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Interregional Effects of Reduced Timber Harvests: The Impact of the Northern Spotted Owl Listing in Rural and Urban Oregon

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A core-periphery, multiregional, input-output model of western Oregon is used to estimate impacts of periphery timber harvest reductions resulting from listing of an endangered species. Under the most probable scenario, 31,620 total jobs would be lost in the two regions. Fourteen percent of this impact is absorbed in the core (Metro) region. Forty percent of periphery and 80% of Metro jobs lost are from service sectors, a result of important core-periphery trade in central place services. Explicit inclusion of unemployment benefits for displaced workers reduces employment loss estimates by 12% to 14%.

Key words: endangered species, input-output modeling, interregional economic linkage, regional impacts, timber supply.

Introduction

Urban areas often are assumed to be relatively insulated from major changes affecting natural resource industries in rural areas. However, there have been few studies which have identified effects specific to either rural or urban regions separately from the overall regional impact. It is therefore difficult to test the validity of this hypothesis. In this article, a core-periphery, multiregional, input-output (MRIO) model is used to estimate the employment impact in both the urban core and the rural periphery regions of timber harvest reductions in rural western Oregon. Such reductions are an anticipated result of the listing of the northern spotted owl as an endangered species.

Oregon's Timber Economy

Oregon's forest resources are economically important. In 1988, timber-related industries provided 77,400 jobs paying combined wages and salaries of more than $2 billion.[1] Eighty-one percent of these jobs were in western Oregon. Timber-related industries represent 6.8% of total Oregon wage and salary employment and 9% of statewide payroll income. In nonmetropolitan counties, employment in timber industries accounted for as much as 29% of wage and salary employment (Greber, Johnson, and Lettman). The distribution of these jobs among industrial sectors is approximately 16% in logging, 25% in sawmilling, 25% in plywood and veneer, 14% in pulp and paper, and 20% in other wood products (Sessions et al.).

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Oregon's 24 million acres of commercial forest contribute about 17% of the United States' softwood harvest and represent about 22% of its softwood sawtimber inventory (Sessions et al.). Sixty-five percent of these lands are publicly owned. In western Oregon there are 13.5 million acres of forest land, 56% of which are publicly owned. Average timber harvest for western Oregon between 1983 and 1987 was 6,096 million board feet (MMBF) per year (Scribner log rule) (Greber, Johnson, and Lettman, table 2).

Changing Timber Supply: Revised Forest Plans and the Northern Spotted Owl

By the late 1980s, there was growing concern that historic harvest levels were no longer sustainable. In response, revised public agency forest plans were proposed which excluded 2.45 million acres (32%) of western Oregon's public forest from the allowable harvest base. This translates into an annual reduction of 245 MMBF (4%) relative to the 1983–87 average harvest.

The Interagency Scientific Committee's (ISC) report released in April 1990 recommended exclusion of an additional 1.56 million acres of western Oregon's public forest from the allowable harvest base for the purpose of maintaining northern spotted owl habitat (Greber, Johnson, and Lettman, tables 7 and 8). This translates into a reduction in average harvest of 1,138 MMBF per year, 19% below the levels proposed in the forest plans.

If conservation measures also were enforced on 418,000 acres of designated private forest land, annual harvests would be reduced by an additional 1,702 MMBF on average. This latter scenario calls for a total average reduction of 2,840 MMBF per year, permitting average harvests of only 3,011 MMBF per year during the 1990s. This is 49% below levels proposed in the forest plans, and less than half the 1983–87 average level for western Oregon (Greber, Johnson, and Lettman, table 13).

In the absence of the ISC's recommendations, the harvest levels proposed in the forest plans probably would have been adopted. For this reason, the magnitude of the "timber shock" treated in this study is measured relative to what allowable harvest would have been under the proposed forest plans and not relative to historic peak or average harvest levels.

Anticipated Effects of Timber Harvest Reduction

Several studies have developed estimates of job loss attributable to the timber supply shocks. Estimates presented by Sessions et al. of job changes resulting from an 11% reduction in timber harvest predict a loss of 12,000 jobs statewide. Of these, 4,600 are from timber-related industries, 800 are farm employees and proprietors, 2,800 are from other (nontimber) manufacturing industries, and 3,800 are from nonmanufacturing sectors.[2]

Projections of average 1990s annual employment for western Oregon under a range of alternative timber availabilities are presented in Greber, Johnson, and Lettman (table 20). These numbers were used to calculate job loss estimates under two timber supply scenarios: (*a*) harvest restrictions affecting only public forest lands, and (*b*) restrictions extended to cover private as well as public forests. Under the first (public-only) scenario, up to 6,000 timber-related jobs and 8,000 other jobs (a total of 14,000) would be lost. Under the second (combined public and private) scenario, a loss of up to 16,000 timber-related jobs and 21,100 other jobs (for a total of 37,100) is predicted.

Purpose

In this study, a core-periphery MRIO model was used to predict employment impacts on the Portland Metro core and trade area periphery regions resulting from timber supply shocks in the trade area periphery. The shocks represent the direct impacts of restrictions on allowable timber harvest anticipated as a result of the listing of the northern spotted owl as an endangered species. Effects on each region individually and on the two regions combined were estimated.

Two different scenarios were treated, corresponding to harvest restrictions on (*a*) public forest land only, and (*b*) public and private forest land. Under each scenario, we show the employment impact of timber supply reductions under two different assumptions regarding the size of the direct employment effect on timber-related industries. In addition, impacts are calculated and compared with and without estimated unemployment benefits paid to workers displaced by the shocks.

The Multiregional Input-Output Model

Model Development

A typical single-region input-output (IO) model is constructed from a set of regional accounts depicting intersectoral transactions, sectoral purchases of factors and imported inputs, and sales by each sector to final demand (including exports outside the region). IO models can be used to estimate the impact of changes in demand for the output of one or more sectors on the total sales of each sector in the region. In a multiregional input-output model, the frame is expanded to include not only intraregional transactions but also transactions occurring between regions as well. When fully developed, an MRIO model can be used to estimate the impact of changes in demand for one or more sector's exports on the sales, employment, and income of each sector in each region of the model.

Although ideally suited to simulating the impacts of changing final demand, the literature also contains several examples of IO models being used to simulate the impact of primary resource shortages.[3] Penn et al. used a national IO matrix as a constraint set in a linear program (LP) to estimate the impact of different energy shock scenarios. Petkovich and Ching used a similar approach to model the impact of mining ore exhaustion in western Nevada under different assumptions regarding the substitutability of imported replacement ore. Penson and Fulton adapted this approach into a quadratic programming model by incorporating linear supply and demand functions in order to model the impact of strike-induced agricultural output reductions in Texas. Casey, Jones, and Lacewell built an IO matrix into the constraint set of their recursive LP in order to simulate long-term effects of the depletion of the Ogallala aquifer on the Texas–Oklahoma regional economy. Martin et al. used a more conventional IO approach to model the effect of farmer participation in the Conservation Reserve Program on three counties in north-central Oregon. A noteworthy feature of this study is the authors' inclusion of positive impacts resulting from increased transfer payments in addition to the negative impacts of reduced agricultural activity.

Johnson and Kulshreshtha developed a generalized method for modeling output capacity or final demand changes in an IO framework by exogenizing the directly impacted sector(s). They used this approach to estimate the relative impact of different farm types on the Saskatchewan economy. Findeis and Whittlesey used an analogous method to estimate the impact of irrigation expansion in Washington state. In their model, direct impacts are modeled as agricultural output changes and changes in the wholesale price of electricity. Elder and Butcher evaluated the same project in an IO framework but included offsetting negative impacts (increased local taxes, etc.) as well as positive direct impacts of the project in their analysis.

In this study, the employment impact of an environmentally induced primary resource shortage was estimated using an MRIO framework. This method allows bifurcation of the total impact vector into components specifically affecting the "urban" core and "rural" periphery regions (Holland, Weber, and Waters). Using an MRIO model, it is thus possible to convey more specific impact information than is possible using a traditional single-region IO approach. In addition to modeling the negative impact of the timber shocks, we also have incorporated the offsetting positive effect of unemployment benefit payments to displaced workers, thereby presenting a more realistic picture of the overall employment impact attributable to the listing of the northern spotted owl.

Central Place Theory and Core-Periphery Modeling. According to the Central Place theory of Christaller, geographic space will be organized in a regular hierarchy of central places. A place at a given level in the hierarchy supplies not only goods and services that are specific to its level, but also all other goods and services of lower order. Goods and services supplied only by major central places are referred to as "central place goods and services."

In this interpretation of central place theory as it relates to core-periphery regional modeling, major urban places will supply central place goods and services. At the same time, the surrounding rural periphery will not be self-sufficient in the supply of these goods and services and must, to some degree, depend on the central place for its supply. The clear implication is that we expect to see flows of central place goods and services down the hierarchy from core to periphery regions.

The problem is that the data available under various sectoring methods (SIC, BEA, IMPLAN) are not sufficiently detailed to permit the identification of central place goods and services. Each sector includes both truly central place commodities along with commodities that are not subject to central place hierarchy. The result is that a given sector may exhibit local sources of supply even though it is subject to central place dominance in some aspects.[4]

The approach used here estimates core-periphery economic linkages after first determining geographic coverage of the economic region. The U.S. Department of Commerce's Bureau of Economic Analysis (USDC/BEA 1975) has mapped principal trading regions of the U.S. into economic areas (EAs). The EAs are defined using counties as the basic building block and provide a convenient picture of functional economic regions consistent with central place perspectives. The economic area becomes the basic concept for defining the economic region. The analysis builds on this mapping by using IMPLAN to provide empirical estimates of possible economic linkage between core and periphery areas within such regions.[5]

Central place theory predicts that in the core of the functional region, we expect the regional supply of central place goods and services to exceed core regional demand. Likewise, we expect the rural periphery to be characterized by excess demand for those same central place goods. Estimates of regional supply and demand can be obtained using the techniques of IMPLAN. If there is excess supply of central place goods in the core and excess demand for those goods in the periphery, then, in accordance with central place theory, the flow of those goods and services from the core to periphery regions seems reasonable. Thus, a modified supply-demand pool approach is used to measure trade in these types of goods and services across the two regions.

Producers of "specialized" (Parr) commodities are able to take advantage of low production costs at a given location and can therefore locate independently of central place considerations. Examples include the abundant moisture and mild climate for timber growing in the Northwest, low energy costs and abundant water for aluminum processing in the Columbia River basin, and the especially favorable climate for wheat growing in the Palouse. Trade in specialized goods may occur across or even up the central place hierarchy, as in the case of agricultural commodities exported from the periphery to the core or elsewhere. There is no reason to expect central place dominance in the case of specialized commodities.

The Regionalization Scheme. The two regions constructed for this model are the Portland metropolitan core [designated "Portland Metro"—roughly, the Portland–Vancouver Consolidated Metropolitan Statistical Area (CMSA)], and its trade area periphery (designated "periphery"—an aggregation of 23 counties in western Oregon and four counties in southwestern Washington). The periphery is defined as the trade area that is served by Portland Metro.

The combined core-periphery region used here corresponds to a merger of the Portland

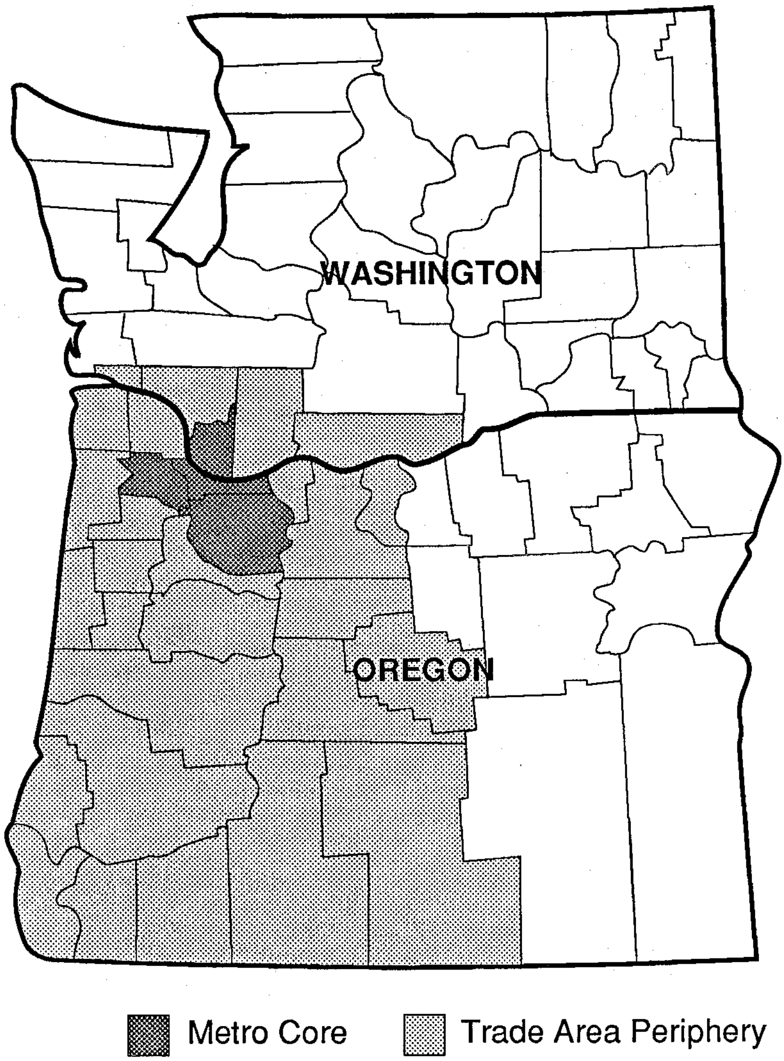

Figure 1. The Portland functional region: Metro and periphery regions

Economic Area with the Eugene Economic Area, as defined by the BEA (USDC/BEA 1975). It extends north into southwestern Washington where it is bounded by competition with Seattle, the dominant central place in the Northwest (fig. 1). The western boundary is the Pacific Ocean, while the eastern boundary extends to the Boise trade area which dominates eastern Oregon. The periphery region extends south down the Interstate-5 corridor to the southern border of Oregon, thus including the Eugene Economic Area, which has been increasingly drawn into the Portland trade area as a result of ease of north-south travel on Interstate 5.

Estimation of Interregional Labor and Labor Earnings Flows. Portland Metro and its trade area are weakly linked economically through flows of labor and income. Data representing labor flows and corresponding earnings payments are presented in table 1. Labor flows are taken from 1980 estimates of interregional commuting (USDC, Bureau of the Census 1980a, b). Earnings flows are constructed from 1982 estimates of dollar earnings by county of work and by county of residence (USDC/BEA 1988).

Journey-to-work data were used to construct a flow matrix depicting the movement of labor services from region of residence (row) to region of work (column). This approach

Table 1. Labor and Earnings Flows Between Portland Metro and Its Trade Area Periphery

Place of Residence		Place of Work: Metro	Periphery	Elsewhere	Totals by POR: Labor	Gross Earn.
Metro Region	Labor	555,857	8,434	4,625	568,916	
	Earnings	$10,681	$268	$147		$11,096
Periphery Region	Labor	15,917	547,431	33,013	596,361	
	Earnings	$306	$9,087	$335		$9,728
Elsewhere	Labor	14,300	4,985			
	Earnings	$275	$83			
Total Labor by POW		586,074	560,850			
Total Earnings by POW		$11,262	$9,438			

Sources: U.S. Department of Commerce, Bureau of the Census (1980a, b); U.S. Department of Commerce, Bureau of Economic Analysis (1988).
Notes: POR = place of residence; POW = place of work. Labor flows are for 1980 and earnings flows for 1982. Gross Earnings by POR are inclusive of Social Security Insurance payments by POW. Labor flows are persons. Earnings flows are in millions of dollars (1982). The Metro Region consists of Multnomah, Washington, and Clackamas Counties, as well as Clark County, Washington. The Periphery Region is an aggregation of 27 counties in western Oregon and southwestern Washington.

was inspired by the recent work on labor market areas by Tolbert and Killian. We can estimate the number of workers commuting from outside a particular region by reading down that region's column in table 1. For example, of 586,074 workers in Portland Metro (labor total for column one) 555,857 (95%) of them also lived in the Metro region, while 15,917 (2.7%) commuted from the periphery and 14,300 (2.4%) commuted from elsewhere. Likewise, reading down the second column, we see that of 560,850 workers in the trade area periphery, 547,431 (97.6%) lived there, 8,434 (1.5%) commuted from Portland Metro, and 4,985 (1%) commuted from elsewhere.

Reading across the rows of table 1, the number of a region's resident labor force commuting to work outside the region can be determined. For example, of 568,916 workers residing in Portland Metro (labor total for row one), 555,857 (98%) of them also worked there, while 8,434 (1.5%) worked in the periphery and 4,625 (1%) worked elsewhere. Also, of 596,361 workers residing in the trade area periphery, 547,431 (92%) worked in the region, while 15,917 (2.7%) worked in Portland Metro and 33,013 (5.5%) worked elsewhere.

Earnings flows also appear in table 1 beneath the corresponding labor flow which generated it.[6] For example, the two entries in the second (periphery) column of the Metro row denote that 8,434 workers residing in the Metro region and commuting to work in the periphery region earned $268 million. Altogether, only 3.7% ($415 million) of the Metro residents' total earnings of $11,096 million were earned outside the region. Periphery residents earned 3.4% ($335 million) of their total earnings of $9,728 million outside the combined region. Only 3.1% ($306 million) of workers' earnings were from jobs in the Metro region.

Estimation of Interregional Trade in Goods and Services. Using IMPLAN and the procedures outlined above, trade in goods and services between Portland Metro and its trade area periphery, and between those two regions and the rest of the U.S., was estimated. Software developed by Holland, which uses information from the IMPLAN regional trade report, was used to derive estimates of possible core-periphery trade. Each interregional trade estimate is consistent with single-region imports and exports as determined by IMPLAN. A different trade determination method is used depending on whether the commodity is judged to be a central place commodity or a specialized commodity (Holland and Hughes).

Trade estimates for these regions are summarized in table 2. The rows show the destinations for output produced in the region, allocating total exports to the periphery (core), the rest of the United States, and to foreign countries. The diagonals show regional

Table 2. Portland Metro–Trade Area Periphery Goods and Services Trade (1982, millions of dollars)

From		To				
		Metro	Periphery	Rest of U.S.	Foreign	TIO
Metro	Total	19,619	2,400	8,086	1,322	31,427
	Goods	4,017	709	4,985	645	10,356
	Services	15,602	1,691	3,101	677	21,071
Periphery	Total	1,039	20,029	9,792	1,695	32,555
	Goods	749	5,848	8,915	1,282	16,794
	Services	290	14,181	877	413	15,761
Rest of World	Total	11,313	13,447			
	Goods	7,650	8,958			
	Services	3,663	4,489			
Gross Regional Demand	Total	31,971	35,876			
	Goods	12,416	15,515			
	Services	19,555	20,361			

Notes: TIO = total industrial output. "Goods" includes utilities (most of which is electrical services), and landscaping and agricultural services; "Services" includes construction services.

absorption of regional production. The columns show the origin of regional absorption, allocating imports between imports from the periphery (core) and imports from the rest of the world.

A striking observation from table 2 is the importance of goods and services trade to both regional economies. The Metro economy is quite open, exporting 37% of total industrial output (TIO). Portland Metro imports slightly more than it exports, indicating there is a net monetary outflow from the region with respect to goods and services trade. Twenty percent of the Metro's exports are to the trade area periphery. In contrast to the labor markets, the goods and services markets are more closely linked across the geographic regions.

Portland Metro satisfies 39% of demand through imports. About 8% of its imports come from the periphery. The net trade balance between Metro and the periphery is in favor of Portland Metro. Metro's exports of goods and services to the periphery ($2.4 billion) are more than two times its imports from there ($1.04 billion). This implies that more than $1 billion flows from the periphery to Portland Metro on the trade account.

The periphery region is similarly open, exporting 38% of TIO and importing 44% of its regional demand. The trade balance is strongly negative with periphery imports exceeding exports by more than $3 billion. The periphery exports little to the core (8% of periphery exports are to the core) and obtains 15% of its imports from Metro.

In table 2, trade in goods is separated from trade in services. Interregional trade in goods between Portland Metro and the periphery region is roughly balanced ($709 million versus $749 million). The important, and anticipated, pattern revealed in table 2 is Metro's large exports of services to the trade area periphery. Thirty-one percent ($1.691 billion) of Portland's total services exports of $5.469 billion are to the periphery. Although both economies are of roughly equal size in terms of total output of goods and services, Portland Metro sells nearly five times as much services to the periphery ($1.691 billion) as the periphery sells to Metro ($290 million). Here, the central place character of the relationship between the Portland Metro and the trade area periphery is clearly illustrated.

Model Structure

Estimated labor services flows were combined with estimates of commodity trade flows and information from the IMPLAN social accounting matrix (SAM) to construct the

Table 3. Exports from Portland Metro to Trade Area Periphery

No.	IMPLAN Sector	Exports to Periphery	% of Total Sales	% of Exports	% of Absorption in Periphery: Industry	House-hold	Govt.	Invest-ment	Total
		($MM)							
1	Livestock	.00	0	0	0	0	0	0	0
11	Crops	.00	0	0	0	0	0	0	0
24	Forestry Prods. & Logging	.00	0	0	0	0	0	0	0
25	Commercial Fishing	.00	0	0	0	0	0	0	0
26	Landscaping & Ag. Services	31.64	47	99	98	1	1	0	100
32	Mining	.34	2	5	100	0	0	0	100
66	Construction	30.99	2	38	27	0	25	48	100
79	Other Manufacturing	270.84	7	10	71	18	1	9	100
82	Food Processing	169.64	13	27	35	62	2	0	100
161	Wood Products	69.82	16	26	98	1	0	0	100
187	Pulp & Paper Products	58.74	6	6	93	6	0	0	100
362	Electronics & Instruments	46.53	2	3	38	12	13	37	100
446	Transportation	162.30	8	17	79	17	4	1	100
454	Communications	153.51	20	34	50	34	11	5	100
456	Utilities	61.27	8	66	67	25	8	0	100
460	Wholesale Trade	458.54	21	51	66	28	0	6	100
462	Retail Trade	108.33	7	52	8	91	0	1	100
464	Financial	85.47	11	70	35	54	11	0	100
467	Insurance & Real Estate	199.95	6	42	24	74	0	2	100
471	Eating, Drinking, & Lodging	151.72	12	51	20	79	1	0	100
472	Other Services	157.82	9	26	25	73	2	0	100
479	Business Services	126.34	9	28	78	19	3	0	100
503	Health Services	54.00	4	10	6	92	2	0	100

MRIO table of the Portland Metro-Trade Area Periphery economies. The MRIO captures goods, services, and labor market linkages between the two regions.

Trade flows to the receiving region were allocated to interindustry uses, households, government, and investment. The allocation of these flows to receiving region institutions was assumed proportional to the allocation of regionally produced supply across those institutions. In other words, imports are allocated in proportion to the absorption of regional supply of a given commodity.

Sectoral Composition of Interregional Trade. The relative importance of each region as a buyer of the other region's goods and services is summarized in tables 3 and 4. Measured by sales, the periphery region is an important market for Portland Metro businesses in the wholesale trade, other manufacturing, insurance and real estate, food processing, transportation, and other services sectors. The largest estimated trade flow was wholesale trade, where 51% ($458 million) of Portland Metro's wholesale trade exports (21% of Metro's total sales of wholesale trade services) is estimated to go to the periphery (table 3).

One working hypothesis was that most of the core-to-periphery trade consisted of central place services that were largely absorbed by periphery households. This hypothesis is fairly easy to test given the approach used for allocating the absorption of imports by the receiving region. The first part of the hypothesis is confirmed. Approximately 69% of Portland Metro's exports to the periphery region are estimated to be services. While households are the major buyers of Metro's consumer services exports to the periphery (table 3), periphery industries are the main consumers of very large flows of wholesale trade, transportation, and communication services. Given this evidence, it is not generally true that periphery households are the major consumers of core exports of services.

Table 4. Exports from Trade Area Periphery to Portland Metro

No.	IMPLAN Sector	Exports to Metro	% of Total Sales	% of Exports	% of Absorption in Metro Region: Industry	Household	Govt.	Investment	Total
		($MM)							
1	Livestock	82.70	17	37	85	14	1	0	100
11	Crops	37.19	5	7	46	49	5	0	100
24	Forestry Prods. & Logging	39.22	1	3	99	1	0	0	100
25	Commercial Fishing	5.42	13	13	83	17	0	0	100
26	Landscaping & Ag. Services	6.70	5	89	93	4	3	0	100
32	Mining	5.32	12	17	100	0	0	0	100
66	Construction	.00	0	0	0	0	0	0	0
79	Other Manufacturing	70.55	3	4	66	24	1	9	100
82	Food Processing	50.16	5	9	36	62	2	0	100
16	Wood Products	24.57	1	1	37	2	1	0	100
187	Pulp & Paper Products	82.21	5	5	96	3	0	1	100
362	Electronics & Instruments	2.90	1	1	49	7	6	38	100
446	Transportation	20.51	3	13	84	12	3	1	100
454	Communications	4.16	1	5	57	29	8	6	100
456	Utilities	342.96	16	27	74	21	4	0	100
460	Wholesale Trade	.00	0	0	0	0	0	0	0
462	Retail Trade	26.60	2	30	8	90	0	2	100
464	Financial	.00	0	0	0	0	0	0	0
467	Insurance & Real Estate	.00	0	0	0	0	0	0	0
471	Eating, Drinking, & Lodging	176.98	15	80	29	70	1	0	100
472	Other Services	47.89	4	25	32	66	2	0	100
479	Business Services	9.02	2	19	83	12	5	0	100
503	Health Services	.00	0	0	0	0	0	0	0

When examining the importance of the Portland Metro market for goods and services exported from the periphery, a very different picture emerges. The periphery provides important flows of resource-based commodities to Metro (table 4). Major goods exports from the periphery to Portland Metro are livestock, pulp and paper products, processed food, and most importantly, electricity from the utility sector. The largest service sector flow from the periphery to Portland Metro is eating, drinking, and lodging, with an estimated flow of $177 million, reflecting the importance of core-generated tourism to the periphery economy.

Model Closure. In creating the core-periphery MRIO model, household income and household expenditures which occur in the two-region area are treated as endogenous. Three distinct household income classes are identified for each region. The resulting MRIO model identifies linkages across regions according to industry, factor of production, and household income class. Thus the model is able to show how an exogenous shock to the Metro (periphery) economy affects payments to households across the size distribution of income in the Metro (periphery) region, and also how that same shock affects households in the various income classes in the periphery (Metro).

The model is closed under the assumption that regional consumption for each household income class is a function of the personal income received by that household group. Personal income is the sum of employee compensation, proprietors' income, government transfers, and property income. The regional contribution to regional personal income is measured as the sum of employee compensation and proprietors' income from the IMPLAN input-output accounts.

All "other property income" generated in the region is assumed paid to capital owners

Table 5. Output Multipliers for the Portland Metro-Trade Area Periphery Multiregional Model

		Metro			Periphery		
No.	IMPLAN Sector	Metro	Periphery	Total	Periphery	Metro	Total
1	Livestock	1.65	.13	1.78	1.77	.18	1.95
11	Crops	1.82	.13	1.95	1.63	.18	1.81
24	Forestry Prods. & Logging	1.78	.18	1.96	1.84	.14	1.98
25	Commercial Fishing	1.53	.06	1.58	1.37	.13	1.50
26	Landscaping & Ag. Services	1.75	.11	1.86	1.60	.18	1.78
32	Mining	1.58	.08	1.66	1.48	.14	1.62
66	Construction	1.80	.08	1.88	1.60	.20	1.80
79	Other Manufacturing	1.60	.08	1.68	1.50	.19	1.69
82	Food Processing	1.69	.19	1.88	1.79	.25	2.03
161	Wood products	2.12	.26	2.38	2.18	.21	2.39
187	Pulp & Paper Products	1.69	.13	1.81	1.66	.19	1.85
362	Electronics & Instruments	1.68	.07	1.75	1.55	.20	1.75
446	Transportation	1.94	.07	2.01	1.58	.18	1.76
454	Communications	1.46	.05	1.50	1.41	.12	1.53
456	Utilities	1.61	.21	1.83	1.32	.08	1.40
460	Wholesale Trade	1.72	.08	1.80	1.59	.19	1.77
462	Retail Trade	1.67	.07	1.74	1.57	.17	1.74
464	Financial	1.80	.07	1.87	1.61	.19	1.80
467	Insurance & Real Estate	1.42	.03	1.45	1.28	.06	1.34
471	Eating, Drinking, & Lodging	1.79	.11	1.90	1.63	.22	1.86
472	Other Services	1.67	.07	1.74	1.54	.16	1.70
479	Business Services	1.72	.07	1.79	1.60	.18	1.78
503	Health Services	1.84	.08	1.92	1.69	.19	1.88
516	Govt. Industry & Enterprise	1.74	.09	1.83	1.64	.18	1.82
526	Household Industry & Other	1.05	.01	1.06	1.05	.01	1.06

outside the combined region. Payments of interest, dividends, and rent to households in each region were treated as exogenous and were taken from the BEA's county data files (USDC/BEA 1988). The distributions of property income and government transfer payments to each household income class were derived from the IMPLAN SAM constructed for each region.

Using the information summarized in table 1, earnings by place of residence were calculated for each region. Earnings spillouts from the Portland Metro region to the periphery were relatively small, totaling only 2.7% of Portland Metro earnings by place of work (POW). Earnings spillouts from the trade area periphery to Portland Metro were 2.8% of periphery earnings by POW.

In the MRIO model, each industry is assumed to pay a fixed proportion of earnings to commuting workers from each region. The proportion is assumed constant for all industries in the region. The standard IO assumption of fixed proportion production functions is used. As is conventional in SAM-type models, employee compensation and proprietors' income are assumed distributed in fixed but different proportions across the size distribution of households in each region. The marginal propensity to consume is assumed equal to the average propensity to consume. The average propensity to consume for each household income class is estimated by normalizing each regional household consumption vector with respect to the claim by that household income class on personal income in the region. Personal income is composed of an endogenous portion derived from earnings within the combined region, and an exogenous portion made up of government transfers and returns to capital outside the region.[7]

Output Multipliers. Household-endogenous output multipliers are derived from the Leontief inverse matrix of the multiregional transactions table. The own-region output multipliers are the column sums of interindustry coefficients in the diagonal blocks of this matrix. These multipliers capture both within-region interindustry linkages and feedback effects from changes in other-region activity induced by a shock in the first region. The cross-regional multipliers are the column sums of interindustry coefficients in the off-diagonal blocks of the inverse matrix. They show the output change across regions for a one-unit change in the exogenous variable of the opposite region.

Own- and cross-regional output multipliers for Portland Metro and the trade area periphery regions are shown in table 5. The own-region effect of a one-unit final demand shock to livestock in Portland Metro is a change of 1.65 units of total supply in the Metro economy. Simultaneously, the cross-regional multiplier for Metro livestock shows a corresponding change of .13 units of total supply from the periphery region. This is referred to as Portland Metro linkage across to the periphery.

The range of Portland Metro-to-periphery cross-regional output multipliers (excluding household industry) is from .03 for insurance and real estate to .26 for wood products. Sectors with the largest linkage across from Metro to the periphery region are wood products, utilities, and food processing. The magnitude of the cross-regional output multiplier is a rough indication of that sector's backward linkage (input purchases) with the other region's economy.

Economic linkage from the periphery to Portland Metro generally is characterized by stronger cross-regional output effects than the linkage in the opposite direction (table 5). The largest cross-regional multipliers from the periphery to Metro are in the food processing; eating, drinking, and lodging; and wood products sectors. The range of cross-regional output multipliers (excluding household industry) is from .06 for insurance and real estate to .25 for food processing. As a general rule, unit changes in final demand for periphery region supply generate output changes ranging from .1 to .2 in the Portland Metro economy. The periphery-to-Metro cross-regional output multipliers are generally larger than the corresponding Metro-to-periphery multipliers. In particular, for most service sectors, the former are about twice the size of their Metro-to-periphery counterparts.

Analysis of the Impact of Timber Supply Shocks

In this section, impacts on employment in the Metro and periphery regions resulting from periphery timber harvest reductions are estimated. Employment effects are calculated directly from the vector of total output changes. We recognize that this treatment may not incorporate the full range of economic impacts. A more complete accounting of the value of environmental goods and services produced should at least include variation in the value of the resource stock resulting from changes in its size and/or unit value. In their work on environmental accounting, writers such as Lutz and El Serafy, and Peskin, among others, criticize the "gross national product" (GNP) type of accounting methods, of which IO is an example, for omitting this important component of income. GNP accounting uses the traditional but erroneous notion that natural resource stocks are free gifts from nature, infinitely abundant so as to be without marginal value (i.e., zero user cost).

The environmental accountant's notion of "income" implies a flow which a recipient can consume without reducing possible consumption in the future (i.e., net of depreciation and depletion of capital stocks). In the case of renewable natural resources like forests, true income by this definition is derived by harvesting any incremental growth in the living asset (i.e., dividend) and by realizing any appreciation in the unit value of the *in situ* natural asset (i.e., capital gain). Any current consumption which reduces the capacity of the capital asset to generate an income flow is by definition unsustainable and therefore does not comprise true income.

There is general agreement that improvements in income accounting conventions are needed to incorporate the true user cost of natural asset management, much as depreciation of man-made capital is netted out from GNP to derive "net national product" (NNP). It is argued that use of "green" NNP accounts (i.e., NNP net of depreciation in natural asset stocks) would provide a more accurate estimate of true income and thus serve as a better yardstick for monitoring the development of resource-based economies.

There is, however, as yet no general consensus on how natural asset depreciation should be estimated or how it should be incorporated into income accounts. Current practice in the United Nation's System of National Accounts (SNA) is to separately calculate changes in value of natural assets which are then displayed as satellite accounts, peripheral to the traditional national income accounts. However, even having accepted this convention and granting that the natural resource stocks could be accurately inventoried, the problem is not yet solved. Since most of the alternative (nontimber) demands for forest resources are not revealed in markets, there is no routine way to ascertain their values and appropriate weights for incorporation into a national accounting framework.

Therefore, for this study, we have tried to address one important aspect of total regional economic impact: the variation in current income as reflected in employment effects. Two different shock scenarios are modeled below. The scenarios simulate two levels of periphery timber harvest which are possible under alternative recovery plans for the northern spotted owl. The first scenario limits the effect of harvest restrictions to public forest lands only. The second scenario extends the harvest restrictions to cover private as well as public forests. The two shock scenarios were derived from estimates in Greber, Johnson, and Lettman, and represent harvest reductions relative to what were proposed as "sustainable" harvest levels in the revised forest plans.

In analyzing these shocks, two different sets of IO labor coefficients for the directly affected timber-related industries were used. One set incorporated IMPLAN estimates (based on 1977 technology) of average regional labor input per dollar of industrial output. The other set was derived using information from two sources to modify the IMPLAN coefficients:

(1) Estimates of marginal direct employment change per MMBF of timber harvest reported in Sessions et al. (appendix I, table 8, p. 179). These embody up-to-date estimates of incremental employment response to changes in harvest given current (1990s) technology.
(2) Estimates of direct employment changes per MMBF timber harvest reported in an electronic spreadsheet, OR-TOTAL.WK1, obtained from the U.S. Forest Service. These, like the IMPLAN coefficients, are based on 1977 technology.

Between 1979 and 1989, wage and salary employment in Pacific Northwest solid wood products industries decreased from 9.2 to 7.0 jobs/MMBF of timber harvest. During the same period, wage and salary employment in pulp and paper products industries decreased from 1.75 to 1.70 jobs/MMBF (Greber).

Based on this evidence, a method for updating the labor coefficients was devised. A factor constructed as the ratio of estimate (1) to estimate (2), above, was used to reduce the IMPLAN labor coefficients for the timber-related industries. These adjusted coefficients are termed "marginal" labor coefficients.

There are four different shock scenarios which are suggested by the above taxonomy and which were used in the analysis: (*a*) public-only shock using IMPLAN labor coefficients, (*b*) combined public and private shock using IMPLAN labor coefficients, (*c*) public-only shock using marginal labor coefficients, and (*d*) combined shock using marginal labor coefficients. Employment effects were estimated for each of the four scenarios with and without inclusion of unemployment benefit payments to displaced workers.

Unemployment benefits were calculated from information supplied by the State of Oregon Employment Division. The average benefit for workers displaced from high-wage, timber-related jobs was calculated as the maximum weekly benefit ($271) received over 52 weeks, i.e., $14,000 in 1992. The average benefit paid to workers laid off from jobs elsewhere in the economy was calculated as the average annual benefit paid during 1991 of $2,086. Inclusion of unemployment benefits somewhat offsets the reduction in spending resulting from the decline in household income. We feel that including unemployment benefits provides a more realistic estimate of the total short-term effect attributable to each shock scenario.

Configuring the Supply Shock for a Demand-Driven Model

The method chosen to implement this impact analysis made it necessary to translate the timber supply reductions into "equivalent" reductions in exogenous demand for the output of timber-related industries. Using this method, it was possible to correctly apply the shock directly to the timber-using industries, excluding less likely direct effects on industries which use finished lumber as raw material (e.g., construction). It can be argued that since users of finished lumber would still be able to procure adequate supplies of imported material, any direct impact on those industries likely would be very small.

The first step was thus to calculate the average reduction in timber harvest relative to the base harvest level indicated under the forest plans. This was done for each of the two timber supply scenarios described above.

Both Metro and periphery regions contain economic timber supplies. Since our objective was to simulate a reduction in *periphery* timber supply, it was necessary to separate the portion occurring in that region from the total harvest reduction for the whole of western Oregon. For this purpose, average timber harvest reductions were estimated by county, and then county totals were summed to obtain average harvest reduction in each respective region (table 6).[8]

Regional proportions of the total harvest reductions (from Greber, Johnson, and Lettman) were found to be 5.3% and 94.7% for the core and periphery, respectively. Estimates of periphery harvest reductions were then adjusted to include an average annual reduction of 26 MMBF resulting from implementation of spotted owl recovery plans in the forests of southwestern Washington, particularly Skamania County.

Next, given the fixed price, fixed proportion production relationships embodied in the model, these estimated timber supply constraints were converted into equivalent reductions in (assumed exogenous) demand for the output of timber-related industries. The demand shock vectors were multiplied by the Leontief inverse matrix of the MRIO model to obtain the estimate of total (direct, indirect, and induced) reduction in output across the Metro and periphery economies resulting from the two hypothetical timber supply shocks to the periphery region. Employment effects were calculated by dividing each sector's estimated total output response by the corresponding output-to-employment ratio for that sector. (Details of the conversion and estimation procedures are available on request).[9]

Overall Employment Effects (Both Regions)

Estimates of total job losses under the varying assumptions regarding labor coefficients and unemployment benefits range from 12,957 to 19,965 for the first scenario, and from 31,620 to 48,712 for the second (table 7). In each case, job loss from the periphery timber industry accounts for at least 40% of the combined region impact. As expected, job loss estimates are greatest under the scenarios which assume IMPLAN labor coefficients and no unemployment benefits.

The range of these estimates compares closely with results by Greber, Johnson, and Lettman, who estimate that, under the first scenario, 14,000 jobs would be lost in western Oregon (6,000 timber-related and 8,000 "other" jobs), and under the second scenario, job losses would total 37,100 (16,000 timber and 21,100 other). Our estimates of job losses using marginal labor coefficients and no unemployment benefits are 14,788 (6,502

Table 6. Estimated Magnitude of Annual Timber Supply Shocks

	Annual Timber Harvest Reduction in MMBF	
	Scenario 1	Scenario 2
Metro	−62	−153
Periphery	−1,118	−2,729
Total	−1,180	−2,882

timber and 8,286 other), and 36,089 (15,869 timber and 20,220 other), respectively, under the two supply scenarios (table 7).[10]

In terms of job losses per MMBF harvest reduction, our estimate of uncompensated total job losses using average labor coefficients and no unemployment benefits is 17.86 jobs/MMBF (9.09 timber-related, 8.77 other). This corresponds closely with U.S. Forest Service estimates for western Oregon of 17.66 jobs/MMBF (9.24 timber, 8.42 other).[11]

Similarly, we estimate job loss using marginal labor coefficients and no unemployment benefit payments to be 13.23 jobs/MMBF (5.82 timber, 7.41 other). This falls within the range from 12.6 (5.6 timber, 7.0 other) to 13.3 (5.8 timber, 7.5 other) estimated wage and salary jobs lost per MMBF harvest reduction reported in Sessions et al. (appendix I, table 7, p. 179).

Own-Region Employment Effects in the Periphery

Timber-related jobs in the rural periphery (which account for 13% of periphery jobs) are estimated to decline from 9% to 35%. However, one-third to one-half of the employment impact in the periphery is absorbed in other sectors, primarily the nonbusiness services sector.[12] Under the second harvest reduction scenario analyzed using marginal labor coefficients and no unemployment benefits (see the last column of table 7), we estimate that a 22% reduction in timber-related employment will precipitate a 2% reduction in total nontimber jobs, 40% of which are from nonbusiness services.

Cross-Regional Employment Effects in Portland Metro

Probably the most novel contribution of this analysis is the ability to estimate the transmitted impact in Portland Metro resulting from an economic shock in the periphery region. Estimated Metro job losses under the first timber supply scenario range from 1,805 to 2,578, and under the second scenario range from 4,403 to 6,288 total jobs (table 7). While even the largest of these estimates comprises barely 1% of the 1982 Portland Metro employment, cross-regional employment effects account for between 12% and 15% of total jobs lost in the two regions. The greatest impact results in cases where IMPLAN labor coefficients and no unemployment benefits are assumed.

The sectoral distribution of cross-regional employment effects is also of interest. Earlier it was noted that Metro's exports to the periphery are predominantly services (table 3). It follows that Metro service sectors show strong periphery-to-core cross-regional employment impacts. Metro service sectors account for about 80% of total Metro jobs lost.[13] This is attributable to two factors: the relatively small output-to-employment ratios of most service industries (i.e., a small output change translates into a relatively large change in employment), and the important central place character of core-periphery trade in services.

Using information from table 3, Metro services can be split into two categories, depending on whether sector exports to the periphery were purchased primarily by producers (producer services) or by consumers (consumer services). Producer services consist of

Table 7. Estimated Job Loss in Portland Metro and Its Trade Area Periphery Due to Listing of the Northern Spotted Owl

		Harvest Restriction On:							
		Public Land Only (−1,118 MMBF/yr.)				Public & Private Land (−2,729 MMBF/yr.)			
Unemployment Compensation:		w/o Benefits		w/Benefits		w/o Benefits		w/Benefits	
I/O Labor Coefficients:		IMPLAN	Marginal	IMPLAN	Marginal	IMPLAN	Marginal	IMPLAN	Marginal
	Sector Employment								
Portland Metro Sectors:									
Timber-Related	13,262	133	84	130	84	325	205	317	204
Other Ag. & Nat. Res.	13,050	121	119	116	114	297	289	282	279
Other Manufacturing	105,839	202	177	155	145	491	430	377	352
Transp., Communic., & Utilities	35,062	244	221	199	192	594	540	485	466
Wholesale Trade	40,491	389	361	337	326	948	880	823	796
Retail Trade	52,037	191	154	123	106	466	375	300	260
Business Services	25,917	250	221	197	185	610	538	481	451
Nonbusiness Services	248,821	1,048	867	735	653	2,557	2,119	1,792	1,595
Metro Totals	534,479	2,578	2,204	1,992	1,805	6,288	5,376	4,857	4,403
Trade Area Periphery Sectors:									
Timber-Related	69,643	10,034	6,418	10,028	6,414	24,491	15,664	24,473	15,661
Other Ag. & Nat. Res.	35,035	571	543	515	506	1,393	1,325	1,255	1,233
Other Manufacturing	61,016	569	522	485	468	1,389	1,277	1,183	1,141
Transp., Communic., & Utilities	27,725	560	518	473	461	1,363	1,263	1,153	1,123
Wholesale Trade	19,458	678	638	604	589	1,652	1,555	1,472	1,436
Retail Trade	57,244	913	684	492	407	2,227	1,670	1,200	993
Business Services	13,188	509	454	410	389	1,241	1,107	1,001	949
Nonbusiness Services	260,946	3,553	2,807	2,205	1,918	8,668	6,852	5,378	4,681
Periphery Totals	544,255	17,387	12,584	15,212	11,152	42,424	30,713	37,115	27,217
Metro + Periphery Totals:	1,078,734	19,965	14,788	17,204	12,957	48,712	36,089	41,972	31,620
Employment Change per MMBF Reduction in Timber Harvest:									
Total Jobs		17.86	13.23	15.39	11.59	17.85	13.22	15.38	11.59
Timber-Related Jobs		9.09	5.82	9.09	5.81	9.09	5.81	9.08	5.81
Nontimber Jobs		8.76	7.41	6.30	5.78	8.76	7.41	6.30	5.77

Notes: "Timber-Related" sectors are forestry products, logging, sawmilling, wood products manufacturing, and pulp and paper industries, as defined in the text. "Other Manufacturing" consists of nontimber-related manufacturing and construction. "Nonbusiness Services" include eating, drinking, and lodging; other services; health services; financial; and insurance and real estate services.

wholesale trade; transportation, communication, and utilities; and business services. Consumer services are retail trade and nonbusiness services.

Based on these classifications, displaced Metro service jobs are fairly evenly split between producer services and consumer services sectors (table 7). This is consistent with an earlier observation regarding the roughly equal importance of periphery businesses and periphery households as markets for Metro-generated services (see table 3).

The Effect of Unemployment Benefits on Job Loss Estimates

As expected, estimated employment effects are less severe when payment of unemployment benefits to displaced workers is explicitly included in the analysis. Unemployment benefits reduce estimated job loss by 14% (from 17.86 to 15.39 jobs/MMBF) using IMPLAN labor coefficients, and by 12% (from 13.23 to 11.59 jobs/MMBF) using marginal labor coefficients (table 7).

While timber-related job loss estimates are only negligibly affected by whether or not unemployment benefits are included, the effect on estimates for nontimber sectors is more marked. This observed dampening in the employment effect is due largely to a reduction in the loss of nontimber jobs, particularly in the service sectors. Inclusion of unemployment benefits reduces the estimated induced effect on both regional economies resulting from the reduction in timber-related incomes.

Conclusions

Under varying assumptions regarding labor coefficients and unemployment benefits, impact estimates range between 12,957 and 19,965 jobs lost for the first (public-only) shock scenario, and from 31,620 to 48,712 jobs lost for the second (public and private) scenario. These estimates compare closely with other published estimates of spotted owl impacts, given equivalent assumptions (Greber, Johnson, and Lettman; Sessions et al.).

Accounting for the effect of unemployment benefits provides more realistic estimates of employment response to the spotted owl listing, reducing job loss estimates from 12% to 14%. Overlooking the effect of unemployment benefits *de facto* assumes all redundant labor leaves the region, thereby overestimating total job loss by a significant amount.

The impact in Portland Metro of the periphery timber shocks affects only a minor proportion of total employment in the Metro region (usually less than 1% of Metro jobs are affected). Yet Metro job loss accounts for 11% to 15% of the total jobs lost in the combined regions. A cross-regional impact of this magnitude indicates significant economic linkage between the two regions. About 80% of the Metro jobs lost are displaced from the service sectors. Reduced periphery demand for Metro-generated, central place services accounts for a significant portion of these losses.

It appears likely that the prevailing timber supply situation will more closely resemble the second of the two scenarios modeled in this article. If the assumptions of marginal labor coefficients and payment of unemployment benefits together constitute the most reasonable representation of reality, then the case presented in the last column of table 7 (and highlighted in table 8) is our best estimate of the likely employment impact in western Oregon resulting from reduced periphery timber supply in response to the listing of the northern spotted owl as an endangered species.

There are two implications for economic development in Oregon which follow from this discussion:

(1) Any negative impacts on Portland Metro resulting from the periphery timber shocks probably will be nearly outweighed by dynamic growth in the Metro region.
(2) In the periphery, where dynamic growth is not anticipated, timber-induced job loss will be severe and difficult to replace.

Some important observations help to illustrate the second point. Under the most likely

Table 8. Estimated Job Loss Under the Most Likely Timber Supply Scenario (with and without Unemployment Benefits)

		w/o Benefits		w/Benefits	
	Employment	Job Loss	%	Job Loss	%
Portland Metro Sectors:					
Timber-Related	13,262	205	−1.5	204	−1.5
Other Ag. & Nat. Res.	13,050	289	−2.2	279	−2.1
Other Manufacturing	105,839	430	−.4	352	−.3
Transp., Communic., & Utilities	35,062	540	−1.5	466	−1.3
Wholesale Trade	40,491	880	−2.2	796	−2.0
Retail Trade	52,037	375	−.7	260	−.5
Business Services	25,917	538	−2.1	451	−1.7
Nonbusiness Services	248,821	2,119	−.9	1,595	−.6
Metro Totals	534,479	5,376	−1.0	4,403	−.8
Trade Area Periphery Sectors:					
Timber-Related	69,643	15,664	−22.5	15,661	−22.5
Other Ag. & Nat. Res.	35,035	1,325	−3.8	1,233	−3.5
Other Manufacturing	61,016	1,277	−2.1	1,141	−1.9
Transp., Communic., & Utilities	27,725	1,263	−4.6	1,123	−4.1
Wholesale Trade	19,458	1,555	−8.0	1,436	−7.4
Retail Trade	57,244	1,670	−2.9	993	−1.7
Business Services	13,188	1,107	−8.4	949	−7.2
Nonbusiness Services	260,946	6,852	−2.6	4,681	−1.8
Periphery Totals	544,255	30,713	−5.6	27,217	−5.0
Metro + Periphery Totals:	1,078,734	36,089	−3.3	31,620	−2.9

Notes: Sectors are as defined in the text (see table 7). Employment figures are 1982 IMPLAN estimates.

scenario (table 8, last column), 22% of periphery timber-related jobs will be eliminated, comprising 58% of total periphery jobs lost. While the nontimber periphery sectors each stand to lose only between 1.7% and 7.4% of sectoral employment, the combined impact on these sectors comprises 42% of periphery jobs lost. Specific government assistance programs most likely will be focused to mitigate the effects of timber-related job loss. However, those affected by loss of nontimber jobs will be just as unemployed as displaced timber workers. This is important to recognize when designing policy to assist workers displaced as a result of environmentally induced limits on natural resource harvest.

Some commentators have suggested that it is in the interest of Oregon communities to enhance their potential natural resource endowment by limiting timber harvest. They argue that by maintaining an attractive natural environment, communities can attract tourism and footloose business investment away from more crowded or despoiled regions. While it may be true that such a policy is necessary to attract tourism and modern high-wage, high-tech, amenity-oriented industries, it is probably not sufficient. It is likely that most of the development benefits resulting from a better environment in the region will accrue along the already dynamic Interstate-5 corridor, whereas most of the economic sacrifice will be felt in smaller, rural communities.

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Notes

[1] In keeping with Sessions et al., timber-related industries include: logging, sawmilling, plywood and veneer preparation, pulp and paper processing, and manufacture of other wood products. Admittedly, this classification understates the contribution of forests to the Oregon economy since it excludes use of forests for recreation and

nontraditional products (e.g., mushrooms), and also excludes forestry services (e.g., transportation, tree planting, etc.).

[2] These numbers are calculated from estimates of intermediate-term effects of timber harvest reductions reported in Sessions et al. This particular scenario was derived as the difference between the 10% harvest reduction and 20% harvest reduction scenarios (relative to the 1983–87 annual average) reported in their appendix I, tables 3 and 4, p. 177.

[3] Environmental IO models, as described in Miller and Blair (chapter 7), supplement standard IO economic accounts with rows and columns accounting for changes in physical stocks of resource inputs and/or environmental outputs. Richardson advocates inclusion of resource and environmental accounts as routine extensions to regional IO analysis. It has been correctly pointed out that we could have enhanced our analysis if we had incorporated resource and environmental accounts. However, unless these accounts were made endogenous to the model, the economic and ecological systems would not be truly integrated. A fully integrated economic-ecologic model, as proposed by Daly, would incorporate the necessary linkages between economic and ecologic subsystems. However, such a model has yet to be implemented due to the difficulty of acquiring ecological data to construct the intra-ecosystem submatrix. While the inclusion of resource and environmental satellite accounts would have provided an interesting and valuable extension to the regional economic accounts, without integrating the economic and environmental components, the resulting model would be no better suited to addressing our basic research questions.

[4] Using medical services as an example, there are some services that are supplied throughout the functional region and certain other services that are available only in medical facilities located in major urban places (e.g., major organ transplants). Even though rural areas supply some medical services, the very specialized services are available only in the urban center. When rural people travel to these centers to consume such services, an "export" of that medical service from the urban to the rural area is the result.

[5] IMPLAN is a data base and modeling system developed for the U.S. Forest Service for regional planning and impact analysis. IMPLAN uses estimated regional commodity purchase coefficients (rpc's) and secondary data estimates of regional commodity supply and demand to "regionalize" a national IO matrix. Using IMPLAN, it is possible to generate an IO model; to derive estimates of regional supply, demand, imports, and exports; and to perform economic impact analysis for any selected county or multi-county region in the U.S. IMPLAN is susceptible to the usual criticisms of IO models; e.g., it assumes fixed proportion production functions, perfectly elastic supply and demand schedules, and invariant production and consumption coefficients. In addition, IMPLAN can be criticized for employing other simplifying assumptions which enable the regionalization of the national technology matrix; e.g., regional industry production functions are assumed identical to the "national" (average) recipe, and each industry uses the same proportion of a given regionally produced commodity (i.e., rpc's are fixed across industries). For further information, see Alward et al.

[6] Earnings are defined by the BEA as the sum of employee compensation and proprietors' income (USDC/BEA 1988).

[7] By disaggregating income and consumption accounts according to income class, we have somewhat compensated for the admittedly strong assumption that marginal equals average propensities to consume. Total induced effects in this model are actually weighted averages of respending by the three income classes. Also, we have not erroneously assumed that all regional personal income is endogenously generated. In this model, a large proportion of income is derived from exogenous profits and transfer payments. When the regional consumption vectors are normalized with respect to these augmented personal income totals, the resulting average consumption propensities are considerably smaller than they would be if the normalization were with respect to only that portion of personal income which is endogenous. While we believe that household income and spending are important components of the regional economy, we are concerned over the potential this creates for inflating regional multipliers. Therefore, we have used what Miller and Blair refer to as "truncated output multipliers" (i.e., column totals net of the household income coefficients; see their p. 105) to estimate impacts under the different scenarios. This practice helps to minimize any likely inflation of regional multipliers.

[8] County estimates were constructed from projections of county employment losses multiplied by county job response coefficients (jobs per MMBF). Data for these calculations were obtained from Schamberger et al. (especially table 15, p. 50, and table 12, p. 47).

[9] The row-normalized, supply-driven IO procedure was considered but rejected due to incompatibility with our research problem. The behavioral assumption of the standard, demand-driven (column-normalized) model—that industry purchases of inputs from other sectors change in direct proportion to changes in final demand—is arguably more defensible than the corresponding assumption of the supply-driven version, i.e., that industry *sales* to other sectors vary in direct proportion to changes in factor supply. In a supply-driven IO system, changes in supply of a primary resource are fed forward throughout the entire economy, affecting all industries which directly or indirectly utilize the resource, regardless of whether or not substitute supplies could be easily imported. Use of a row-normalized IO framework to model the timber supply shortage would thereby have overestimated the likely regional impact by shutting down too much downstream economic activity.

[10] The results from Greber, Johnson, and Lettman summarized here were derived independently using the Oregon Economic Opportunities (OREO) simulation model. OREO uses a system of sectoral supply and demand equations incorporating econometrically estimated behavioral parameters to project annual employment and payrolls for Oregon timber and nontimber sectors. Inputs to OREO include current and lagged timber harvest estimates, a series of national indicator variables (*PPI*s, *CPI*, *GNP*, population, housing starts, etc.), and a summary of endogenous variables generated by the model for the previous year. A brief description of the OREO model is presented in Sessions et al., appendix II, pp. 181–83.

[11] See OR-DIRECT.WK1 and OR-TOTAL.WK1 electronic spreadsheet files provided by the U.S. Forest Service.

[12] "Nonbusiness services" include: financial services; insurance and real estate services; eating, drinking, and lodging; other services; and health services.

[13] "Services" include: transportation, communications, and utilities; wholesale and retail trade; financial services; insurance and real estate services; eating, drinking, and lodging; other services; health services; and business services.

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