	.24681	.46834	.37494	.23521
(25)	Leakages	.69996	.36692	.43459	.68783	.25517	.27010	.46906	.23547
	Total direct purchase	.30005	.63308	.59541	.31217	.74483	.72990	.53094	.76453

Table 1. Continued.

	Sector	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1)	Silviculture	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00027
(2)	Logging and log hauling	.00000	.00000	.00061	.00000	.00000	.00000	.00000	.00000
(3)	Sawmills	.00000	.00000	.00030	.00000	.00000	.00000	.00000	.01348
(4)	Other wood processing	.00000	.00000	.00000	.00000	.00000	.00000	*	.00403
(5)	Commercial agriculture	.00000	.00000	.00000	.00274	.00000	.00000	.47271	.00000
(6)	Commercial fishermen	.00000	.00088	.00763	.00000	.00000	.00000	.00000	.00000
(7)	Oyster aquaculture	.00000	.00000	.00000	.00216	.00000	.00000	.00000	.00000
(8)	Seafood processing	.00000	.00709	.00429	.00968	.00000	.00000	.00000	.00000
(9)	Formal tourist lodging	.00000	.00000	.00000	.00000	.00000	.00000	.00001	.00000
(10)	Informal tourist lodging	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
(11)	Sport fishing and marinas	.00000	.00993	.00000	.00000	.00000	.00003	.00000	.00000
(12)	Cafes and taverns	.00000	.00138	.00345	.00000	.00000	.00052	.00005	.00097
(13)	Service stations	.00226	.01829	.01070	.00631	.00000	.00000	.00024	.00690
(14)	Auto and farm implements	.01669	.00078	.00567	.00274	.00258	.00158	.00057	.02808
(15)	Manufacturers	.00000	.00156	.02837	.01062	.00022	.00065	.00022	.00034
(16)	Construction	.03851	.11552	.03643	.00500	.00611	.00337	.00330	.24160
(17)	Retain and wholesale sales	.02589	.06582	.11695	.27162	.44724	.01711	.00980	.01748
(18)	Transportation	.00000	.00007	.00171	.00058	.00000	.00133	.00022	.00470
(19)	Medical services	.00000	.00000	.00000	.00023	.00000	.00030	.00008	.00162
(20)	Other professional services	.02314	.01184	.00730	.01341	.00571	.00099	.00118	.01452
(21)	Financial services	.02863	.04733	.00000	.00852	.00070	.00654	.00023	.00687
(22)	Retail services	.10416	.13894	.03497	.04118	.01587	.00498	.00389	.01645
(23)	Local government	.04276	.05443	.01493	.00680	.00287	.00202	.00378	.00405
(24)	Households	.26441	.22567	.37743	.41560	.17605	.14404	.14243	.28548
(25)	Leakages	.45355	.30045	.34926	.20281	.34268	.81656	.36130	.35315
	Total direct purchase	.54645	.69955	.65074	.79719	.65732	.18344	.63870	.64685

Table 1. Continued.

	Sector	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
(1)	Silviculture	.00000	.00000	.00000	.00000	.00000	.00000	.00061	.00002
(2)	Logging and log hauling	.00000	.00000	.00000	.00000	.00000	.00008	.00000	.00000
(3)	Sawmills	.00046	.00000	.00000	.00000	.00000	.00000	.00000	.00006
(4)	Other wood processing	.00000	.00000	.00000	.00000	.00000	.00000	.00003	.00028
(5)	Commercial agriculture	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00065
(6)	Commercial fishermen	.00000	.00000	.00000	.00000	.00000	.00000	.00000	*
(7)	Oyster aquaculture	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00010
(8)	Seafood processing	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00013
(9)	Formal tourist lodging	.00005	.01499	.00000	.00000	.00000	.00000	.00000	.00089
(10)	Informal tourist lodging	.00005	.00000	.00000	.00007	.00000	.00000	.00000	.00055
(11)	Sport fishing and marinas	.00041	.00000	.00000	.00000	.00000	.00115	.00000	.00081
(12)	Cafes and taverns	.00011	.00000	.00117	.00128	.00000	.00101	.00104	.04409
(13)	Service stations	.00320	.00450	.00467	.02160	.00000	.00763	.00153	.02752
(14)	Auto and farm implements	.00285	.01139	.00663	.00476	.00000	.00957	.00265	.11464
(15)	Manufacturers	.00003	.00000	.00067	.00000	.00000	.00050	.00387	.00444
(16)	Construction	.00286	.00000	.00894	.01136	.00000	.01529	.02081	.08450
(17)	Retail and wholesale sales	.08008	.00051	.01971	.02547	.02480	.04909	.05101	.19271
(18)	Transportation	.00298	.00000	.00054	.00000	.00000	.00021	.00067	.00034
(19)	Medical services	.00020	.00000	.01690	.00029	.00000	.00035	.00100	.03999
(20)	Other professional services	.00462	.00540	.02895	.01735	.00008	.01592	.00902	.01839
(21)	Financial services	.00309	.00139	.00318	.00000	.00000	.00650	.00162	.01063
(22)	Retail services	.01536	.01051	.03447	.03144	.01852	.03836	.02854	.08931
(23)	Local government	.00464	.06119	.00792	.00519	.00868	.03838	.02180	.03631
(24)	Households	.20755	.34779	.62889	.67348	.77073	.37292	.54458	.01942
(25)	Leakages	.67146	.54232	.23737	.20770	.17719	.44305	.31122	.31421
	Total direct purchases	.32854	.45768	.76263	.79230	.82281	.55695	.68878	.68579

* Non-zero values less than .000005.

of a given industry from each other industry for each dollar of output. A specific technical coefficient then represents the amount of goods and services required from one local industry to produce a unit of output in another local industry. Table 1 is the matrix of technical coefficients for the Tillamook County as estimated by Ives (1977).

The method of reading the table is simple. Each sector appears twice, as a producer of output and user of input. Reading down the Silviculture column, for each dollar of output by Silviculture direct purchases are made of 0.1 cents from itself, 1 cents from the logging and log hauling sector, 4 cents from the construction sector and so on. The total direct purchases inside Tillamook County are .30005. This is indicative of how much is bought locally by Silviculture sector to produce one dollar of output.

The sum of these technical coefficients for any one column must be equal to or less than one.

Interdependence Coefficients or Direct and Indirect Coefficients

Conceptually, there is an important distinction that must be made between the technical coefficients and interdependence coefficients with respect to sales. The technical coefficients refer to a change of one dollar in the production of output of the endogenous sector regardless of whether it goes to final demand or is used

locally. The interdependence coefficients refer to a dollar change in final demand only.

As illustrated in Table 1, the direct purchases are needed by a particular sector to produce one dollar of output. However, this does not represent the total additional output resulting from an increase in sales to final demand or sales outside of Tillamook County. There are also indirect effects from increases in export production, each sector benefiting from these direct sales require additional inputs from all its supplying sectors. In turn, they must increase production and purchase more from their supplying sectors.

Table 2 represents the matrix of direct and indirect coefficients or interdependence coefficients (Ives, 1977). Each coefficient in this table shows the sum of the direct and indirect requirements of the industry in a column for output from industries in the rows per dollar delivered to final demand. For example, reading down the first column, Silviculture sector purchases, directly or causes to be purchased indirectly, $1.002 from itself, 14 cents in logging and log hauling, 0.1 cent in the sawmill sector and so on, for each dollar of sales to the final demand.

Table 2 also allows one to compute the business output multipliers for Tillamook County. (The direct and indirect dollar contributions to the Tillamook County economy associated with one dollar increase in business output of each sector in the input-output

Table 2. Direct and indirect coefficients matrix for Tillamook County, Oregon, including output multipliers and direct household income.

	Sector	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)	Silviculture	1.00168	.00187	.18621	.05009	.00039	.00040	.00030	.00038
(2)	Logging and log hauling	.01378	1.07435	.12117	.05057	.00025	.00024	.00017	.00022
(3)	Sawmills	.00143	.00134	1.02195	.00076	.00155	.00165	.00115	.00155
(4)	Other wood processing	.00049	.00055	.00039	1.00696	.00058	.00064	.00047	.00061
(5)	Commercial agriculture	.00132	.00312	.00189	.00120	1.09147	.00852	.00226	.00567
(6)	Commercial fishermen	.00008	.00019	.00011	.00008	.00016	1.00705	.00016	.43562
(7)	Oyster aquaculture	.00006	.00014	.00009	.00006	.00012	.00023	1.00585	.00495
(8)	Seafood processing	.00018	.00042	.00026	.00019	.00035	.01653	.00036	1.02319
(9)	Formal tourist lodging	.00029	.00092	.00045	.00032	.00090	.00074	.00057	.00113
(10)	Informal tourist lodging	.00017	.00040	.00025	.00018	.00035	.00044	.00034	.00041
(11)	Sport fishing and marinas	.00032	.00080	.00050	.00035	.00075	.00088	.00072	.00081
(12)	Cafes and taverns	.01365	.03203	.01952	.01417	.02695	.03577	.02708	.03426
(13)	Service stations	.01024	.03007	.01653	.01485	.02934	.05822	.03494	.04268
(14)	Auto and farm implements	.03961	.10587	.05970	.04091	.12393	.12244	.07990	.10050
(15)	Manufacturers	.00232	.00545	.00329	.00200	.19251	.01677	.00379	.01082
(16)	Construction	.09845	.08514	.06524	.04193	.09986	.10461	.07406	.10057
(17)	Retail and wholesale sales	.08817	.25435	.15331	.09383	.30030	.34018	.20681	.25533
(18)	Transportation	.00160	.00260	.00184	.00120	.02304	.00268	.00143	.03205
(19)	Medical services	.01236	.02918	.01798	.01307	.02806	.03864	.02494	.03418
(20)	Other professional services	.01009	.02860	.01419	.00932	.04815	.02664	.03067	.03454
(21)	Financial services	.00513	.01837	.00764	.00514	.03860	.02691	.00942	.02070
(22)	Retail services	.03984	.09594	.07384	.04216	.11715	.09933	.12026	.10228
(23)	Local government	.13416	.04085	.05100	.02578	.06234	.04840	.05937	.04455
(24)	Households	.29433	.70934	.43293	.31668	.60034	.76674	.60531	.71685
	Output multipliers	1.76975	2.52187	2.25029	1.73181	2.78742	2.72465	2.29032	3.00387
	Direct Household Income	.11444	.43833	.19161	.18577	.24681	.46834	.37494	.23521

Table 2. Continued.

	Sector	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1)	Silviculture	.00044	.00079	.00052	.00039	.00026	.00012	.00029	.00421
(2)	Logging and log hauling	.00026	.00048	.00097	.00023	.00016	.00007	.00017	.00259
(3)	Sawmills	.00178	.00335	.00225	.00161	.00113	.00047	.00118	.01927
(4)	Other wood processing	.00065	.00112	.00071	.00060	.00036	.00019	.00045	.00582
(5)	Commercial agriculture	.00213	.00341	.01710	.01118	.00164	.00114	.51682	.00243
(6)	Commercial fisherman	.00015	.00424	.00973	.00441	.00011	.00006	.00013	.00016
(7)	Oyster aquaculture	.00011	.00016	.00016	.00237	.00008	.00005	.00010	.00012
(8)	Seafood processing	.00033	.00769	.00493	.01033	.00025	.00013	.00029	.00036
(9)	Formal tourist lodging	1.00053	.00060	.00066	.00073	.00043	.00023	.00063	.00066
(10)	Informal tourist lodging	.00031	1.00035	.00037	.00043	.00026	.00012	.00028	.00034
(11)	Sport fishing and marinas	.00073	.01080	1.00079	.00096	.00067	.00027	.00058	.00067
(12)	Cafes and taverns	.02488	.02932	.03267	1.03297	.01862	.01033	.02207	.02800
(13)	Service stations	.02152	.04091	.03290	.03137	1.01499	.00704	.02072	.02861
(14)	Auto and farm implements	.08654	.08213	.08788	.09409	.05484	1.02846	.08450	.11012
(15)	Manufacturers	.00361	.00620	.03510	.01664	.00279	.00204	1.09251	.00416
(16)	Construction	.12035	.23152	.12790	.09677	.05984	.03073	.07637	1.39088
(17)	Retail and wholesale sales	.18207	.25769	.30770	.49217	.59482	.07543	.20611	.18596
(18)	Transportation	.00158	.00270	.00414	.00350	.00236	.00186	.01159	.00759
(19)	Medical services	.02290	.02579	.02706	.03068	.01721	.00936	.02190	.02679
(20)	Other professional services	.04132	.03443	.02741	.03585	.01961	.00706	.02962	.03601
(21)	Financial services	.03809	.05896	.01119	.02089	.00851	.00989	.02161	.01831
(22)	Retail services	.17188	.21908	.11129	.12831	.06936	.02932	.08201	.08896
(23)	Local government	.07379	.09143	.04795	.04409	.02505	.01241	.04291	.03471
(24)	Households	.55263	.61676	.65226	.73680	.41560	.21998	.49167	.59804
	Output multipliers	2.34857	2.7989	2.54364	2.79736	2.30895	1.44676	2.72451	2.59478
	Direct Household Income	.26441	.22567	.37743	.41560	.17605	.14404	.14243	.28548

Table 2. Continued.

	Sector	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
(1)	Silviculture	.00026	.00029	.00047	.00050	.00049	.00038	.00109	.00061
(2)	Logging and log hauling	.00016	.00015	.00028	.00030	.00029	.00031	.00029	.00036
(3)	Lawmills	.00119	.00104	.00193	.00204	.00198	.00147	.00193	.00247
(4)	Other wood processing	.00028	.00044	.00079	.00082	.00083	.00057	.00079	.00105
(5)	Commercial agriculture	.00126	.00212	.00383	.00360	.00391	.00263	.00504	.00492
(6)	Commercial fishermen	.00009	.00014	.00025	.00026	.00028	.00018	.00022	.00036
(7)	Oyster aquaculture	.00007	.00011	.00020	.00020	.00022	.00013	.00017	.00028
(8)	Seafood processing	.00020	.00032	.00057	.00059	.00063	.00038	.00050	.00080
(9)	Formal tourist lodging	.00042	.01551	.00090	.00093	.00101	.00059	.00079	.00128
(10)	Informal tourist lodging	.00024	.00031	.00054	.00063	.00061	.00035	.00047	.00077
(11)	Sports fishing and marinas	.00083	.00060	.00106	.00110	.00117	.00188	.00093	.00143
(12)	Cafes and taverns	.01525	.02474	.04380	.04547	.04825	.02888	.03800	.06099
(13)	Service stations	.01437	.02217	.03566	.05339	.03400	.02819	.02826	.04265
(14)	Auto and farm implements	.04447	.07898	.12314	.12551	.13116	.08630	.10419	.16548
(15)	Manufacturers	.00212	.00359	.00653	.00599	.00651	.00453	.00930	.00816
(16)	Construction	.04482	.06835	.12640	.13343	.12859	.09637	.12699	.16165
(17)	Retail and wholesale sales	1.17658	.14840	.27084	.29305	.30296	.22183	.27097	.34680
(18)	Transportation	.00396	1.00121	.00264	.00221	.00227	.00181	.00272	.00274
(19)	Medical services	.01416	.02280	1.05646	.04103	.04449	.02604	.03511	.05625
(20)	Other professional services	.01444	.02124	.05600	1.04472	.02888	.03428	.03236	.03571
(21)	Financial services	.00847	.01016	.01758	.01488	1.01591	.01631	.01433	.01981
(22)	Retail services	.05418	.07392	.14034	.14034	.13526	1.10986	.12061	.14571
(23)	Local government	.02136	.08867	.05288	.05139	.05816	.06945	1.06127	.06115
(24)	Households	.33881	.55315	.95440	.99007	1.08269	.62243	.82740	.36948
	Output multipliers	1.75799	2.13842	2.89749	2.95242	3.03056	2.35514	2.68371	2.49090
	Direct Household Income	.20755	.34779	.62889	.67348	.77073	.37292	.54458	.01942

table.) The business output multipliers are calculated by summing each column in the inverse matrix. The multiplier values are given in the next to last row of Table 2.

The data in Table 2 are also called the Leontief inverse. It is the matrix designated in the previous chapter as the direct/indirect coefficient matrix $(I-A)^{-1}$. In essence, these data are the empirical heart of the model. They establish the necessary input which will be mated with the environmental matrix (developed in the next chapter) to estimate the total direct and indirect environmental impact of specific changes in the level of economic activity.

Table 3 illustrates the direct and indirect relationship between export sales and the total value of goods and services produced in the Tillamook County. Sector 15 (Manufacturers sector), for example, had external sales of $17,145,000 which generated directly and indirectly $46,712,000 of local economic activity ($17,145,000 times the multiplier 2.72451). The total figure accounts for approximately 15.98 percent of the total economic activity of the Tillamook County. That is, the manufacturers sector directly generates 5.86 percent ($17,145,000) of the economic activity, but indirectly supports an additional 10.11 percent ($29,567,000) of the total economic activity. A brief summary of the local economy by major export base of the Tillamook County economy in 1973 is given in Table 4. The Table shows the importance, in terms of the economic activity generated

Table 3. Economic sector output multipliers, exports, total output and contribution to the county economy, Tillamook County, 1973.

	Sector	Output Multipliers	Exports ($1,000)	Total Output ($1000)	% share of Total Output
(1)	Silviculture	1.76975	$16,228	$28,720	9.82
(2)	Logging and log hauling	2,52187	283	714	.24
(3)	Sawmills	2.25029	19,223	43,257	14.80
(4)	Other wood processing	1.73181	30,055	52,050	17.80
(5)	Commercial agriculture	2.78742	4,187	11,671	3.99
(6)	Commercial fisherman	2.72465	267	727	.25
(7)	Oyster aquaculture	2.29032	216	495	.17
(8)	Seafood processing	3.00387	1,274	3,827	1.31
(9)	Formal tourist lodging	2.34857	2,053	4,822	1.65
(10)	Informal tourist lodging	2.72989	377	1,029	.35
(11)	Sport fishing and marinas	2.54364	361	918	.31
(12)	Cafes and taverns	2.79736	1,714	4,795	1.64
(13)	Service stations	2.30895	1,961	4,528	1.55
(14)	Auto and farm implements	1.44676	2,024	2,928	1.00
(15)	Manufacturers	2.72451	17,145	46,712	15.98
(16)	Construction	2.59478	2,039	5,291	1.81
(17)	Retail and wholesale sales	1.75799	5,045	8,869	3.03
(18)	Transportation	2.13842	9	19	.01
(19)	Medical services	2.89749	355	1,029	.35
(20)	Other professional services	2.95242	146	431	.15
(21)	Financial services	3.03056	188	570	.19
(22)	Retail services	2.35514	1,022	2,407	.82
(23)	Local government	2.68371	2,273	6,100	2.09
(24)	Households	2.49090	24,272	60,459	20.68
	Total		132,777	292,369	100

Table 4. Major exporting sectors contributions to the county economy, Tillamook County, 1973.

	Sector	% of County Exports	Output Multiplier	Exports ($1,000)	Total Output ($1,000)	% share total Output
(1)	Silviculture	12.2	1.76975	$ 16,228	$ 28,720	9.82
(3)	Sawmills	14.5	2.25943	19,223	43,257	14.80
(4)	Other Wood Processing	22.6	1.73181	30,055	52,050	17.80
	Subtotal of Wood Products	49.3		65,506	124,027	42.42
(5)	Commercial Agriculture	3.2	2.78742	4,187	11,671	3.99
(15)	Manufacturing (largely Cheese)	12.9	2.72451	17,145	46,712	15.98
	Subtotal for Agriculture Products	16.1		21,332	58,383	19.97
(6)	Commercial Fisheries	0.2	2.72465	267	727	.25
(7)	Oyster Aquaculture	0.2	2.29032	216	495	.17
(8)	Seafood Processing	1.0	3.00387	1,274	3,827	1.31
	Subtotal of Marine Resources	1.4		1,757	5,049	1.73
	Recreation-Tourism	9.1*		12,118	26,860	9.19
	TOTAL	75.9		$100,713	$214,319	73.31

* Are aggregate figure from sectors 9, 10, 11, 12, 13, 16, 17, 18, 22.

through business output, of the various sectors. For example, wood products firms export 49. 3 percent of county exports and generate 42. 4 percent, by far the major portion, of the total economic activity in Tillamook County.

Household Income Multipliers

Conceptually, when the sales of an industry increases, the industry will also make a proportional increase in the amount of labor. The model does not allow for substitution of capital for labor. This increase is reflected through the household income multiplier. Termed by some writers as the interindustry income multiplier, it is the total increase in payments to all households per dollar increase in household payments from a given industry.

The income multipliers are listed in column 4, Table 5 for all 24 industry sectors of Tillamook County. Using Manufacturers as an example, the income multiplier implies that the total impact on county households' income would be an estimated increase of $3. 45 of total household income in the county per $1. 00 increase in wages and salaries paid directly by the manufacturing sector. The same method can be used for all 24 industries.

The Manufacturing sector with a $2, 440, 000 annual payroll would add more than this amount to the total Tillamook County households' income,

Table 5. Direct and indirect contributions to total household income by sectors, Tillamook County, 1973.

		Direct income change from Table 1, row 24 (1)	Direct and indirect income change from Table 2, row 24 (2)	Indirect and Indirect income change (column 2 - column 1) (3)	Income multiplier from Appendix * (4)	Exports ($1,000) (5)	Direct income (column 5 x column 1) ($1,000) (6)	Direct and indirect income (column 5 x column 4) ($1,000) (7)	% share of direct income (8)	% share of direct and indirect income Total annual income (9)
(1)	Silviculture	.11444	.29433	.17989	2.57192	16,288	1,864	4,794	8.66	8.83
(2)	Logging and hauling	.43833	.70934	.27101	1.61828	283	123	201	.57	.37
(3)	Sawmills	.19161	.43292	.24141	2.25943	19,223	3,685	8,327	17.11	15.35
(4)	Other wood processing	.18577	.31668	.13091	1.70469	30,055	5,583	9,518	25.92	17.54
(5)	Commercial agriculture	.24681	.60531	.35353	2.4320	4,187	1,033	2,513	4.80	4.63
(6)	Commercial fisherman	.46834	.76674	.29840	1.63714	267	125	207	.58	.38
(7)	Oyster aquaculture	.37494	.60531	.23037	1.61442	216	81	131	.38	.24
(8)	Seafood processing	.23521	.41685	.48163	3.04770	1,274	300	913	1.39	1.68
(9)	Formal tourist lodging	.26441	.55263	.28822	2.09005	2,053	543	1,135	2.52	2.09
(10)	Informal tourist lodging	.22567	.61676	.39109	2.73302	377	85	233	.39	.43
(11)	Sport fishing and marinas	.37743	.65226	.27483	1.72816	361	136	235	.63	.43
(12)	Cafes and taverns	.41560	.73680	.32120	1.77286	1,714	712	1,263	3.31	2.33
(13)	Service stations	.17605	.41560	.23953	2.36069	1,961	345	815	1.60	1.50
(14)	Auto and farm implements	.14404	.21998	.07544	1.52721	2,024	292	445	1.36	.82
(15)	Manufacturers	.14243	.49167	.34933	3.45201	17,145	2,440	8,424	11.33	15.52
(16)	Construction	.28548	.59804	.31256	2.09486	2,039	582	1,219	2.70	2.25
(17)	Retail and wholesale sales	.20755	.33881	.13126	1.63243	5,045	1,047	1,709	4.86	3.15
(18)	Tranportation	.34779	.55315	.20536	1.59047	9	3	5	.01	.01
(19)	Medical services	.62889	.95440	.32551	1.51759	355	233	339	1.04	.62
(20)	Other professional services	.67348	.99007	.31659	1.47088	146	98	145	.46	.27
(21)	Financial services	.77073	1.08269	.31196	1.40476	188	145	204	.67	.38
(22)	Retail services	.37292	.62243	.24951	1.66907	1,022	381	636	1.77	1.17
(23)	Local government	.54458	.82740	.28256	1.51934	2,273	1,238	1,881	5.75	3.47
(24)	Households	.01945	.36948	.35006	19.02572	24,272	472	8,973	2.19	16.54
	Total					132,777	21,546	54,264	100.0	100.0

* The income multipliers are calculated by performing a divide of the direct and indirect household-coefficients (Table 2, row 24) by the direct household-coefficients (Table 1, row 24).

$$3.45201 \ (\$2,440,000) = \$8,424,000$$

This is the estimated direct plus indirect income effect on all household income in Tillamook County.

As Miernyk (1965) mentioned, the greater the degree of interdependence within the economy, or conversely the lesser its dependence on imports, the greater will be direct income change. However, it does not follow that large direct income changes are associated with large multipliers. For example Finances services industry is quite labor intensive while Manufacturers industry is capital intensive. Table 5, column 1, shows a labor intensive industry (Financial services .77073) produces a larger direct income change than one which is capital intensive (Manufacturers .24681). But by the time direct and indirect changes are taken into account, these differences might be eliminated or reversed. Thus the income effects of the capital intensive industry (Manufacturers 3.45) are larger than those of the labor intensive industry (Finances service 1.40) as shown in Table 5. The reasons for this are fairly clear. An industry which uses a great deal of labor but not many other local inputs will generate fewer interactions with other industries than one which utilizes a considerable amount of locally acquired capital equipment and other factors of production. When an industry uses a great deal of local inputs expands its output, the chain reaction will spread this impact throughout many sectors of the economy.

IV. ECONOMIC-ECOLOGIC LINKAGES

In the previous chapter, the input-output matrix for Tillamook County was described. In this chapter, the discussion turns to the second part of the model, the environmental matrix.

The Interindustry Transaction Environmental Table

The Interindustry Transaction Environmental Table which has been constructed for the Tillamook County is shown in Table 6. There is one column for each of the 24 endogenous sectors of the input-output matrix. There are seventeen rows, each row represents either a natural resource input into the Tillamook County economy or an emission from the economy into the environment. The unit of measurement differs between them; however, the unit used is noted in each row.

Source of Data

The data used to construct the Interindustry Transaction Environment Table (Table 6) were obtained from a large number of sources. Unfortunately, the firm survey of Ives' in 1973 did not include questions concerning natural resource use or waste disposal. Later work by Ives (1977) dealt with solid waste in Tillamook County and provides one part of the information needed for the

Table 6. Transactions matrix showing ecologic linkages to Tillamook County economy, 1973.

Environmental Resources or Emissions	Silviculture	Logging and Log Hauling	Sawmills	Other Wood Processing	Commercial Agriculture	Commercial Fisherman	Oyster Aquaculture	Seafood Processing
Particulates (lbs)	- 65, 040	- 555, 360	- 322, 400	- 240, 600	- -7, 732			
Sulfur oxide (lbs)			-10, 800	- 334, 600	-4, 457			
Carbon monoxide (lbs)	-462, 460	-4, 162, 140	- 1, 729, 200	- 418, 000	-17, 018			
Nitrogen oxide (lbs)	- 14, 460	- 130, 140	- 209, 200	- 174, 600	-47, 899			
Total organic (lbs)	- 86, 720	- 780, 480	- 49, 800	- 22, 800	-10, 409			
Domestic water (gal)			1, 417, 500	2, 145, 000		411, 600	112, 500	262, 500
Cooling water (gal)			4, 266, 755	8, 999, 910			1, 286, 750	1, 973, 410
Processing water (gal)			8, 533, 320	3, 150, 150	109, 864, 990		1, 286, 750	34, 679, 090
Total water intake (gal)			14, 217, 575	14, 295, 060	109, 864, 990	411, 600	2, 686, 000	36, 915, 000
Water discharge (gal)			-11, 658, 409	-9, 719, 804	-93, 511, 620		-2, 283, 100	-29, 532, 500
Five day BOD (lbs)				-6, 442	-39, 278		-23, 230	-631, 196
Suspended solids (lbs)				-6, 442	-241, 188		-13, 659	-289, 224
Solid wastes (cu. yds)	- 28, 904	- 260, 138	-89, 768	-44, 122	-1, 130			-2, 469
Wood (ton)			121, 363	50, 467				
Desiel and oil (gal)			2, 310, 000	1, 350, 000	143, 000			
Gas (10^6 BTU)				126, 000				
Electricity (Kg watt hr)	45, 840	163, 200	6, 896, 000	1, 989, 000	783, 500	56, 100	51, 580	91, 680

Table 6. Continued.

Environmental Resources or Emissions	Formal Tourist Lodging	Informal Tourist Lodging	Sports Fishing and Marinas	Cafes and Taverns	Service Stations	Auto and Farm Implement	Manufacturers	Construction
Particulates (lbs)	-759			-20, 471	-206, 220		-4, 000	-71, 660
Sulfur oxide (lbs)	-6, 506			-175, 467	-53, 620		-1, 200	-7, 940
Carbon monoxide (lbs)	-132			-3, 557	-15, 075, 200		-1, 500	-814, 840
Nitrogen oxide (lbs)	-1, 980			-53, 400	-2, 074, 180		-52, 500	-93, 300
Total organic (lbs)	-132			-3, 557	-3, 060, 160		-1, 000	-48, 800
Domestic water (gal)	37, 445, 990	1, 795, 800	192, 000	74, 160, 010	1, 709, 990	5, 519, 670	750, 000	
Cooling water (gal)							31, 199, 940	
Processing water (gal)							64, 999, 980	
Total water intake (gal)	37, 445, 990	1, 795, 800	192, 000	74, 160, 000	1, 709, 990	5, 519, 670	96, 949, 920	
Water discharge (gal)	-29, 956, 800	-1, 436, 640	-163, 200	60, 811, 200	1, 282, 500	-4, 415, 730	-77, 559, 940	
Five day BOD (lbs)							-4, 103	
Suspended solids (lbs)							-5, 969	
Solid wastes (cu. yds)	-2, 696	-3, 412		-4, 049			-1, 429	
Wood (ton)								
Desiel and oil (gal)	33, 000			890, 000	13, 860, 000		500, 000	
Gas (10^6 BTU)							165, 316	414, 300
Electricity (Kg watt hr)	17, 476, 000	143, 250	91, 680	11, 404, 810	1, 009, 000	155, 800	21, 000, 000	481, 320

Table 6. Continued

Environmental Resources or Emissions	Retail and Wholesale	Transportation	Medical Services	Other Professional Services	Financial Services	Retail Services	Local Government	Households
Particulates (lbs)		-56, 180	-1, 012			-83, 800	-7, 407	-5, 220
Sulfur oxide (lbs)		-65, 400	-8, 675			-5, 200	-63, 484	-84, 100
Carbon monoxide (lbs)		-1, 383, 100	-176			-445, 800	-1, 287	-10, 420
Nitrogen oxide (lbs)		-703, 200	-2, 640			-31, 400	-19, 320	-37. 540
Total organic (lbs)		-284, 840	-176			-304, 800	-1, 287	-2, 080
Domestic water (gal)	17, 700, 000		8, 401, 100	1, 055, 990	5, 510, 560	13, 348, 130	17, 308, 470	591, 299, 620
Cooling water (gal)								
Processing water (gal)								
Total water intake (gal)	17, 700, 000		8, 401, 100	1, 055, 990	5, 510, 560	13, 348, 130	17, 308, 470	591, 299, 620
Water discharge (gal)			-6, 720, 010	-860, 620	-4, 518, 670	-11, 212, 490	-13, 846, 780	-473, 039, 530
Five day BOD (lbs)								
Suspended solids (lbs)								
Solid wastes (cu. yds)		-10						-21, 812
Wood (ton)								1, 067
Desiel and oil (gal)		1, 729, 000	44, 000				322, 000	2, 086, 000
Gas (10^6BTU)								
Electricity (Kg watt hr)	8, 160, 000	63, 030	6, 120, 000	1, 344, 600	153, 000	6, 985, 100	16, 960, 000	143, 401, 920

interindustry transaction environmental table.

However, the interindustry transaction environmental table has been done with assistance from various knowledgeable persons. Atmospheric emissions information was received from David W. St. Louis, supervisor of the Air and Noise Program, Salem-North Coast Region, Department of Environmental Quality, State of Oregon. Information data about non-market resource inputs and residuals of productive process of manufacturers, especially the Tillamook County Creamery Association, was provided by Roy Stein, plant superintendent. A major portion of the data on water use was developed by Sylvia L. Fisher, Office of the Manager, Tillamook Water Commission; Dennis Sheldow, City Recorder, Garibaldi; and a publication of the Department of Environmental Quality, "Oregon Administrative Rule," Chapter 340, Division 7, 1976. Liquid waste information data mainly came from Murray M. Tilson, Supervisor North Coast Branch, Department of Environmental Quality, State of Oregon, and Michael R. Soderquest, Environmental Associates, Inc., Corvallis, Oregon. Solid waste information data came mainly from Edward Ives, Department of Agricultural Resource and Economics, Oregon State University; Larry E. Watson, County Engineering Section, Tillamook County, and Robert O. McMahon, Associate Professor of Forest Products Economics, Oregon State University. Electricity use information was provided by Bruce

Stacy, power use advisor, Tillamook P. U. D.

A critical examination of Table 6 will reveal that there are little or no data in many sectors which one would expect to have important linkages to the environment. For example, commercial fishermen in Tillamook County surely produce some emission outputs into the environment, but it was not possible to obtain data for this and other sectors because no information from the firm survey is available nor were there published sources available. Because there are cases where blank cells exist that should have numbers that are presently not available, there will be a bias introduced into the estimates of the environmental impact of economic activities and this impact will be understated.

Underlying Assumptions

Since almost all of the interindustry transaction environmental data in Table 6 had to be computed from secondary data, it was necessary to make certain assumptions to perform the needed calculations. The most important of these, at least conceptually, is the assumption of linearity. Because of the nature of the input-output model, it is necessary to assume that the same amount of natural resource usage or environmental emission per dollar of gross output will occur at one dollar of gross output or one million dollars for each specific process. Certainly this assumption of linearity

relating to environmental linkages is not always realistic. For example, one would hardly expect miles of automobile use to increase proportionately with household incomes. Consequently, automobile exhaust emissions from private households will not be a linear function of gross household income. To minimize the problems arising from the assumption of linearity, the transactions related to private automobile emissions are much more likely to be linearly associated with gasoline sales than household income. In general, the convention was to charge a linkage to the sector where linearity was most likely to be realistic, rather than to the sector directly responsible for a specific emission (Laurent and Hite, pp. 57-60).

Other assumptions of a less general nature were also needed. Households were assumed to drive each automobile owned about 5,000 miles per year locally. Commercial truck transportation was allocated between local and long distance hauls based on information obtained from the Department of Transportation, State of Oregon.

The Environmental Matrix

The direct interaction of the natural and economic matrix is represented in Table 7. Rows indicate non-market resource inputs and residuals of productive processes that are taken from or returned to the environment. No restriction on the number of rows allocated

Table 7. Direct ecologic linkages to Tillamook County economy: resource inputs and waste outputs per dollar of gross output.

Environmental Resources or Emissions	Silviculture	Logging and Log Hauling	Sawmills	Other Wood Processing	Commercial Agriculture	Commercial Fisherman	Oyster Aquaculture	Seafood Processing
Particulates (lbs)	-.002728	-.138514	-.016713	-.007994	-.000602			
Sulfur oxide (lbs)			-.000560	-.011118	-.000347			
Carbon monoxide (lbs)	-.019398	-.984889	-.089642	-.013889	-.001326			
Nitrogen oxide (lbs)	-.000607	-.030795	-.010845	-.005801	-.003732			
Total organic (lbs)	-.003638	-.184685	-.002582	-.000758	-.000811			
Domestic water (gal)	.043886		.073484	.071272		.491756	.487013	.204122
Cooling water (gal)			.221190	.299040			5.570346	1.534533
Processing water (gal)			.442370	.104670	8.559130		5.570346	26.966633
Total water intake (gal)			.737044	.474982	8.559130	.491756	11.627705	28.705288
Water discharge (gal)			-.604376	-.322960	-7.285106		-9.883550	22.964619
Five day BOD (lbs)				-.000214	- .003060		-.057273	-.490821
Suspended solids (lbs)				-.000214	.018790		-.059130	-.224902
Solid wastes (cu. yds)	-.001212	-.061557	-.004654	-.001466	-.000088			-.001920
Wood (ton)			.006687	.001423				
Diesel and oil (gal)			.119751	.044856	.011141			
Gas (10^6 BTU)				.004187				
Electricity (Kg watt hr)	.01923	.038618	.357491	.066089	.061039	.067025	.223290	.071281

Table 7. Continued.

Environmental Resources or Emissions	Formal Tourist Lodging	Informal Tourist Lodging	Sports Fishing and Marinas	Cafe and Taverns	Service Stations	Auto and Farm Implement	Manufacturers	Construction
Particulates (lbs)	-.000350			-.003729	-.039130		-.000214	-.006192
Sulfur oxide (lbs)	-.002997			-.031967	-.010190		-.000064	-.000686
Carbon monoxide (lbs)	-.000061			-.000648	-2.864918		-.000080	-.070409
Nitrogen oxide (lbs)	-.000912			-.009729	-.394181		-.002815	-.008062
Total organic (lbs)	-.000061			-.000648	-.581558		-.000054	-.004217
Domestic water (gal)	17.248268	4.245390	.435474	13.510660	.324970	.445998	.040210	
Cooling water (gal)							1.672740	
Processing water (gal)							3.484880	
Total water intake (gal)	17.248268	4.245390	.435374	13,510660	.324970	.445998	5.197830	
Water discharge (gal)	13.798618	3.396313	.370068	11.078739	.243729	.356798	4.158264	
Five day BOD (lbs)							-.000220	
Suspended solids (lbs)							-.000320	
Solid wastes (cu. yds)	-.001242	-.008066		-.000077			-.000077	
Wood (ton)								
Diesel and oil (gal)	.015200			.162142	2.633979		.026807	.035799
Gas (10^6 BTU)							.008863	
Electricity (Kg watt hr)	8.049747	.338652	.207891	2.077610	.191752	.012589	1.125885	.041590

Table 7. Continued.

Environmental Resources or Emissions	Retail and Wholesale	Transportation	Mechanical Services	Other Professional Services	Financial Services	Retail Services	Local Government	Households
Particulates (lbs)		-.065536	-.000273			-.006412	-.000701	-.000063
Sulfur oxide (lbs)		-.075433	-.002336			-.000398	-.006005	-.001011
Carbon monoxide (lbs)		-1.595271	-.000047			-.034109	-.000122	-.000125
Nitrogen oxide (lbs)		-.811096	-.000711			-.002404	-.001827	-.000451
Total organic (lbs)		-.328535	-.000047			-.023321	-.000122	-.000025
Domestic water (gal)	.580918		2.262618	.351879	2.965856	1.021280	1.637199	7.108590
Cooling water (gal)								
Processing water (gal)								
Total water intake (gal)	.580918		2.262618	.351879	2.965856	1.021280	1.637199	7.108590
Water discharge (gal)			1.809860	.286778	2.432008	.857880	1.060584	5.686870
Five day BOD (lbs)								.116692
Suspended solids (lbs)								
Solid wastes (cu. yds)		-.000012						-.000262
Wood (ton)								.000013
Diesel and oil (gal)		1.994233	.011850				.030458	.025078
Gas (10^6 BTU)								
Electricity (Kg watt hr)	.267813	.072699	1.648262	.448051	.823466	.535238	1.604258	1.723974

to each process exists. The analysis can proceed regardless of the number of rows, unit 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.

Waste Treatment Possibilities

The environmental matrix, Table 7, and interindustry transaction environmental table, Table 6, are based on estimates of current intakes or discharges. One perhaps should have several different levels of treatment for different communities, but such data are difficult to obtain because in any given locale, such as Tillamook, there are considerable differences prevailing in the levels of treatment.

> ....the input model itself, and the assumption of static technology which it requires, also poses a problem to the incorporation of waste treatment possibilities into the environmental matrix. Each column in the input-output table indicates the current purchases of the firms in that sector, given the in-place technical processes. Even if it were practical to build environmental matrices for alternative levels of treatment, one would have difficulty in combining the two matrices to complete the model. That is, an input-output model based on current practices would require changes in purchasing patterns for each alternative level of treatment.... Ideally, one would desire various sets of input-output and environmental matrices based on alternative levels for each of the types of discharges. If such information were available, one could then use the technique of comparative statistics to analyze the economic activity, but also changing the level of treatment (Laurent and Hite, 1971, p. 60).

At present, these extensive data are not available. As a result, the next chapter is restricted to observation of changes in the level of various economic activities on pecuniary income and on the environment in Tillamook County.

V. THE ECONOMIC-ECOLOGIC MODEL AND ENVIRONMENTAL PLANNING

The two previous chapters report the utilization of an economic input-output model and described the building of an ecologic matrix for Tillamook County. This chapter is involved with mating the two matrices to complete the economic-ecologic model, and with describing the economic versus the ecologic impacts in the local community.

Direct and Indirect Environmental Linkages

Utilizing the inverse matrix of the input-output model (Table 2) and the environmental matrix (Table 7), both the direct and indirect environmental impacts of economic activity in Tillamook County may be estimated. These impacts are shown in Table 8. Table 8 was developed by post-multiplying the environmental matrix by the inverse matrix of the I-0 model. The result of this operation are measures of the direct and indirect changes in uses of environmental goods (ecologic imports from and economic exports to the ecologic system) from an increase of one dollar in the business output of the twenty-four sectors in the input-output model. It is these measures which indicate the impacts on Tillamook County due to goods and services exported, tax monies for the operation of local units of government from state and federal government agencies or in the form of

Table 8. Coefficients of direct and indirect environmental impacts per one dollar of business output, Tillamook County, 1973.

Environmental Resources or Emissions	Silviculture	Logging and Log Hauling	Sawmills	Other Wood Processing	Commercial Agriculture	Commercial Fisherman	Oyster Aquaculture	Seafood Processing
Particulates (lbs)	.006208	.151538	.036162	.016489	.004979	.004041	.002928	.005331
Sulfur oxide (lbs)	.001885	.002665	.002371	.012444	.004462	.00321	.002463	.005144
Carbon monoxide (lbs)	.073399	1.157973	.272082	.113737	.133790	.182365	.112084	.184494
Nitrogen oxide (lbs)	.007811	.048739	.024158	.015059	.036657	.027126	.016520	.044721
Total organic (lbs)	.014056	.219415	.037949	.020499	.028772	.037605	.023985	.038263
Domestic water (gal)	2.70620	5.99403	3.782272	2.733917	5.313139	7.076800	5.652942	6.54192
Cooling water (gal)	.004946	.011010	.232553	.305268	.323747	.552646	5.61022	.161832
Processing water (gal)	.025203	.058447	.487177	.128339	10.02381	.579239	5.64575	27.706549
Total water intake (gal)	2.69239	6.06340	4.493840	3.16532	15.66070	7.71129	16.90870	35.86470
Water discharge (gal)	2.08559	4.73704	3.53554	2.43102	12.86540	5.62109	14.01420	28.41058
Five day BOD (lbs)	.034442	.082999	.056576	.003727	.073618	.097634	.128425	.596157
Suspended solids (lbs)	.000070	.000163	.000100	.000284	.020656	.003897	.059990	.230520
Solid wastes (cu. yds)	.002150	.066337	.012598	.004739	.000297	.000266	.000200	.002184
Wood (ton)	.000014	.000019	.006840	.001442	.000019	.000021	.000016	.000020
Diesel and oil (gas)	.047789	.112396	.187881	.099524	.166022	.190186	.119500	.205830
Gas (10^6 BTU)	.000023	.000051	.000029	.004233	.001709	.000151	.000036	.000098
Electricity (Kg watt hr)	.857297	1.61747	1.379692	.774304	1.73830	1.82818	1.62264	1.73228

Table 8. Continued.

Environmental Resources or Emissions	Formal Tourist Lodging	Informal Tourist Lodging	Sport Fishing and Marinas	Cafe and Taverns	Service Stations	Auto and Farm Implements	Manufacturers	Construction
Particulates (lbs)	.003403	.004972	.003466	.006892	.040851	.000860	.003311	.011715
Sulfur oxide (lbs)	.005347	.003054	.002854	.034818	.011802	.000898	.002939	.003703
Carbon monoxide (lbs)	.079103	.146178	.114993	.107807	2.918546	.026462	.087198	.199593
Nitrogen oxide (lbs)	.012750	.021543	.018571	.026892	.403115	.004854	.023944	.029832
Total organic (lbs)	.017705	.030910	.023879	.023545	.592983	.005550	.018645	.027663
Domestic water (gal)	22.151152	9.865048	6.05917	19.9003	4.097843	2.316371	4.29212	5.08671
Cooling water (gal)	.007736	.024136	.067865	.057407	.0058	.004038	1.82885	.014196
Processing water (gal)	.040627	.260611	.403515	.446214	.031498	.020953	8.239765	.054892
Total water intake (gal)	22.2000	10.149802	6.530436	20.4039	4.13530	2.34136	14.360639	5.15561
Water discharge (gal)	17.6738	7.99725	5.10857	16.3732	3.01827	1.83994	11.6187	4.04247
Five day BOD (lbs)	.064662	.075651	.078601	.091224	.048269	.025744	.059344	.069980
Suspended solids (lbs)	.000121	.001805	.001451	.002679	.000093	.000054	.010131	.000137
Solid wastes (cu. yds)	.001419	.008297	.000263	.000032	.000013	.000067	.000081	.000426
Wood (ton)	.000019	.000032	.000024	.000021	.000013	.000006	.000015	.000145
Diesel and oil (ga	.100115	.145405	.124392	.281532	2.69498	.031182	.133146	.163929
Gas (10^6BTU)	.000035	.000060	.000314	.000150	.000026	.000019	.009685	.000061
Electricity (Kg watt hr)	9.420718	1.93751	1.746368	3.81075	1.24141	.503519	2.405014	1.400800

Table 8. Continued.

Environmental Resources or Emissions	Retail and Wholesale	Transportation	Mechanical Services	Other Professional Services	Financial Services	Retail Services	Local Government	Households
Particulates (lbs)	.001591	.067626	.003883	.004327	.003529	.009213	.003878	.004262
Sulfur oxide (lbs)	.001495	.077815	.005870	.003731	.003765	.002973	.009150	.004662
Carbon monoxide (lbs)	.052834	1.668402	.120764	.171331	.115367	.128879	.099099	.143754
Nitrogen oxide (lbs)	.009754	.822267	.019333	.025328	.017770	.016794	.017445	.022139
Total organic (lbs)	.011169	.343917	.025587	.035737	.024348	.043393	.020917	.029950
Domestic water (gal)	3.483976	4.973004	10.3115	8.64785	11.9726	6.37105	8.61915	11.3228
Cooling water (gal)	.004570	.007474	.013525	.012733	.013743	.009350	.017983	.017256
Processing water (gal)	.024521	.040512	.072828	.696870	.075342	.049879	.090711	.094737
Total water intake (gal)	3.51314	5.02228	10.3978	8.73024	12.0616	6.43027	8.72772	11.4347
Water discharge (gal)	2.26564	3.93776	8.19839	6.86034	9.57414	5.07883	6.60978	8.99666
Five day BOD (lbs)	.039644	.064720	.111678	.115847	.126677	.072836	.096821	.160231
Suspended solids (lbs)	.000074	.000120	.000214	.000214	.000230	.000144	.000220	.000291
Solid wastes (cu. yds)	.000110	.000197	.000289	.000301	.000325	.000197	.000256	.000410
Wood (ton)	.000013	.000015	.000026	.000026	.000028	.000019	.000025	.000036
Diesel and oil (gal)	.059387	2.07885	.1493406	.184550	.136472	.104426	.144649	.170988
Gas (10^6 BTU)	.000020	.000034	.000061	.000057	.000061	.000042	.000086	.000077
Electricity (Kg watt hr)	1.04300	1.49260	3.77970	2.618613	3.167217	1.99146	3.45979	2.92029

transfer payments to households.

One of the most important aspects of Table 8 is that there is an entry in every cell. Even those sectors which did not show direct ecologic linkages in Table 7, show linkages in Table 8. This results from the economic interdependence among sectors in the economy. A given sector's activities may have little or no direct effect on the environment; however, it must purchase inputs from other sectors, some of which do draw directly upon environmental resources. In this sense the given sector, by causing increases in the production of supplying sectors, may indirectly require use of environmental resources. Laurent and Hite (1971) gave a good example: the purchase and use of additional air conditioners due to increases in household income may appear to have no effect on the natural environment. However, through the use of additional electricity, this may result in increased levels of air or thermal pollution many miles away, where the electric energy is generated. Table 8 demonstrates that all economic sectors in Tillamook County have ecologic linkages and are responsible for some level of natural environmental resource usage.

Atmopsheric Emissions

Environmental impact through atmospheric emissions of particulates, sulfur dioxide, carbon monoxide, nitrogen oxides

and total organics appear to result from economic activity in most sectors of the Tillamook County economy (see Table 8). On the basis of the measures used in Table 8 the operations of the logging and log hauling sector result in the largest emission of particulates: .152 pounds of particulate matter per dollar delivery to final demand. Transportation and service stations deliveries to final demand account for .068 lbs. and .041 lbs., respectively. Among those sectors for which no direct particulate linkage could be estimated (see Table 7) seafood processing showed the largest indirect linkage.

Sulfur oxides emission accounted for the largest emission, .078 lbs. per dollar delivery to final demand resulting from the operations of transportation. Cafe and taverns, other wood processing and service stations deliveries to final demand account for .035 lbs., .0124 lbs., and .0118 lbs of sulfur oxides, respectively. Among those sectors for which no direct sulfur oxide linkage could be estimated (see Table 7) again seafood processing showed the largest indirect linkage.

Carbon monoxide emissions were allocated to only one sector, service stations. From an engineering viewpoint, transportation should also have a carbon monoxide link. Passenger cars, buses, and trucks annual mileage was estimated by the Department of Transportation, about 180 million miles totally traveled by passenger cars, buses and trucks around Tillamook County. About 0.87 percent

of truck ton miles or 9.3 million miles traveled and used about 1.73 million gallons of fuel by heavy trucks. Comparison with passenger cars which traveled around Tillamook County, including in county, in state and out of state, totaled about 129 million miles and consumed about 14 million gallons of fuel. Motor vehicle emissions were attributed to service stations and the transportation sector rather than households or other economic sectors. Service stations showed the largest emissions of carbon monoxide, 2.92 lbs. of carbon monoxide per dollar delivery to final demand. Transportation and logging and log hauling deliveries to final demand account for 1.67 lbs. and 1.16 lbs., respectively.

Nitrogen oxides emissions were largest from the operation of the transportation sector, 0.822 lbs. of nitrogen oxides matter per dollar delivery to final demand. Service stations and logging and log hauling accounted for .40 lbs. and .05 lbs. of nitrogen oxide respectively.

Total organic emissions were accounted for in a manner identical to carbon monoxide. Service stations and transportation were again demonstrated to be leading contributors to generation of atmospheric pollutants. Service stations and transportation were estimated to be responsible for .60 and .34 lbs., respectively per final demand dollar.

Water Directed Emissions

Public concern for the present and future quality of water resources is based on man's personal, industrial and frequently on the aesthetic needs of preserved aquatic life. Two specific residuals of productive processes biochemical oxygen demand (BOD) and suspended solids were used to account for water emissions as well as the quasi-residual water discharge.

BOD has on occasion been used to monitor changes in water quality. Although COD (chemical oxygen demand) and coliforms also play important roles in monitoring changes in water quality, BOD still remains a key target of scientific measurement and public concern. Direct and indirect linkages show, in Table 8, that seafood processing, is by far, the largest BOD loading sector, estimated at .59 lbs. per final demand dollars. At the time of the analysis, the seafood processing sector in the county was being monitored to determine the magnitude of certain residuals of concern to the Environmental Protection Agency, this information may assist a subsequent study.

Direct suspended solids linkages were developed for five sectors; other wood processing, commercial agriculture, oyster aquaculture, seafood processing, and manufacturing. The total residuals, in Table 8, reveal that seafood processing (.231 lbs.) is the major discharger of suspended solids per dollar of output.

Oyster aquaculture and commercial agriculture are ranked second (.061 lbs.) and third (.021 lbs.) respectively.

Water Inputs

Tillamook County economy includes sectors utilizing municipally and privately provided water inputs. Sectors such as commercial agriculture draw water from rainfall, rivers, as well as public water systems. The nature of productive processes such as seafood processing and manufacturing 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 obtaining the water, the available data permitted accounting for water inputs as domestic, cooling, or processing uses.

Domestic water is the first of water inputs listed in Table 8. Domestic water is used in drinking, washing, flushing and consuming in the household, commercial and industry. Formal tourist lodging used (22.2 gals.) and cafe and taverns (19.8 gals.) per dollar of business and rank at the top of domestic water using sectors. Financial service (12.0 gals.) and household (11.3 gals.) are the third and fourth ranked places, respectively.

Water use for industrial cooling was estimated to be directly linked to sawmills, other wood processing, oyster aquaculture,

seafood processing and manufacturing. Oyster aquaculture (5.61022 gals.) and manufacturing (1.8 gals.) rank at the top among cooling water users, after allowing for indirect use by all sectors. Among those sectors for which no direct water cooling users linkages could be estimated (see Table 6) commercial fishermen show the largest indirect linkage.

The processing water coefficients in Tables 7 and 8 are subject to becoming dated very rapidly. The speed of change in process water utilization will depend on industry initiated changes in technology and process changes imposed by water resource managers. Table 8 coefficients for processing water showed seafood processing (27.7 gals.), commercial agriculture (10.0 gals.) and manufacturers (8.2 gals.) per dollar of sales are the top ranking sectors.

Water intake coefficients were developed by summing up domestic, cooling and process water altogether. Seafood processing (35.8 gals.) and formal tourist lodging (22.2 gals.) were at the top of all sectors with regards to water intake.

Solid Waste

Solid waste or refuse can be considered to be anything in solid or semi-solid form which any individual, commercial operation, public body, or industry discards. All of this material must be either converted to some further use or disposed of.

Tillamook County generates approximately 8,000 to 10,000 tons of solid waste annually. This does not include some illegal roadside disposals. Several categories of special wastes such as discarded autos, tires, appliances, etc., pose problems because there is not a coordinated plan for their disposal. The recreation-tourism sector presents one of the greatest challenges for solid waste management problem during the peak load season in July and August.

Elements of Table 8 reveal the distribution of responsibility for generation of solid waste (cu. yds.) among all sectors depicted in Tillamook County. Logging and log hauling (.066 cu. yds.) rank first in solid waste generation; sawmills (.013 cu. yds.) and informal tourist lodging (.008 cu. yds.) are distant second and third generators respectively.

Energy

Darmstader has made an interesting observation about energy. To quote:

> Economic history attests to the critical role played by the consumption of inanimate energy in advancing the material well being of manking--both by providing an essential input into economic growth and by satisfying a wide range of wants made possible by the resultant increases in real income. The Industrial Revolution and the growth of industry in the nineteenth century are almost synonymous with the significant contribution of coal to development of the iron and steel industry, to railways, and to factory mechanization. In the twentieth century, electrification and motorized transport, while

> reshaping society in ways which we know produced also serious damaging effects, nonetheless served to support this historic process and, on balance, to step up tangible economic progress. And even as one ponders the potentially harmful environmental consequences of expanding levels of energy consumption in the years ahead, it is important to note that, quite apart from conventional applications, energy resources may in fact have to be increasingly deployed to deal with pressing environmental and other problems in the United States and around the world. For example, materials recycling and waste management, minerals extraction, water desalination (Ridher, ed. 1972, p. 107).

Energy resources on earth include tidal energy, nuclear energy, the heat of the earth's core and so on. In this research energy source concern is with wood, oil and diesel, gas, and electricity from hydroelectric power.

Woods and Residues

The United Nations (1971) reported that, in 1969, 43 percent of the wood cut was for fuel, and 34 percent of the world's round wood production was for sawlogs, veneer logs, and railroad ties. Much variation of roundwood use for fuel occurred among various counties. Corder (1973) reported the more industrial countries use less and the less industrial countries used more of their roundwood for fuel.[8] In 1952, the latest year for which we have complete

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[8] In 1969, Latin American countries used 85%, Africa, 89%, Mainland China, 77%, Western Europe, 20%, and the United States only 6%.

national statistics for roundwood and residues, the Forest Service (1958) reports that 25 percent of the timber output of the highly industrialized United States was used for fuel. The amount of wood used for fuel was greater than that for lumber.

However, the quantity of wood burned for fuel in this country has been decreasing continually since the late 1800's. Sixteen percent of the roundwood cut in 1952 was for fuel wood but, in 1969, it was only 6 percent. Reasons for the decrease are easy to find. Increasing value for other uses of roundwood and expanding uses of wood residues for pulp and board manufacture have been major reasons.

Corder (1973) reported that fuelwood consumption in the U.S. reached a peak of about 140 million cords in 1875 and has declined steadily to about 40 million cords in 1970. Fuelwood now accounts for about 1 percent of the national use of energy. Schurr (1960) reported that more than 90 percent of the 100 million cords of firewood consumed in 1850 was used domestically for heating and cooking, and about 75 percent of the total was burned in open fireplaces. An American family in the 1850's used about 18 cords of wood per year for home heating. As recently as 1940, 20 percent of occupied dwellings used wood fuel central heating or cooking, but this dropped to about 10 percent by 1950. A further decrease in domestic use of wood fuel has occurred since 1960. However, one domestic use of

wood fuel has not declined. Standford Research Institute (1954) reported 14 million cords of wood used in fireplaces in 1950 and projected use of 17 million cords in 1975.

Although coal and oil replaced wood for rail and water transportation in this country at about the turn of the century, wood fuel has continued to supply heat and power for many industrial, commercial, institutional, and utility operations. In Oregon, 32 forest industry operations generated electricity with wood and bark residues in 1942 and 21 in 1968, according to reports issued by the Federal Power Commission. Installed generating capacity of these plants was about 90 megawatts. Many more forest industry companies were using wood and bark residues to produce steam, mainly for drying lumber and veneer (Corder, 1973, p. 1).

Corder studied and reported on wood-bark residuals used as fuel.

> Most logs harvested in this country go into the manufacture of lumber, plywood or pulp. Less than half the volume of a log ends up as lumber or plywood; the rest is such items as bark, slabs, edgings, sawdust, shavings, veneer and plywood trim, cores, and sander dust. Although more of this residue, in recent years, has been used as a raw material for pulp and composition board manufacture, large amounts still are available for other uses, such as fuel. In Oregon, most of the raw material for pulp plants is obtained from wood residues of sawmills and plywood plants, but, in the eastern part of the country, much pulp is made from roundwood. Before processing, the bark normally is removed from the roundwood and remains as residue. A variety of uses can be made of these wood and bark residues. If a plant

> does not have sufficient uses and markets for residues, however, then it has disposal problems. Use as fuel could be a solution (1973), pp. 4-5).

The Tillamook County economy includes wood as an energy source as the fuel linkages were developed for three sectors: sawmills, other wood processing and households. Indirect linkages were shown to be numerous since all sectors have entries in the wood row. The total wood shown in Table 8 and rankings in Table 9 reveal that sawmills (.0064 dry ton) and other wood processing (.0017 dry ton) are major users of wood as fuel. Households, with direct use of wood in the fireplace, drop from the top ten after allowance for indirect use of wood is generated within the county.

Oil and Diesel

Oil accounted for one-third of U.S. energy use during and immediately after World War II, almost reaching a 45 percent share in 1960. Its subsequent percentage place has been one of relative stability. In this research electric utilities are treated as consuming sectors for oil and diesel and have been separated from utility sales to their customers. These sales largely represent secondary energy use based on the primary fuel (oil and diesel).

Oil and diesel use for fuel was estimated to be directly linked to sawmills, other wood processing, commercial agriculture, formal tourist lodging, cafe and taverns, service stations, manufacturers,

construction, transportation, medical service, local government, and households. Service stations (2.7 gals.) and transportation (2.1 gals.) retain top rank among oil and diesel users after allowance for indirect use by all sectors. Among those sectors for which no direct linkage could be estimated (see Table 6), seafood processing and commercial fishermen showed the largest indirect linkage.

Gas

During the past two decades, the use of natural gas has made the most rapid strides in expanded use among the basic energy sources. With an average annual growth rate of over seven percent, the natural gas share of overall energy consumption rose from around 14 percent after World War II to one-third by 1970.

Direct gas users data were developed for two sectors: other wood processing and manufacturers. Manufacturers ($.01010^6$ BTU) per dollar retains top rank among gas users after allowance for indirect use by all sectors.

Electricity

Historically, hydroelectric and steam electric plants have been the two principal sources of the nation's electric energy production. Hydroelectric share, scarcely ever above 4.5 percent of the nation's total energy consumption, rose during the first 50

years of the century, but has leveled off in the last two decades since the practical potential for developing new hydroelectric sites in the country is limited. Nevertheless hydroelectric capacity is expected to continue to be a major source of power supply in the Pacific Northwest. The power supply to Tillamook County from Bonneville Power Administration tended to increase year by year, for example it totaled 192,866,000 Kwh in 1967; 257,100,000 Kwh in 1973, and rose to 303,038,000 Kwh in 1976. However, average yearly Kwh use per family has not increased. The average yearly use per family was 20,112 Kwh in 1973 and leveled steadily till 1976 (20,190) Kwh) (Annual Report P. U. D. 1976).

On the basis of measures used in Table 7 the operations of formal tourist lodging sector resulted in the largest use of electricity: 9.4 Kwh of electric power per dollar delivery to final demand. Cafe and taverns and medical services deliveries to final demand account for 3.8 Kwh per dollar.

Table 9. Rankings (1 thru 10) of economic sectors direct and indirect relationship to selected environmental goods: Tillamook County, Oregon 1973.

Environmental Resource or Emission	1	2
Particulates (lbs)	Logging and Log Hauling .151538	Transportation .067625
Sulfur oxide (lbs)	Transportation .077815	Cafes and Taverns .034818
Carbon monoxide (lbs)	Service Stations 2.918546	Transportation 1.668404
Nitrogen oxide (lbs)	Transportation .822264	Service Stations .403114
Total organic (lbs)	Service Stations .592982	Transportation .343914
Domestic water (gal)	Formal tourist lodging 22.151152	Cafes and Taverns 19.828856
Cooling water (gal)	Oyster Aquaculture 5.61022	Manufacturers 1.828886
Processing water (gal)	Seafood processing 27.706549	Commercial Agriculture 10.023761
Total water intake (gal)	Seafood processing 35.8647	Formal tourist lodging 22.200076
Water discharge (gal)	Seafood processing 28.4105	Formal tourist lodging 17.6738
Five day BOD (lbs)	Seafood processing .586157	Household .160231
Suspended solids (lbs)	Seafood processing .230520	Oyster Aquaculture .059990
Solid wastes (cu. yds)	Logging and Log hauling .066337	Sawmills .012598
Wood (ton)	Sawmills .006436	Other wood processing .001697
Diesel and oil (gal)	Service stations 2.694970	Transportation 2.078538
Gas (10^6 BTU)	Manufacturers .009685	Other wood processing .004233
Electricity (Kg watt hr)	Formal tourist lodging 9.420718	Cafes and taverns 3.810687

Table 9. Continued.

Environmental Resource or Emission	3	4
Particulates (lbs)	Service stations .040851	Sawmills .036162
Sulfur oxide (lbs)	Other wood processing .012444	Service stations .011803
Carbon monoxide (lbs)	Logging and log hauling 1.157963	Sawmills .272047
Nitrogen oxide (lbs)	Logging and log hauling .048737	Seafood processing .044718
Total organic (lbs)	Logging and log hauling .219413	Retail services .042914
Domestic water (gal)	Finances services 11.972415	Households 11.322759
Cooling water (gal)	Seafood processing 1.616316	Commercial fisherman .552646
Processing water (gal)	Manufacturers 8.239765	Oyster Aquaculture 5.64575
Total water intake (gal)	Cafes and Taverns 20.4039	Oyster Aquaculture 16.9087
Water discharge (gal)	Cafes and Taverns 16.3732	Oyster Aquaculture 14.0142
Five day BOD (lbs)	Oyster Aquaculture .128425	Financial Services .126677
Suspended solids (lbs)	Commercial Agriculture .020656	Manufacturers .010137
Solid wastes (cu. yds)	Informal tourist lodging .008297	Other wood processing .004739
Wood (ton)	Construction .000139	Local government .000035
Diesel and oil (gal)	Cafes and Taverns .281545	Seafood processing .205811
Gas (10^6 BTU)	Commercial Agriculture .001709	Sport fishing and marinas .000314
Electricity (Kg watt hr)	Medical services 3.779660	Local government 3.459733

Table 9. Continued.

Environmental Resource or Emission	5	6
Particulates (lbs)	Other wood processing .016489	Construction .011715
Sulfur oxide (lbs)	Local government .009150	Medical services .005902
Carbon monoxide (lbs)	Construction .199581	Seafood processing .184472
Nitrogen oxide (lbs)	Commercial Agriculture .036651	Construction .029832
Total organic (lbs)	Seafood processing .038259	Sawmills .037942
Domestic water (gal)	Medical services 10.311236	Informal tourist lodging 9.865048
Cooling water (gal)	Commercial Agriculture .323747	Other wood processing .305268
Processing water (gal)	Other professional services .696787	Commercial fisherman .579239
Total water intake (gal)	Commercial Agriculture 15.6607	Service stations 14.360639
Water discharge (gal)	Commercial Agriculture 12.8657	Manufacturers 11.6187
Five day BOD (lbs)	Medical services .11678	Other Professional service .115847
Suspended solids (lbs)	Commercial fisherman .003897	Cafes and Taverns .002679
Solid wastes (cu. yds)	Seafood processing .0022184	Silviculture .002150
Wood (ton)	Informal tourist lodging .000031	Financial Services .000028
Diesel and oil (gal)	Commercial fisherman .190181	Sawmills .187846
Gas (10^6 BTU)	Commercial fisherman .000151	Cafes and Taverns .000150
Electricity (Kg watt hr)	Finances services 3.167167	Households 2.998425

Table 9. Continued.

Environmental Resource or Emission	7	8
Particulates (lbs)	Retail services .009213	Cafes and Taverns .006892
Sulfur oxide (lbs)	Formal tourist lodging .005344	Seafood processing .005149
Carbon monoxide (lbs)	Commercial fisherman .182365	Other professional services .171331
Nitrogen oxide (lbs)	Commercial fisherman .027124	Cafes and Taverns .026895
Total organic (lbs)	Commercial fisherman .037605	Other professional services .035740
Domestic water (gal)	Other professional services 8.647929	Local government 8.619021
Cooling water (gal)	Sawmills .232553	Sport fishing and marinas .067865
Processing water (gal)	Sawmills .487176	Cafes and Taverns .446222
Total water intake (gal)	Finances services 12.06156	Households 11.4347
Water discharge (gal)	Finances services 9.57414	Households 8.99666
Five day BOD (lbs)	Commercial Fisherman .097631	Local Government .096821
Suspended solids (lbs)	Informal tourist lodging .001805	Sport fishing and marinas .001451
Solid wastes (cu. yds)	Formal tourist lodging .001419	Construction .000426
Wood (ton)	Other professional services .000027	Medical services .000025
Diesel and oil (gal)	Other professional services .184561	Households .170988
Gas (10^6 BTU)	Seafood processing .000098	Local government .000086
Electricity (Kg watt hr)	Other professional services 2.608653	Manufacturers 2.405014

Table 9. Continued.

Environmental Resource or Emission	9	10
Particulates (lbs)	Silviculture .006208	Seafood processing .005331
Sulfur oxide (lbs)	Households .004567	Commercial Agriculture .004462
Carbon monoxide (lbs)	Informal tourist lodging .146202	Households .143742
Nitrogen oxide (lbs)	Other professional services .025330	Sawmills .024159
Total organic (lbs)	Informal tourist lodging .030915	Households .029948
Domestic water (gal)	Commercial fisherman 7.074219	Seafood processing 6.541610
Cooling water (gal)	Cafes and Taverns .057407	Local Government .017983
Processing water (gal)	Sport fishing and marinas .403515	Informal tourist lodging .260611
Total water intake (gal)	Medical services 10.39778	Informal tourist lodging 10.149802
Water discharge (gal)	Medical services 8.19839	Informal tourist lodging 7.99725
Five day BOD (lbs)	Cafe and Taverns .091224	Logging and log hauling .082999
Suspended solids (lbs)	Households .000292	Other wood processing .000285
Solid wastes (cu. yds)	Households .000410	Financial services .000325
Wood (ton)	Local government .000024	Sport fishing and marinas .000023
Diesel and oil (gal)	Commercial Agriculture .166005	Construction .163914
Gas (10^6 BTU)	Households .000077	16, 19, 21* .000061
Electricity (Kg watt hr)	Retail services 1.991423	Informal tourist lodging 1.937526

*16 = Construction, 19 = Medical services, 21 = Finances services

Environmental Impacts Per Dollar of a) Total Business Output b) Total Household Income

Input-output models provide a means of computing multipliers (business and household income multipliers)[11] for various sectors in the Tillamook County economy. The business output multipliers can be related to the elements of Table 8[12] for insight into the environmental impact per dollar of business output.

The elements of Table 8 can be related to the household row of Table 2 for insight into environmental impact per dollar of household income. Table 8 alone is inadequate to evaluate possible trade-offs among business and/or household income with environmental quality. Laurent and Hite (1971) stated that there is no reason to assume that the environmental impact and impact of economic growth in any sector will be proportional. However, EBOC (Table 10) and EHC (Table 11) will be helpful in evaluating possible

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[9] EBOC means the direct and indirect environmental impact per dollar of the direct and indirect sales of businesses in the economy. However, Roberts refers to EBOC as Environmental Income Multipliers (Roberts, 1973, p. 93).

[10] EHC means the direct and indirect environmental impact per dollar of the direct and indirect household income. However, Laurent and Hite refer to EHC as Environmental Income Multipliers (Laurent and Hite, 1971, p. 72).

[11] See method to compute output multipliers on page 29 and also see the method to compute household income multipliers on page 33.

[12] The estimate in Table 8 may be useful in assessing the environmental impact per dollar of final demand of various sectors of the Tillamook County economy.

Table 10. Coefficient of direct and indirect environmental impacts per dollar of business output, Tillamook County, Oregon, 1973.

Environmental Resources or Emissions	Silviculture	Logging and Log Hauling	Sawmills	Other Wood Processing	Commercial Agriculture	Commercial Fisherman	Oyster Aquaculture	Seafood Processing
Particulates (lbs)	.003507	.060089	.016070	.009521	.001787	.001483	.001278	.001775
Sulfur oxide (lbs)	.001065	.001056	.001054	.007186	.001601	.001183	.001076	.001712
Carbon monoxide (lbs)	.041464	.459168	.120894	.065673	.048003	.066932	.048939	.061411
Nitrogen oxide (lbs)	.004410	.019325	.010736	.008691	.013149	.009955	.007214	.014887
Total organic (lbs)	.007940	.087004	.016861	.011837	.010323	.013802	.010472	.012737
Domestic water (gal)	1.504290	2.376819	1.680792	1.578643	1.906171	2.597324	2.468189	2.177727
Cooling water (gal)	.002799	.004363	.103349	.176267	.116144	.202797	.244954	.538078
Processing water (gal)	.014270	.023178	.216539	.074106	3.696071	.212578	2.464961	9.223618
Total water intake (gal)	1.529142	2.404288	1.997005	1.827752	5.618278	2.830194	7.382776	11.939494
Water discharge (gal)	1.179466	1.974384	1.5711486	1.403745	4.615523	2.063050	6.188830	9.457965
Five day BOD (lbs)	.019461	.032911	.022677	.002152	.026411	.035832	.190637	.195134
Suspended solids (lbs)	.000040	.000065	.000044	.000165	.007410	.001430	.026153	.076741
Solid wastes (cu. yds)	.001220	.026313	.005587	.002742	.000106	.000106	.000086	.000734
Wood (ton)	.000008	.000007	.003039	.000980	.000007	.000008	.000007	.000007
Diesel and oil (gal)	.027003	.044566	.083476	.057465	.059555	.069800	.052177	.068515
Gas (10^6 BTU)	.000013	.000020	.000013	.002244	.000613	.000055	.000016	.000033
Electricity (Kg watt hr)	.484417	.641355	.613112	.447107	.623614	.670972	.708477	.576655

Table 10. Continued.

Environmental Resources or Emissions	Formal Tourist Lodging	Informal Tourist Lodging	Sport Fishing and Marinas	Cafe and Taverns	Service Stations	Auto and Farm Implements	Manufacturers	Construction
Particulates (lbs)	.001449	.001459	.001363	.002464	.017692	.000549	.001215	.004515
Sulfur oxide (lbs)	.002278	.001119	.001122	.012447	.005112	.000621	.001078	.001427
Carbon monoxide (lbs)	.033681	.053556	.045201	.038542	1.264014	.018285	.031993	.076913
Nitrogen oxide (lbs)	.005430	.007893	.007299	.009614	.174588	.003352	.008786	.011497
Total organic (lbs)	.007540	.011325	.009387	.008418	.256819	.003835	.006841	.010660
Domestic water (gal)	9.431761	3.613716	2.382045	7.113957	1.774765	1.601974	1.575373	1.960304
Cooling water (gal)	.003298	.008842	.026686	.020528	.002531	.002800	.671270	.005466
Processing water (gal)	.017484	.095483	.158665	.159515	.013636	.014432	3.024302	.021122
Total water intake (gal)	9.452593	3.718026	2.567359	7.293911	1.790936	1.618167	5.270907	1.986891
Water discharge (gal)	7.525345	2.929513	2.008369	5.453090	1.307204	1.271765	4.264510	1.557923
Five day BOD (lbs)	.027532	.027712	.039080	.032611	.021061	.017792	.021781	.026969
Suspended solids (lbs)	.000052	.000661	.000570	.000958	.000040	.000037	.003721	.000052
Solid wastes (cu. yds)	.000611	.003042	.000112	.000359	.000016	.000046	.000108	.000171
Wood (ton)	.000008	.000011	.000009	.000008	.000006	.000004	.000005	.000054
Diesel and oil (gal)	.042632	.053264	.042895	.100647	1.167184	.021544	.048858	.063171
Gas (10^6 BTU)	.000015	.000022	.000123	.000054	.000011	.000013	.003555	.000024
Electricity (Kg watt hr)	4.011257	.709745	1.470113	1.362244	.537615	.348000	.876939	.539839

Table 10. Continued.

Environmental Resources or Emissions	Retail and Wholesale	Transportation	Mechanical Services	Other Professional Services	Financial Services	Retail Services	Local Government	Households
Particulates (lbs)	.000904	.031624	.001340	.001466	.001164	.003912	.001445	.001711
Sulfur oxide (lbs)	.000850	.036389	.002037	.001264	.001243	.001262	.003409	.001871
Carbon monoxide (lbs)	.030046	.780204	.041670	.058031	.038066	.054711	.036932	.057707
Nitrogen oxide (lbs)	.005546	.384519	.006670	.008579	.005864	.007127	.006700	.008887
Total organic (lbs)	.006352	.160826	.008829	.012105	.008034	.018424	.007796	.012023
Domestic water (gal)	1.981795	2.326205	3.558679	2.929099	3.950562	2.705113	3.211607	4.545650
Cooling water (gal)	.002611	.003494	.004685	.004314	.004543	.003983	.006683	.006944
Processing water (gal)	.013943	.018944	.025134	.235976	.024857	.021178	.033800	.038033
Total water intake (gal)	1.998384	2.348592	3.588543	2.957018	3.979961	2.730299	3.252165	4.590685
Water discharge (gal)	1.288767	1.841434	2.829479	2.323632	3.159198	2.156487	2.462926	3.611810
Five day BOD (lbs)	.022550	.003026	.003843	.039240	.041799	.030926	.0360772	.064326
Suspended solids (lbs)	.000042	.000056	.000074	.000072	.000076	.000061	.000082	.000117
Solid wastes (cu. yds)	.000068	.000100	.000110	.000112	.000117	.000092	.000095	.000181
Wood (ton)	.000007	.000009	.000009	.000009	.000009	.000008	.000009	.000014
Diesel and oil (gal)	.033773	.972142	.051556	.062512	.045030	.044323	.053896	.068645
Gas (10^6 BTU)	.000011	.000016	.000021	.000019	.000020	.000018	.000032	.000031
Electricity (Kg watt hr)	.593231	.698005	1.304460	.886936	1.045076	.845565	1.289161	1.172383

Table 11. Coefficient of direct and indirect environmental impact per dollar of household income, Tillamook County, Oregon, 1973.

Environmental Resources or Emissions	Silviculture	Logging and Log Hauling	Sawmills	Other Wood Processing	Commercial Agriculture	Commercial Fisherman	Oyster Aquaculture	Seafood Processing
Particulates (lbs)	.02109	.21363	.08353	.05209	.00830	.00527	.00484	.00744
Sulfur oxide (lbs)	.00640	.00376	.00548	.03930	.00743	.00420	.00407	.00718
Carbon monoxide (lbs)	.24932	1.63245	.62839	.35914	.22288	.23784	.18517	.25734
Nitrogen oxide (lbs)	.02652	.06819	.05580	.04753	.06105	.03538	.02730	.06238
Total organic (lbs)	.04775	.30932	.08764	.06473	.04793	.04905	.03962	.05337
Domestic water (gal)	9.04501	8.44885	8.73644	8.62693	8.85048	9.22972	9.33892	9.12549
Cooling water (gal)	.01693	.01551	.53719	.96394	.53926	.72065	9.26827	2.25475
Processing water (gal)	.08581	.08240	1.12353	.40526	16.69681	.75541	9.32670	38.65041
Total water intake (gal)	9.19444	8.45015	10.38006	9.995326	26.08605	10.05724	27.93431	50.02309
Water discharge (gal)	7.085889	6.67881	8.16653	7.67659	21.43019	7.33115	23.15210	39.63242
Five day BOD (lbs)	.116943	.11700	.13068	.01176	.12262	.12733	.21516	.81768
Suspended solids (lbs)	.00024	.00023	.00023	.00090	.03441	.00508	.09896	.32157
Solid wastes (cu. yds)	.00734	.09355	.02904	.01500	.00050	.00038	.00033	.00308
Wood (ton)	.00006	.00003	.015799	.00536	.00003	.00003	.00003	.00003
Diesel and oil (gal)	.16237	.15844	.43399	.31426	.27652	.24804	.19742	.28710
Gas (10^6 BTU)	.00008	.00007	.00007	.01337	.00285	.00020	.00006	.00014
Electricity (Kg watt hr)	2.91270	2.28017	3.18686	2.44507	2.89548	2.38435	2.67796	2.41640

Table 11. Continued.

Environmental Resources or Emissions	Formal Tourist Lodging	Informal Tourist Lodging	Sport Fishing and Marinas	Cafe and Taverns	Service Stations	Auto and Farm Implements	Manufacturers	Construction
Particulates (lbs)	.00616	.00646	.00531	.00935	.09829	.00391	.00673	.01959
Sulfur oxide (lbs)	.00968	.00495	.00438	.04726	.02880	.00408	.00598	.00619
Carbon monoxide (lbs)	.14314	.23705	.17627	.14633	7.02249	.12026	.17728	.33373
Nitrogen oxide (lbs)	.02308	.03494	.02846	.03650	.96996	.02205	.04869	.04988
Total organic (lbs)	.03204	.05012	.03661	.03196	1.42681	.02523	.03791	.04625
Domestic water (gal)	40.08315	15.99495	9.28934	27.00909	9.86006	10.52901	8.72967	8.50538
Cooling water (gal)	.01402	.03914	.10407	.07794	.01406	.01842	3.71974	.02371
Processing water (gal)	.07430	.42262	.61875	.60562	.07576	.09491	16.75868	.09164
Total water intake (gal)	40.17168	16.45665	10.01201	27.69231	9.94991	10.64233	29.20788	8.62073
Water discharge (gal)	31.98125	12.96655	7.83210	22.22204	7.26244	8.36412	23.63109	6.75546
Five day BOD (lbs)	.11700	.12265	.12050	.12381	.11700	.11702	.12069	.11694
Suspended solids (lbs)	.00022	.00293	.00222	.00364	.00022	.00025	.02062	.00023
Solid wastes (cu. yds)	.00260	.01348	.00044	.00136	.00009	.00030	.00060	.00074
Wood (ton)	.00034	.00005	.00004	.00003	.00031	.00003	.00003	.00023
Diesel and oil (gal)	.18118	.23576	.19068	.38212	6.45453	.14169	.27074	.27409
Gas (10^6 BTU)	.00006	.00010	.00048	.00020	.00006	.00009	.01970	.00010
Electricity (Kg watt hr)	17.04706	3.14146	2.67741	5.17194	2.98683	2.28872	4.87152	2.34226

Table 11. Continued.

Environmental Resources or Emissions	Retail and Wholesale	Transportation	Mechanical Services	Other Professional Services	Financial Services	Retail Services	Local Government	Households
Particulates (lbs)	.00469	.12225	.00407	.00437	.00326	.01480	.00469	.00311
Sulfur oxide (lbs)	.00441	.14068	.00618	.00377	.00348	.00478	.01106	.00340
Carbon monoxide (lbs)	.15590	3.01619	.12651	.17305	.10655	.20702	.11979	.10496
Nitrogen oxide (lbs)	.02877	1.48651	.02025	.02558	.01641	.02697	.02173	.01616
Total organic (lbs)	.03296	.62174	.02680	.03610	.02249	.06971	.02529	.02187
Domestic water (gal)	10.28298	8.99287	10.80389	8.73466	11.05803	10.23455	10.41699	8.26793
Cooling water (gal)	.01355	.01351	.01422	.01286	.01272	.01507	.02168	.01263
Processing water (gal)	.07234	.07393	.07630	.70369	.06958	.08013	.10963	.06917
Total water intake (gal)	10.36905	9.07941	10.89456	8.81792	11.14032	10.33086	10.54855	8.34984
Water discharge (gal)	6.68705	7.11879	8.39009	6.92914	8.84291	8.15968	7.98861	6.56939
Five day BOD (lbs)	.11700	.71700	.11701	.11700	.117002	.11701	.11701	.117001
Suspended solids (lbs)	.00022	.00022	.00022	.00022	.00021	.00023	.00027	.00021
Solid wastes (cu. yds)	.00035	.00039	.00033	.00033	.00033	.00031	.00031	.00033
Wood (ton)	.00004	.00003	.00003	.00003	.00003	.00003	.00003	.00003
Diesel and oil (gal)	.17524	3.78980	.15654	.18641	.12604	.16771	.17482	.12486
Gas (10^6 BTU)	.00005	.00006	.00006	.00006	.00006	.00007	.00010	.00006
Electricity (Kg watt hr)	.07842	2.69841	3.96025	2.64487	2.72528	3.19943	4.18145	2.13240

tradeoffs between economic growth and encironmental quality.

In order to obtain the EBOC estimates in Table 10 it was necessary to perform a division of the elements in Table 8 by the respective output multipliers (Table 3, column I) (see Roberts, 1973, p. 93). Information in Table 10 can be interpreted as an estimate of the environmental impact of one dollar's change in the total business output arising for each sector. Similarly, to get the EHC estimates in Table 11, it was necessary to divide elements of Table 8 by the respective direct and indirect household coefficients (Table 2, row 24).[13] The information in Table 11 can be interpreted as estimates of the environmental impact of one dollar's change in household income arising in each sector of the Tillamook County economy.

From Table 10 silviculture was estimated to contribute .004 lbs. of particulates per dollor of additional business output generated, "logging and log hauling", .060 lbs., "sawmills" .016 lbs. and so on. Compared with Table 11 silviculture contributed .021 lbs., of particulates per dollar of household income generated, "logging and log hauling" .213 lbs., "sawmills" .084 lbs. and so on.

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[13] Laurent and Hite viewed EHC as Environmental Income Multipliers. The way they computed Environmental Income Multipliers by performing a division of Table 8 by income multipliers which derived from summation of each column of a value added matrix. The value added matrix was calculated by an appropriate value added coefficient (Laurent and Hite, 1971, p. 71).

Table 12 and Table 13 represent the ranking of major economic sectors which have relatively large direct and indirect relationships between environmental impacts and business output coefficients or household income coefficients. For example, service stations and transportation are the top ranking industry sectors for air emissions. Seafood processing is the leader among water usage and direct water emission. The purpose of ranking sectors on the basis of environmental impact business income coefficients and/or environmental impact household income coefficients is to provide a measure of economic returns to non-market resources used for stimulating local growth. Analysis and descriptive information on the structure of market and non-market activities for development purposes should result from this process.

From the analysis, it is clear that these tables (8 or 9, 10 or 12, 11 or 13) do not give the same ranking of input from major economic sectors for direct and indirect environmental impact for:

a) per dollar of exports

(Table 8 or 9)

b) per dollar of total business output

(Table 10 or 12)

c) per dollar of household income

(Table 11 or 13)

The reasons are: (1) coefficients of direct and indirect

Table 12. Economic sectors exhibiting relatively large environmental impact per dollar of business output, Tillamook County, Oregon, 1973.

Environmental Resource or Emission	1	2
Particulates (lbs)	Logging and log hauling .060089	Transportation . .031624
Sulfur oxide (lbs)	Transportation .036389	Cafes and Taverns .012447
Carbon monoxide (lbs)	Service Stations 1.264014	Transportation .780204
Nitrogen oxide (lbs)	Transportation .384519	Service Stations .174588
Total organic (lbs)	Service Stations .256819	Transportation .160826
Domestic water (gal)	Formal tourist lodging 9.431761	Cafes and Taverns 7.113975
Cooling water (gal)	Oyster Aquaculture 2.44969	Manufacturers .671270
Processing water (gal)	Seafood processing 9.223618	Commercial Agriculture 3.596071
Total water intake (gal)	Seafood processing 11.937978	Formal tourist lodging 9.452593
Water discharge (gal)	Seafood processing 9.457965	Formal tourist lodging 7.525345
Five day BOD (lbs)	Seafood processing .1951334	Oyster Aquaculture .190637
Suspended solids (lbs)	Seafood processing .1951337	Oyster Aquaculture .190637
Solid wastes (cu. yds)	Logging and log hauling .026313	Sawmills .005587
Wood (ton)	Sawmills .002860	Other wood processing .000980
Diesel and oil (gas)	Service Stations 1.167184	Transportation .971997
10^6 Gas (BTU)	Cafes and Taverns .035802	Manufacturers .003555
Electricity (Kg watt hr)	Formal tourist lodging 4.011257	Sport fishing and marinas 1.470113

Table 12. Continued.

Environmental Resource or Emission	3	4
Particulates (lbs)	Service Station .017692	Sawmills .016070
Sulfur oxide (lbs)	Other wood processing .007186	Service Station .005112
Carbon monoxide (lbs)	Logging and log hauling .459168	Sawmills .120894
Nitrogen oxide (lbs)	Logging and log hauling .019325	Seafood processing .014887
Total organic (lbs)	Logging and log hauling .087004	Retail services .018221
Domestic water (gal)	Households 4.545650	Finances services 3.950562
Cooling water (gal)	Seafood processing .538078	Commercial fisherman .202797
Processing water (gal)	Manufacturers 3.024302	Oyster Aquaculture 2.46505
Total water intake (gal)	Oyster Aquaculture 7.382776	Cafes and Taverns 7.293911
Water discharge (gal)	Oyster Aquaculture 6.118830	Cafes and Taverns 5.853090
Five day BOD (lbs)	Commercial fisherman .002993	Cafes and Taverns .001875
Suspended solids (lbs)	Household .064326	Financial services .041799
Solid wastes (cu. yds)	Informal tourist lodging .003046	Other wood processing .002742
Wood (ton)	Construction .000054	Households .000014
Diesel and oil (gas)	Cafes and Taverns .100647	Sawmills .083476
Gas (10^6BTU)	Other wood processing .002444	Commercial Agriculture .000613
Electricity (Kg watt hr)	Cafes and Taverns 1.362244	Medical services 1.304460

Table 12. Continued.

Environmental Resource Or Emission	5	6
Particulates (lbs)	Other wood processing .009521	Construction .004515
Sulfur oxide (lbs)	Local Government .003409	Formal tourist lodging .002278
Carbon monoxide (lbs)	Construction .076916	Commercial fisherman .066932
Nitrogen oxide (lbs)	Commercial Agriculture .013149	Construction .011497
Total organic (lbs)	Sawmills .016861	Commercial fisherman .013802
Domestic water (gal)	Informal tourist lodging 3.613716	Medical services 3.558679
Cooling water (gal)	Other wood processing .176267	Commercial Agriculture .116144
Processing water (gal)	Other professional services .235976	Sawmills .216539
Total water intake (gal)	Commercial Agriculture 5.618278	Manufacturers 5.270907
Water discharge (gal)	Commercial Agriculture 4.615523	Manufacturers 4.264510
Five day BOD (lbs)	Informal tourist lodging .001391	Commercial Agriculture .001278
Suspended solids (lbs)	Other Professional services .039240	Sport fishing and marinas .039010
Solid wastes (cu. yds)	Silviculture .001220	Seafood processing .000734
Wood (ton)	Informal tourist lodging .000011	11, 19, 20, 23 * .000009
Diesel and oil (gas)	Commercial fisherman .069800	Households .068645
Gas (10^6 BTU)	Sport fishing and marinas .000123	Commercial fisherman .000055
Electricity (Kg watt hr)	Households 1.217239	Local government 1.203752

Table 12. Continued.

Environmental Resource or Emission	7	8
Particulates (lbs)	Retail services .003912	Silviculture .003507
Sulfur oxide (lbs)	Medical services .002037	Households .001833
Carbon monoxide (lbs)	Other wood processing .065673	Seafood processing .061411
Nitrogen oxide (lbs)	Sawmills .010736	Commercial fisherman .009955
Total organic (lbs)	Seafood processing .012737	Other professional services .012106
Domestic water (gal)	Local government 3.211607	Other professional services 2.929099
Cooling water (gal)	Sawmills .103349	Sport fishing and marinas .026686
Processing water (gal)	Commercial fisherman .212578	Cafes and Taverns .159515
Total water intake (gal)	Households 4.590685	Financial services 3.979061
Water discharge (gal)	Households 3.611811	Financial services 3.159178
Five day BOD (lbs)	Sport fishing and marinas .000979	Manufacturers .000723
Suspended solids (lbs)	Local Government .0360772	Medical Services .003843
Solid wastes (cu. yds)	Formal tourist lodging .000611	Cafes and Taverns .000359
Wood (ton)	1, 6, 9, 12, 22 * .000008	2, 5, 7, 8, 7, 17, 18 * .000007
Diesel and oil (gas)	Seafood processing .068515	Construction .063171
Gas (10^6 BTU)	Seafood processing .000033	Local government .000032
Electricity (Kg watt hr)	Financial services 1.045076	Other professional services .885564

Table 12. Continued.

Environmental Resource or Emission	9	10
Particulates (lbs)	Cafes and Taverns .002464	Commercial Agriculture .001787
Sulfur oxide (lbs)	Seafood processing .001712	Commercial Agriculture .001601
Carbon monoxide (lbs)	Other professional services .058031	Households .057707
Nitrogen oxide (lbs)	Cafes and Taverns .009614	Households .008887
Total organic (lbs)	Households .012023	Other wood processing .011837
Domestic water (gal)	Retail services 2.705113	Commercial fisherman 2.597332
Cooling water (gal)	Cafes and Taverns .020528	Informal tourist lodging .008842
Processing water (gal)	Sport fishing and marinas .158665	Informal tourist lodging .095483
Total water intake (gal)	Informal tourist lodging 3.719026	Transportation 3.588543
Water discharge (gal)	Informal tourist lodging 2.929513	Transportation 2.829478
Five day BOD (lbs)	Other wood processing .000182	Households .000171
Suspended solids (lbs)	Logging and log hauling .032911	Commercial fisherman .000165
Solid wastes (cu. yds)	Households .000181	Construction .000171
Wood (ton)	Service Stations .000006	Manufacturers .000005
Diesel and oil (gas)	Other professional services .062512	Commercial Agriculture .059555
Gas (10^6 BTU)	Households .000031	Construction .000024
Electricity (Kg watt hr)	Manufacturers .876939	Retail services .845565

* 1 = Silviculture, 2 = Logging and Log Hauling, 5 = Commercial Agriculture, 6 = Commercial fisherman, 7 = Oyster Aquaculture, 8 = Seafood processing, 9 = Formal tourist lodging, 12 = Cafes and Taverns, 17 = Retail and Wholesale sales, 18 = Transportation, 22 = Retail services.

Table 13. Economic sectors exhibiting relatively large environmental impact per dollar of income, Tillamook County, Oregon, 1973 (Ranking 1-10).

Environmental Resource or Emission	1	2
Particulates (lbs)	Logging and log hauling .21363	Transportation .12225
Sulfur oxide (lbs)	Transportation .14068	Cafes and Taverns .04726
Carbon monoxide (lbs)	Service Stations 7.03294	Transportation 3.01619
Nitrogen oxide (lbs)	Transportation 1.48651	Service Stations .96996
Total organic (lbs)	Service Stations 1.42681	Transportation .62174
Domestic water (gal)	Formal tourist lodging 40.08315	Cafes and Taverns 26.91213
Cooling water (gal)	Oyster Aquaculture 9.26827	Manufacturers 3.71974
Processing water (gal)	Seafood processing 38.65041	Manufacturers 16.75868
Total water intake (gal)	Seafood processing 50,02460	Formal tourist lodging 40.17168
Water discharge (gal)	Seafood processing 39.63240	Formal tourist lodging 31.981253
Five day BOD (lbs)	Seafood processing .817684	Oyster Aquaculture .2151640
Suspended solids (lbs)	Seafood processing .32157	Oyster Aquaculture .09846
Solid wastes (cu. yds)	Logging and log hauling .09355	Sawmills .02904
Wood (ton)	Sawmills .01487	Other wood processing .00536
Diesel and oil (gal)	Service Stations 6.48453	Transportation 3.75764
Gas (10^6 BTU)	Cafes and Taverns .13593	Other wood processing .01337
Electricity (Kg watt hr)	Formal tourist lodging 17.04706	Cafes and Taverns 5.17194

Table 13. Continued.

Environmental Resource Or Emission	3	4
Particulates (lbs)	Service Stations .09829	Sawmills .08353
Sulfur oxide (lbs)	Other wood processing .03930	Service Stations .02840
Carbon monoxide (lbs)	Logging and log hauling 1.63243	Sawmills .62839
Nitrogen oxide (lbs)	Logging and log hauling .06819	Seafood processing .06238
Total organic (lbs)	Logging and log hauling .30932	Sawmills .08764
Domestic water (gal)	Informal tourist lodging 15.99495	Financial services 11.05903
Cooling water (gal)	Seafood processing 2.25475	Other wood processing .96394
Processing water (gal)	Commercial Agriculture 16.69681	Sawmills 1.12553
Total water intake (gal)	Manufacturers 29.20788	Oyster Aquaculture 27.93431
Water discharge (gal)	Manufacturers 23.631094	Oyster Aquaculture 23.15210
Five day BOD (lbs)	Sawmills .13068	Commercial Fisherman .127331
Suspended solids (lbs)	Commercial Agriculture .03441	Manufacturers .02062
Solid wastes (cu. yds)	Other wood processing .01500	Other wood processing .002786
Wood (ton)	Formal tourist lodging .00034	Service Station .00031
Diesel and oil (gal)	Sawmills .43386	Cafes and Taverns .38212
Gas (10^6 BTU)	Manufacturer .01970	Commercial Agriculture .00285
Electricity (Kg watt hr)	Manufacturer 4.89152	Local government 4.18145

Table 13. Continued.

Environmental Resource or Emission	5	6
Particulates (lbs)	Other wood processing .05209	Silviculture .02109
Sulfur oxide (lbs)	Local government .01106	Formal tourist lodging .00968
Carbon monoxide (lbs)	Other wood processing .35914	Construction .33373
Nitrogen oxide (lbs)	Commercial Agriculture .06105	Sawmills .05580
Total organic (lbs)	Retail services .06893	Other wood processing .06473
Domestic water (gal)	Medical services 10.80389	Auto and Farm implements 10.52901
Cooling water (gal)	Commercial fisherman .72065	Commercial Agriculture .53926
Processing water (gal)	Oyster Aquaculture .93270	Commercial fisherman .75541
Total water intake (gal)	Cafe and Taverns 27.69231	Commercial fisherman 26.08605
Water discharge (gal)	Cafe and Taverns 22.22041	Commercial Agriculture 21.430190
Five day BOD (lbs)	Cafes and Taverns .123812	Informal tourist lodging .122659
Suspended solids (lbs)	Commercial fisherman .00508	Cafes and Taverns .00364
Solid wastes (cu. yds)	Cafes and Taverns .001511	Silviculture .00006
Wood (ton)	Construction .00023	Silviculture .000016
Diesel and oil (gal)	Other wood processing .31426	Seafood processing .28710
Gas (10^6BTU)	Sport fishing and marinas .00048	Commercial fisherman .00020
Electricity (Kg watt hr)	Medical services 3.96025	Retail services 3.19943

Table 13. Continued.

Environmental Resource or Emission	7	8
Particulates (lbs)	Construction .01959	Retail services .01410
Sulfur oxide (lbs)	Commercial Agriculture .00743	Seafood processing .00718
Carbon monoxide (lbs)	Seafood processing .25734	Silviculture .24932
Nitrogen oxide (lbs)	Construction .04988	Manufacturers .04869
Total organic (lbs)	Seafood processing .05337	Informal tourist lodging .05012
Domestic water (gal)	Local government 10.41699	Retail and wholesale services 10.21298
Cooling water (gal)	Sawmills .53719	Sports fishing and marinas .10407
Processing water (gal)	Other professional services .70369	Sport fishing and marinas .61875
Total water intake (gal)	Informal tourist lodging 16.45665	Financial services 11.14032
Water discharge (gal)	Informal tourist lodging 12.96655	Medical services 8.842919
Five day BOD (lbs)	Commercial Agriculture .122627	Manufacturers .120698
Suspended solids (lbs)	Informal tourist lodging .00293	Sports fishing and marinas .00222
Solid wastes (cu. yds)	Formal tourist lodging .00260	Cafes and Taverns .00136
Wood (ton)	Informal tourist lodging .00005	Sport fishing and marinas .000045
Diesel and oil (gal)	Commercial Agriculture .27652	Construction .27409
Gas (10^6BTU)	Seafood processing .000148	Retail services .000143
Electricity (Kg watt hr)	Sawmills 3.18686	Informal tourist lodging 3.14146

Table 13. Continued.

Environmental Resource or Emission	9	10
Particulates (lbs)	Cafes and Taverns .00935	Commercial Agriculture .002559
Sulfur oxide (lbs)	Silvaculture .00640	Construction .00619
Carbon monoxide (lbs)	Commercial fisherman .23784	Informal tourist lodging .23705
Nitrogen oxide (lbs)	Other wood processing .04753	Cafes and Taverns .03650
Total organix (lbs)	Commercial fisherman .04905	Commercial Agriculture .04793
Domestic water (gal)	Retail services 10.23455	Service Stations 9.86006
Cooling water (gal)	Cafes and Taverns .07794	Informal tourist lodging .011804
Processing water (gal)	Cafes and Taverns .60562	Informal tourist lodging .42262
Total water intake (gal)	Medical services 10.89456	Auto and farm implement 10.64233
Water discharge (gal)	Financial services 8.892919	Auto and farm implement 8.364124
Five day BOD (lbs)	Sport fishing and marinas .120506	Retail services .117019
Suspended solids (lbs)	Other wood processing .00090	Local government .00027
Solid wastes (cu. yds)	Construction .00074	Manufacturers .00060
Wood (ton)	Retail and wholesale sales .000041	Logging and log hauling .00003
Diesel and oil (gal)	Manufacturers .27074	Commercial fisherman .24804
Gas (10^6 BTU)	Informal tourist lodging .00010	Construction .00010
Electricity (Kg watt hr)	Retail and wholesale sales 3.078921	Service Stations 2.98683

environmental impact per dollar of final demand are different among sectors; and (2) output multipliers and direct and indirect household coefficients are different among sectors in the Tillamook County economy.

For example, Table 14 shows the different rank (1-10) of major economic sectors with regard to:

1. having relatively high water intake per dollar of exports,
2. having high water intake per dollar of business output,
3. having relatively high water intake per dollar of household income.

As the result, we perceive that there are different rank orders of environmental impact for major economic sectors. Cafe and taverns rank third in water intake per dollar of final demand, however, comparisons between per dollar of total sales and per dollar of household income that the relationship of water intake with respect to cafe and taverns rank 4 and 5, respectively.

Economic-Ecologic Model Use in Environmental Planning

Local communities who are concerned with the development of the community, can utilize the essential information of economic-ecologic model for assisting local decisions. They realize that business output and/or household income cannot be generated without use of some environmental goods. If an area, community or county is

Table 14. Three different ranking order (1-10) of major economic sectors relative to natural input (water intake) categories of direct and indirect environmental linkage coefficients, environmental impact business income coefficients, and environmental impact household income coefficients.

	Silviculture	Logging and log hauling	Sawmills	Other wood processing	Commercial Agriculture	Commercial fisherman	Oyster Aquaculture	Seafood processing	Formal tourist lodging	Informal tourist lodging	Sport fishing and marinas	Cafes and Taverns
	Rank Order											
	1	2	3	4	5	6	7	8	9	10	11	12
A	2.7	6.1	4.5	3.3	15.7 5	7.7	16.9 4	35.9 1	22.2 2	10.1 10	6.5	20.4 2
B	1.5	2.4	2.0	1.983	5.6 3	2.8	7.4 3	11.9 1	9.4 2	3.7 9	2.6	7.3 4
C	9.1	8.5	10.4	10.3	26.1	10.0 6	27.9 4	50.0 1	40.2 2	16.5 7	10.0	27.7 5

	Service Stations	Auto and farm implements	Manufacturers	Construction	Retail and Wholesale sales	Transportation	Medical Services	Other Profes-sional services	Financial services	Retail services	Local government	Households
	Rank Order											
	13	14	15	16	17	18	19	20	21	22	23	24
A	4.1 6	2.3	14.4	5.2	3.5	5.0	10.4 9	8.7	12.1 7	6.4	8.7	11.4 8
B	1.8	1.6	5.3 6	1.996	1.992	2.3 10	3.6	3.0	4.0 8	2.7	3.2	4.6 7
C	9.9	10.6 10	29.2 3	8.6	10.3	9.1	10.9 9	8.8	11.1 8	10.3	10.5	8.3

A refer to direct and indirect natural resource input (water intake) per dollar of direct and indirect of final demand (Table 8, column I).

B refer to direct and indirect natural resource input (water intake) per dollar of direct and indirect of sales (Table 10, column I).

C refer to direct and indirect natural resource input (water intake) per dollar of direct and indirect of household income (Table 11, column I).

to develop and grow, a decision as the proper level of tradeoffs between "business and/or household" income and environmental quality needs to be made.

Table 15 compares the direct and indirect ecologic linkages of selected sectors to the environmental business output coefficients (EBOC) and the environmental impact household income coefficients. In all cases, the direct and indirect ecologic linkages are larger than the EBOC but smaller than EHC. For example, Silviculture discharges .006 pounds of particulates per dollar of final demand, but .004 pounds per dollar of business income and .02 pounds per dollar of household income generated.

At the moment, one may raise the question "what kind of income, business and/or household, should one be concerned with and what tradeoffs should one be willing to make with environmental quality in making local economic decisions? It seems to be a dichotomous decision to make. Both business[14] and household[15] have been used in the past when making tradeoffs with environmental quality.

In a general sense, the model provides two alternatives for a

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[14]Robert (1973) used business income to compare in making tradeoffs with the environmental quality.

[15]Laurent and Hite (1971) used household income in order to tradeoff with the environmental quality.

Table 15. Comparison of direct and indirect environmental linkage coefficients of selected sectors with environmental business output coefficients and environmental impact households income coefficients, Tillamook County, 1973.

	Silviculture			Sawmills		
	(a)	(b)	(c)	(a)	(b)	(c)
Particulates	.006208	.003507	.02109	.036162	.016070	.08353
Sulfur oxide	.001885	.001065	.00640	.002371	.001054	.00548
Carbon monoxide	.073382	.041464	.24932	.272047	.120894	.62839
Nitrogen oxide	.007806	.004410	.02652	.024159	.010736	.05580
Total organic	.014053	.007940	.04775	.037942	.016861	.08764
Five day BOD	.000096	.000054	.00033	.000132	.000062	.00032
Suspended solid	.000076	.000040	.00024	.000100	.000044	.00023
Solid Waste	.002159	.001220	.00734	.012573	.005587	.02904
	Other Wood Processing			Commercial Agriculture		
	(a)	(b)	(c)	(a)	(b)	(c)
Particulates	.016499	.009521	.05209	.004982	.001786	.00830
Sulfur oxide	.012444	.007186	.03930	.004462	.001601	.007432
Carbon monoxide	.113734	.065673	.35914	.133804	.048003	.22288
Nitrogen oxide	.015051	.008691	.04753	.036651	.013149	.061050
Total organic	.020999	.011837	.06473	.028775	.010323	.047931
Five day BOD	.000316	.000182	.00100	.003561	.001278	.00593
Suspended solid	.000285	.000165	.00090	.020656	.007410	.03441
Solid waste	.004749	.002742	.01500	.000317	.000114	.00053

Table 15. Continued.

	Manufacturers			Commercial Fisheries		
	(a)	(b)	(c)	(a)	(b)	(c)
Particulates	.003311	.001215	.00673	.004041	.001483	.00527
Sulfur oxide	.002939	.001078	.00598	.003222	.001183	.00420
Carbon monoxide	.087165	.031993	.17728	.182365	.066932	.23784
Nitrogen oxide	.023937	.008786	.04869	.027124	.009955	.03538
Total organic	.018639	.006841	.03791	.037605	.013902	.04905
Five day BOD	.001970	.000723	.00401	.008156	.002993	.01064
Suspended solid	.010137	.003721	.02062	.003897	.001430	.00508
Solid waste	.000295	.000108	.00060	.000289	.000106	.00038
	Oyster Aquaculture			Seafood Processing		
	(a)	(b)	(c)	(a)	(b)	(c)
Particulates	.002928	.001278	.00484	.005331	.001775	.00744
Sulfur oxide	.002464	.001076	.00407	.005144	.001712	.00718
Carbon monoxide	.112086	.048939	18517	.184472	.061411	.25734
Nitrogen oxide	.016522	.007214	.02730	.044718	.014887	.06238
Total organic	.023985	.010472	.03962	.038259	.012737	.05337
Five day BOD	.057793	.025234	.09548	.502507	.167287	.70099
Suspended solid	.059601	.026023	.09846	.230520	.076741	.32157
Solid waste	.000200	.000087	.00039	.002206	.000734	.00308

Table 15. Continued.

	Formal Tourist Lodging			Informal Tourist Lodging		
	(a)	(b)	(c)	(a)	(b)	(c)
Particulates	.003403	.001449	.00618	.003992	.001459	.00646
Sulfur oxide	.005349	.002278	.00968	.003055	.001119	.00495
Carbon monoxide	.079103	.033681	.14314	.146202	.053556	.23705
Nitrogen oxide	.012753	.005730	.02308	.021547	.007898	.03494
Total organic	.017708	.007540	.03204	.030915	.011325	.05012
Five day BOD	.000176	.000075	.00032	.003796	.001391	.00615
Suspended solid	.000122	.000052	.00022	.001805	.000661	.00293
Solid waste	.001435	.000611	.00260	.008316	.003046	.01348

	Sport Fishing and Marinas			Cafe and Taverns		
	(a)	(b)	(c)	(a)	(b)	(c)
Particulates	.003466	.001363	.00531	.006892	.002464	.00938
Sulfur oxide	.002855	.001122	.00438	.034818	.012447	.04726
Carbon monoxide	.114974	.045201	.17627	.107817	.039542	.14633
Nitrogen oxide	.018566	.007299	.02846	.026895	.009614	.03650
Total organic	.023876	.009387	.03661	.023547	.008418	.03196
Five day BOD	.002489	.000979	.00382	.005244	.001875	.00712
Suspended solid	.001451	.000670	.00222	.002679	.000958	.00364
Solid waste	.000284	.000112	.00044	.001005	.000359	.00136

Table 15. Continued.

	Service Station			Construction		
	(a)	(b)	(c)	(a)	(b)	(c)
Particulates	.040851	.017692	.09829	.011715	.004515	.01959
Sulfur oxide	.011803	.005112	.02840	.003704	.001427	.00619
Carbon monoxide	2.918546	1.264014	7.02249	.199581	.076913	.33373
Nitrogen oxide	.403114	.174588	.96996	.029832	.011497	.04988
Total organic	.592982	.256819	1.42681	.027661	.010660	.04625
Five day BOD	.000133	.000058	.00032	.000193	.000074	.00032
Suspended solid	.000093	.000040	.00022	.000136	.000052	.00023
Solid waste	.000038	.000016	.00009	.000445	.000171	.00074

	Retail and Wholesale			Transportation		
	(a)	(b)	(c)	(a)	(b)	(c)
Particulates	.001590	.000904	.00469	.067625	.031624	.12225
Sulfur oxide	.001495	.000850	.00441	.077815	.036389	.14068
Carbon monoxide	.052820	.030046	.155901	1.668404	.780204	3.01619
Nitrogen oxide	.009749	.005546	.02877	.822264	.384519	1.48651
Total organic	.011167	.006352	.03296	.343914	.160826	.62174
Five day BOD	.000107	.000061	.00032	.000171	.000080	.00031
Suspended solid	.000074	.000042	.00022	.000120	.000056	.00022
Solid waste	.000119	.000069	.00035	.000213	.000100	.00039

Table 15. Continued.

	Retail Service			Local Government		
	(a)	(b)	(c)	(a)	(b)	(c)
Particulates	.009213	.003912	.01480	.003878	.001445	.00469
Sulfur oxide	.002973	.001262	.00478	.009150	.003409	.01106
Carbon monoxide	.128858	.054711	.20702	.099114	.036932	.11979
Nitrogen oxide	.016784	.007127	.02697	.017447	.006501	.02109
Total organic	.042914	.018221	.06895	.020921	.007796	.02529
Five day BOD	.000203	.000086	.00033	.000273	.000102	.00033
Suspended solid	.000144	.000061	.00023	.000220	.000082	.00027
Solid waste	.000216	.000092	.00035	.000218	.000081	.00026

	Households		
	(a)	(b)	(c)
Particulates	.004262	.001711	.00311
Sulfur oxide	.004567	.001833	.00333
Carbon monoxide	.143742	.057707	.10496
Nitrogen oxide	.022137	.008887	.01616
Total organic	.029998	.012023	.02187
Five day BOD	.000426	.000171	.00031
Suspended solid	.000292	.000117	.00021
Solid waste	.000450	.000181	.00033

(a) Direct and indirect ecologic linkages.

(b) Environmental impact business income coefficients (EBC).

(c) Environmental impact household income coefficients (EHC).

local committee making decisions concerned with development of the community. As an example, a community willing to sacrifice something in air quality for additional business output might encourage manufacturing or oyster aquaculture which have lower levels of air quality problems per dollar; while the second planning alternative might consider seeking additional household income which is increased most from retail and wholesale trade and/or oyster aquaculture which have relatively low levels of air problems per dollar of household income.

However, the previous analysis has been concerned only with air quality and eliminates the other elements of environmental quality, which also play important roles in tradeoffs between economic and environmental consideration in decision making of local counties planning for community. If a local committee attempting to encourage business and/or household income while maintaining a high level of environmental quality might usefully trace through Table 15 for indications of the differing impacts of industries on Tillamook County.

However, for the purpose of demonstration, economic and environmental tradeoffs between two industry sectors (other wood processing, plywood mills; and seafood processing, salmon plant) is provided in Table 16. It is assumed that environmental quality, which included air quality (particulates), water quality (5 day BOD),

Table 16. Economic and environmental tradeoffs.

	Use in Emissions per Dollar of Total Output			
	Other Wood Processing (Plywood mill)		Seafood Processing (Salmon plant)	
Particulate (lbs./$)				
EBOC**	.009	(0)	.002	(1)
EHC**	.052	(0)	.007	(1)
5 Day BOD (lbs./$)				
EBOC	.002	(1)	.196	(0)
EHC	.012	(1)	.818	(0)
Solid wastes (Cu. Yd./$)				
EBOC	.0027	(0)	.0007	(1)
EHC	.015	(0)	.003	(1)
Water intake (Gal./$)				
EBOC	1.8	(1)	11.9	(0)
EHC	10.0	(1)	50.0	(0)
Electricity (Kwh./$)				
EBOC	.45	(1)	.58	(0)
EHC	2.442	(0)	2.416	(1)

*EBOC - The direct and indirect environmental impact business output coefficient.

**EHC - The direct and indirect environmental impact household income coefficient.

solid wastes, water intake and electricity, play an equal role of importance in decision making when choosing between the two industrial sectors. Criteria for selecting between the two sectors in this example might include concern with both business output and household income in relation to tradeoffs with environmental quality. For convenience in evaluation, we will put (1) for the industry sector having the least impact and (0) for the other. From Table 16, if we use business output tradeoffs with environmental quality, we will select other wood processing (plywood mills) in the environmental categories of 5 Day BOD (water quality), water intake and electricity. If household income is of higher interest in tradeoffs with environmental quality, we will select seafood processing (salmon plant) in categories of air quality (particulates), solid wastes, and electricity.

Ives's (1977) discussed the input-output model as used to estimate the impact of changes in local sector's export. His work showed the impact on the county economy of loss of a plywood mill which had exports of $14 million annually. Household income dropped by $4.4 million with a total economic loss of about $24 million. Moreover, he showed how the model could be used by Tillamook County for evaluation of the impact that a new plant on the local economy. He used two salmon aquaculture plants to demonstrate impact on the Tillamook County economy.

His work provides a tool which will aid people in the county in making decisions on issues which they find important. And the model can be used as long as the direct coefficients remain fairly constant.

However, the modified input-output (economic - ecologic model) from the present study, shows, in addition, the impact to the county in environmental terms. For example, the salmon aquaculture plants that could operate on Tillamook Bay are examined. Assume that the new plant has only minor local sales with about $536,000 of exports. By treating the entire output as export, and using direct and indirect ecologic linkage coefficients matrix it is possible to evaluate the impact of the new plant on the county in environmental terms. The total result of this new business activity is estimated to generate 2859 pounds of particulates, 275,589 pounds of 5 Day BOD, and 1,170 cubic yards of solid waste in the county and will consume 19,223,500 gallons of water and 928,503 kilowatt hours of electricity. These computations are easily carried out on a desk calculator, and they are shown in Table 17.

Moreover, the economic-ecologic model is still adequate to estimate the impact on the environmental quality of the county even though the proposed plant, such as salmon aquacultural development, does not fit in any of the industrial sectors currently in the county. The estimate of the impact on environmental quality can be done

Table 17. Impact of Environmental on Tillamook County of Addition of $536,000 of a Salmon Exports.

Environmental Resource or Emission (Unit of Measure)	Gain from addition on salmon exports (Dollars)	Coefficients from direct and indirect linkage (Table 8) (Impact per dollar)	Environmental impact
Particulates	$536,000	.005331	2,857 lbs.
Sulfur oxide	536,000	.005144	2,757 lbs.
Carbon monoxide	536,000	.184494	98,889 lbs.
Nitrogen oxide	536,000	.044721	23,970 lbs.
Total organic	536,000	.038262	20,509 lbs.
Domestic water	536,000	6.541920	3,506,470 gal.
Cooling water	536,000	1.616316	866,346 gal.
Processing water	536,000	27.706549	14,850,700 gal.
Total water intake	536,000	35.864700	19,223,500 gal.
Water discharge	536,000	28.410500	15,288,000 gal.
5 Day BOD	536,000	.586157	314,180 lbs.
Suspended solids	536,000	.230520	123,558 lbs.
Solid wastes	536,000	.002184	1,170 cu. yds.
Wood	536,000	.000020	11 tons
Diesel and oil	536,000	.205830	110,325 gal.
Gas	536,000	.000095	53 10^6 BTU
Electricity	536.000	1.732280	928,503 KWH

if we know the basic expenditure pattern of the proposed new plant. This basic expenditure pattern of the proposed new plant can be treated entirely as being exported. In this example, the basic expenditure of the proposed salmon aquaculture development is: purchasing from sawmills $1,000, other wood processing $1,000, cafe and taverns $3,000, service stations $3,000, auto and farm implements $9,000, construction $13,000, retail and wholesale sales $22,000, medical services $3,000, other professional services $2,000, financial services $1,000, retail services $7,000, local government $6,000, households $65,000. The result of this activity, for example, will generate 780 pounds particulates, 14,720 pounds of 5 Day BOD and 59 cubic yards of solid waste to the county and will consume 1,148,010 gallons of water intake, and 307,260 kilowatt hours of electricity. Again the computations can be carried out on a desk calculator by creating a table similar to Table 17 for each of the affected sectors and summing the environmental inputs across the table.

VI. SUMMARY

Air, water, and solid waste pollution are separate components of the overall interrelationship of economic and environmental concerns in Tillamook County, Oregon.

The general objective of this study is to develop a systematic evaluation of the interrelationships between issues of the environment and economic growth for Tillamook County. In order to gain some appreciation for the complexities between environment and economic development, specific objectives were established: 1) to identify relevant economic-ecologic linkages in Tillamook County and quantify these linkages for incorporation into the model (Chapter 4), 2) to develop environmental impact business output and household income coefficients (Chapter 5), and 3) to indicate the use of the economic-ecologic model in environmental planning (Chapter 5).

Fulfillment of the first objective required incorporation of environmental and pecuniary values into a single model. That required an economic-ecologic model with empirical content, which evolved from an input-output developed by Ives (1977). The second step necessitated building a seventeen by twenty-four environment matrix representing seventeen environmental use or pollutant loads and the utilization of these loads by the twenty-four economic sectors. The data in the environmental matrix was obtained from

both interview and secondary resources. The final step in completing economic-ecologic model was accomplished by multiplying the environmental matrix by the inverse matrix of the input-output matrix (Leontief inverse matrix). The interaction between the two systems is translated into exports to and the imports from the ecologic system by the economic system. One should realize that the estimation of the ecologic impacts of various economic activities, however, did not necessarily require qualification of the entire ecologic system but only the points where the economic and ecologic systems are directly linked.

To fulfill the second objective two manipulations were made on the data provided by the model. Estimates were developed of environmental impact business output coefficients (EBOC), and environmental household income coefficients (EHC). EBOC (Table 10) and EHC (Table 11) will be helpful in evaluating possible trade-offs between economic growth and environmental quality which can be used in environmental planning.

With the EBOC and EHC the third objective can be fulfilled, a community or a local committee concerned with environmental quality, can now determine which sector will result in the least environmental load per dollar of business and/or household income generated. This analysis permits the community to select one

among several alternatives in which one may wish to review various tradeoffs between business output and household income with environmental quality.

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APPENDICES

APPENDIX A

Sector and Strata Definitions for Tillamook County Input-Output Model

Sector No.	Strata No.	Sector Name/Strata Definition	Population Size	Sample Size
01		Silviculture: firms and government agencies engaged in the establishment, culture, and sale of standing timber		
	01	U. S. Forest Service, U. S. Bureau of Land Management, Oregon State Forestry Department, and divisions of private companies engaged in the establishment, culture and sale of standing timber in Tillamook County.	4	4
		Total	4	4
02		Logging and log hauling firms		
	01	Logging firms in Tillamook County which do their own log hauling	5	2
	02	Logging firms in Tillamook County which do not do their own hauling	12	4
	03	Log hauling firms in Tillamook County	15	2
		Total	32	8
03		Sawmills		
	01	Firms, or divisions of firms, which operate sawmills in Tillamook County requiring the purchase of timber	3	2
	02	Sawmills with their own timber supply in Tillamook County	1	1
		Total	4	3
04		Other wood processing firms		
	01	Plywood mills in Tillamook County	2	1
	02	Shake and shingle companies and other primary wood processing companies in Tillamook County	7	4
		Total	9	5
05		Commercial agricultural firms		
	01	Tillamook County dairy farms which sell their milk to firms located in Tillamook County	175	6
	02	Tillamook County dairy farms which sell their milk to firms not located in Tillamook County	74	6
	03	Fur farms in Tillamook County	8	2
		Total	257	14
06		Commercial fishermen		
	01	Licensed commercial fishermen who live and own boats in Tillamook County and derive primary income from fishing, crabbing, etc.	13	5
	02	Licensed commercial fishermen who live and own boats in Tillamook County and derive secondary income from fishing, etc.	36	3
		Total	49	8

Sector No.	Strata No.	Sector Name/Strata Definition	Population Size	Sample Size
07		Oyster aquaculture firms		
	01	Firms which raise oysters commercially in Tillamook County	3	3
		Total	3	3
08		Seafoos processors		
	01	Firms which process seafood in Tillamook County	4	2
		Total	4	2
09		Formal tourist lodging		
	01	Hotels and motels in Tillamook County	79	9
		Neskowin Lodge and Condominiums	1	1
		Total	80	10
10		Informal tourist lodging		
	01	Campgrounds in Tillamook County operated by agencies of the Federal, State, or County governments	4	4
	02	Private campgounds and trailer parks in Tillamook County	21	7
		Total	25	11
11		Sport fishing and marinas		
	01	Marinas and moorages in Tillamook County	9	5
	02	Charter fishing services in Tillamook County	7	2
		Total	16	7
12		Cafes and taverns		
	01	Bars and taverns in Tillamook County	20	4
	02	Fast food establishments in Tillamook County	10	4
	03	Restaurants and cafes in Tillamook County	44	7
		Total	74	15
13		Service stations		
	01	Gasoline stations in Tillamook County	45	5
		Total	45	5
14		Automobile and farm implement sales firms		
	01	New and used car, truck, and farm implement sales firms in Tillamook County	8	3
		Total	8	3
15		Manufacturing firms		
	01	Food manufacturers (Tillamook County Creamery Assn.)	1	1
	02	Iron works, machine shops, marine builders and repair companies, tipi makers, non-wood roofing materials manufacturers, and non-profit manufacturing by handicapped workers in Tillamook County	12	4
		Total	13	5

Sector No.	Strata No.		Population Size	Sample Size
16		Construction firms		
	01	Building contractors and developers in Tillamook County	25	4
	02	Plumbing, heating, painting, roofing, electrical, and floor covering contractors, and cabinet makers in Tillamook County	28	3
	03	Excavating, paving, sand and gravel, landscaping, and forest road building companies in Tillamook County	18	3
	04	Building materials suppliers in Tillamook County	8	3
		Total	79	13
17		Retail and wholesales sales firms		
	01	Grocery stores, bakeries, pharmacies, retail liquor and wine stores, and gift shops in Tillamook County	70	10
	02	Hardware, sporting goods, appliance, auto parts and accessories, clothing, yardage, variety, music, catalogue, pet, office equipment and supply, book, carpet, paint, bicycle, gum, jewelry, and furniture stores, florists, nurseries, and printing shops in Tillamook County	89	11
	03	Art galleries, antique shops, 2nd hand stores, rock, candle, and ceramics shops in Tillamook County	20	5
	04	Wholesale suppliers of firms listed above, feed and seed, and other agricultural supply stores, loggers' and welders' supply stores, beer, wine and soft drink distributors, hotel and motel suppliers, and petroleum products and bottled gas distributors in Tillamook County	31	6
		Total	210	32
18		Transportation firms		
	01	Rail and motor transportation companies in Tillamook County	5	2
		Total	5	2
19		Medical services		
	01	Hospitals and nursing homes in Tillamook County	5	3
	02	Physicians, osteopaths, chiropractors, and dentists practicing in Tillamook County	26	3
		Total	31	6
20		Other professional services		
	01	Accountants, business and tax consultants, surveyors, lawyers, morticians, veterinarians, consulting engineers, dental laboratories, ambulance services, real estate and insurance agencies, and credit referral services in Tillamook County	66	6
		Total	66	6
21		Financial services		
	01	Banks, savings and loan associations, credit unions, and finance companies in Tillamook County	10	3
		Total	10	3

Sector No.	Strata No.	Sector Name/Strata Definition	Population Size	Sample Size
22		Retail services		
	01	Barber and beauty shops, cleaners, and recreation places in Tillamook County	42	8
	02	Auto and appliance repair shops, breeding services, private day care centers and kindergartens, janitorial services, auctions, towing services, pet grooming shops, septic tank cleaners, garbage collection services, dispatching companies, towing services, and photographers in Tillamook County	55	4
	03	Telephone and telegraph companies, newspapers, broadcasting companies, private grade schools and high schools, industrial parks, and electric utility companies in Tillamook County	13	6
	04	Public water systems in Tillamook County not operated by the incorporated cities of Tillamook, Bay City, Garibaldi, Rockaway, Wheeler, Nehalem, and Manzanita	33	3
	05	Churches in Tillamook County	34	3
		Total	177	24
23		Local Government		
	01	Tillamook County Government (excluding a county operated campground included in sector 10) th governments of the seven incorporated cities in Tillamook County, the seven school districts in Tillamook County, assorted other small taxing authorities including sanitary districts, rural fire protection districts special districts, and port authorities (exclusing the airport industrial park of the Port of Tillamook Bay which is included in sector 22)	16[1]	15[1]
		Total	16	15
24	01	Households in Tillamook County	N/A	N/A

[1]The assorted small taxing authorities accounted for about 2% of the total local government sector. Rather than interview

APPENDIX B

Table 18. Output multipliers and income multipliers by sector for Tillamook County, Oregon, economy.

		Output Multiplier	Income Multiplier
1.	Silviculture	1.76975	2.57192
2.	Logging and log hauling	2.52187	1.61828
3.	Sawmills	2.25029	2.25943
4.	Other wood processing	1.73181	1.70469
5.	Commercial agriculture	2.78742	2.4320
6.	Commercial fisherman	2.72465	1.63714
7.	Oyster aquaculture	2.29032	1.61442
8.	Seafood processing	3.00387	3.04770
9.	Formal tourist lodging	2.34857	2.09005
10.	Informal tourist lodging	2.72989	2.73302
11.	Sport fishing and marinas	2.54364	1.72816
12.	Cafes and taverns	2.79736	1.77286
13.	Service stations	2.30895	2.36069
14.	Auto and farm implements	1.44676	1.52721
15.	Manufacturers	2.72451	3.45201
16.	Construction	2.59478	2.09486
17.	Retail and wholesale sales	1.75799	1.63243
18.	Transportation	2.13842	1.59047
19.	Medical services	2.89749	1.51759
20.	Other professional services	2.95242	1.47088
21.	Finances services	3.03056	1.40476
22.	Retail services	2.35514	1.66907
23.	Local government	2.68371	1.51934
24.	Households	2.49090	19.02572