United States Department of Agriculture

Forest Service

North Central Forest Experiment Station

General Technical Report **NC-82**

Estimating Economic Impacts of Timber-Based Industry Expansion in Northeastern Minnesota

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North Central Forest Experiment Station
Forest Service—U.S. Department of Agriculture
1992 Folwell Avenue
St. Paul, Minnesota 55108
Manuscript approved for publication September 24, 1982
1982

ESTIMATING ECONOMIC IMPACTS OF TIMBER-BASED INDUSTRY EXPANSION IN NORTHEASTERN MINNESOTA[1]

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Minnesota has found itself, not unlike other Lake States, in a situation where softwood supplies are decreasing. Pure softwood stands that are easily accessible and economically feasible to harvest are no longer readily available. Recent legislation closing the Boundary Waters Canoe Area to logging removed a substantial area of such stands. Much of the remaining softwood supply is not in pure stands but in mixed stands characteristically containing low-grade hardwoods such as aspen, birch, and balsam poplar. The softwood volume in many of these stands has been too small to harvest separately, but a large area of this mixed-species resource exists.

Fortunately, recent developments in the timber industry have introduced a technology to utilize this extensive resource. Waferboard, which can be made from a variety of hardwood species, promises to revitalize the Minnesota forest products industry in the 1980's. Consequently, what were once considered "low-value" hardwoods have suddenly become an important resource, in addition to providing an economically feasible means of getting at the scattered softwood supply.

Serious questions arise, however, with the advent of such a shift in the forest products industry. Unbalanced age class distributions as well as less than optimal distribution of species and cover types present two major problems forest managers must face in the near future. In addition, in the absence of proper silvicultural treatments, forest stands have become less productive and more susceptible to insect and disease attack.

Industry expansion must be paced to match the availability of necessary species and the means of sustaining their harvest over time. Regional labor supplies and the necessary capital for investment could both become limiting factors with too high a level of development. On the other hand, the potential for increased socioeconomic benefits should be evaluated. New jobs, increased industrial growth, and a revitalization of the wood industry can contribute to increased regional economic stability. Forest managers and other decisionmakers need information about the timber resource, potentials for industrial development, and the socioeconomic impacts of potential developments in order to make plans for the future.

A recently completed forest inventory of Minnesota's forests (Spencer and Ostrom 1979) provides detailed information about the forest resource. Also, a newly developed Forest Resources Evaluation Program (FREP) tree growth projection system (USDA Forest Service 1979) provides detailed inventory projections, with and without timber harvesting, to aid in examining the impact of harvest options on the resource. The FREP system mimics the biological function of tree growth over time, allowing growth

[1]*This work was carried out under a cooperative agreement between the USDA Forest Service—North Central Forest Experiment Station, and the University of Minnesota.*

simulations of timber stands and projections of timber volumes standing (and perhaps removed) at some point in time.

Any increase in forest activity, such as increasing the allowable cut, will also have regional socioeconomic impacts. These impacts are not always easy to identify at first glance, but they can be evaluated using a submodule of the Minnesota Regional Economic Impact Forecasting and Simulation (REIFS) model (Maki *et al.* 1979). Developed by personnel in the Department of Agricultural and Applied Economics, University of Minnesota, the model forecasts changes in the economy over time, either with or without major changes by man. That is to say, either the status quo is maintained over time with some assumed level of annual increase (e.g., a 4-percent increase in GNP/year), or substantial changes are made over time, perhaps to simulate the advent of new technology or markets.

The question arises, then, as to how one might link these two models in order to investigate various alternative timber management opportunities. Each alternative may or may not be associated with substantial regional economic impacts. Will new jobs be created? What will be the effect over time on the service industries by expansion in one sector? How will changes in the timber industry influence regional demographics in 20 years? The answer to the linkage question lies in the development of scenarios based on the output of the timber resource evaluation system (fig. 1).

This paper reports the results of a joint study by the University of Minnesota College of Forestry and the North Central Forest Experiment Station (USDA Forest Service) designed to:

(1) Develop methods of linking the FREP Lake States Tree Growth Projection System to the Minnesota Regional Economic Impact Forecasting and Simulation model for regional economic analysis, and

(2) Test these methods in northeastern Minnesota for a selected forest type by identifying a potential forest management strategy and evaluating its regional economic impact.

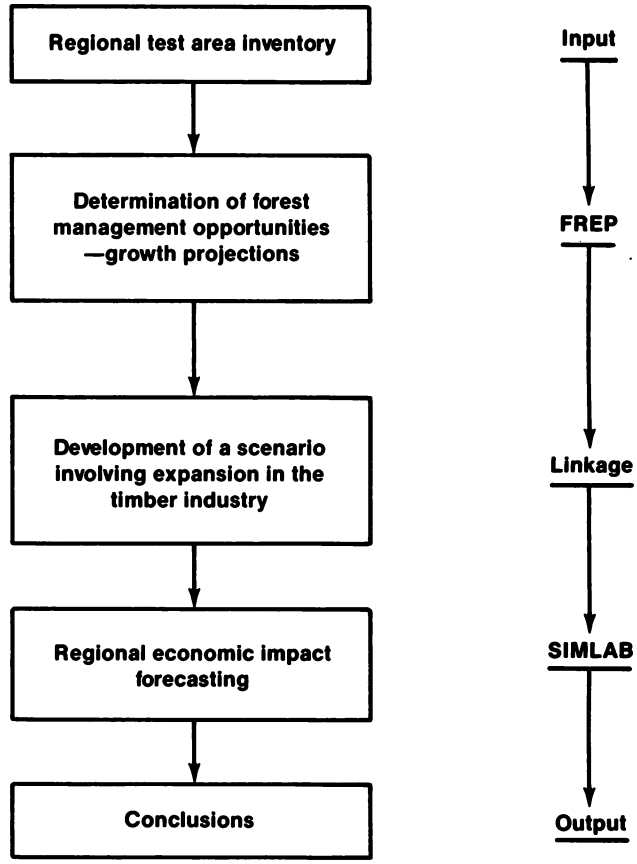

Figure 1.—*Overview of study.*

MODEL DESCRIPTIONS

The FREP Tree Growth Projection System

One does not need to argue at great length about the advantages of growth projection models. At a time when the forest resource land base is dwindling, the ability to utilize models in which the timber resource can be manipulated via simulation is extremely useful. With a resource that is far too valuable to experiment with through trial and error, such simulation models aid researchers and forest decisionmakers by giving them the ability to, in effect, see into the future and realize the consequences of decisions made today (Shannon 1975).

The main element of the FREP tree growth projection system is its growth processor. Because the data base being worked with is a collection of forest inventory plots, the ability to predict growth on these plots is essential. The system developed by the North

Central Forest Experiment Station is an individual tree growth model. Such models have been widely used and discussed in the literature (for example, Arney 1974, Daniels and Burkhart 1975, Ek and Monserud 1974, Heggi 1974, Mitchell 1975). The FREP system is able to handle such forest management options as precommercial thinnings, partial cuttings, etc., as well as a stand's response to these activities (for a detailed description, see USDA Forest Service 1979).

The Minnesota Regional Economic Impact Forecasting and Simulation (REIFS) Model

The study of regional economics has been greatly enhanced by the use of the input-output model approach. The input-output table, representing an industry's role as a purchaser of goods in order to sell goods, is the heart of the model. The investigator constructing the table must become familiar with the regional economy (i.e., inter-industry transactions), if the model is to be of any value. If the table mirrors the region accurately, the analyst can experiment with hypothetical or expected changes in economic activity and examine the implications for industry outputs. Such changes may be linked to alternative government policies and programs or to different projections of investment behavior (Isard 1969). Further discussion of input-output model theory can be found in texts by Miernyk (1965), Leontief (1966), and Richardson (1972).

Applications to the forestry community are widespread (for example, Flick 1974, 1976; Hughes 1970, Kaiser 1969). The advantages of being able to predict direct and often more importantly indirect impacts resulting from industrial change can be numerous. With large industrial expansion (i.e., new forest products facilities), regional development may be significant.

The Minnesota Regional Development Simulation Laboratory, or SIMLAB, is the computer-based simulation module of REIFS consisting of the core regional input-output model. REIFS includes, in addition to the production module (i.e., input-output), the demand forecasting modules, auxiliary modules, operational control modules, and SIMLAB II, the interactive module. The demand forecasting modules include the export market, regional investment, and regional demand. Value added, employment, labor force, population, and households are all contained as auxiliary modules. For further description of REIFS, the SIMLAB User's Reference Manual is helpful (Maki *et al.* 1979).

NORTHEASTERN MINNESOTA TEST PROJECTION

The first phase of the study was to pick an area of Minnesota where forest management opportunities exist. USDA Forest Service Survey Unit 1, the Aspen-Birch Unit, was selected because the most up-to-date and complete data base for the regional economic impact model was available for this area (fig. 2). Table 1 shows the total land area by county along with the associated percentages of forest and commercial forest land (Arrowhead Regional Development Commission 1978).

In making a projection of this nature, one must identify what it is that may be of interest. In this instance, two observations were selected: (1) a comparison between two growth projections, one assuming timber harvest when silviculturally desirable, the other assuming no management activity at all, and (2) an indication of the harvest potential beyond the current level of cut.

As a start it was decided the projection would be made using the 1977 Minnesota inventory data. The two runs, with and without management, would project only plots of the aspen cover type in State ownership for one 10-year period. In both cases the plots would be brought up to 1980 as a starting point. Stand volumes by age and site were recorded, and the 10-year projection begun. When year 1990 was reached for both runs, the stand volumes were recorded, although in the management projection the appropriate silvicultural treatment, as built into the model, was carried out prior to the final stand tally. Consequently, the management run not only reflects the stand volumes in 1990 after harvest but also the removal volumes (table 2a). The acreage represented by each site index and age class combination is shown in table 2b.

Projection Observations

As noted, two management options were investigated in this test case.

In the no-harvest projection, the imbalances between age classes that existed in 1980 are continued. Additionally, not only is there an even larger standing volume of aspen type in the 45-65 year age class, but the 75 years and older age class also continues

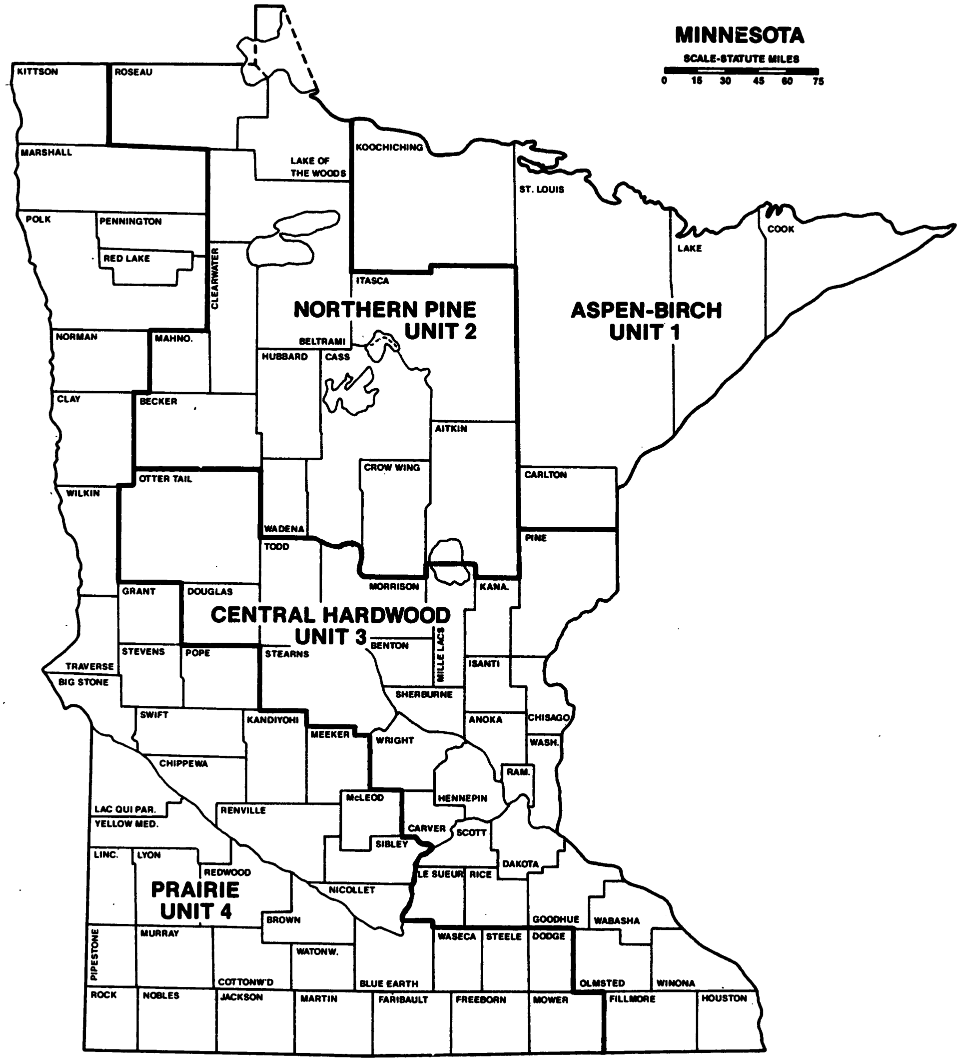

Figure 2.—*Boundaries of USDA Forest Service Survey Units 1-4.*

Table 1.—*Total land area, forested land, and commercial forest land, Region 1*

County	Land area	Forested	Commercial forest land
	Acres	*Percent*	
Carlton	551,800	61	57
Cook	861,400	99	74
Koochiching	2,001,300	89	63
Lake	1,319,800	96	73
St. Louis	3,899,100	83	68
Total	8,633,400	72	68

growth. This allows for overmature stands to become ready targets for insect and disease infestation, even beyond the maximum suggested rotation age of 70 years if sawtimber or veneer products are the desired ends (Perala 1977).

The managed run shows the removals for timber, especially in the oldest age grouping, in addition to a substantial reduction of volume in the middle-age category, across all site indexes. This balancing out reflects the need to manage according to site and geographical limitations with respect to rotation age. This is, in effect, cashing in on the resource instead of losing it to deterioration by natural causes. It should be pointed out that the decrease in volume in the 35 years and below age group (for both the no-management and management runs) is caused by mortality in the former and also thinning in the latter. Hence, natural removals equal management removals on those sites where stands are overstocked.

Simulated removals on state-owned aspen lands from 1980-1990 total 2,286,500 cords, an average of

Table 2a.—*Ten-year FREP growth projections for state-owned stands in Minnesota's aspen type, with and without management*

(In thousand cords)

Site index		Age class (years)			
		35 and below	45–65	75 and above	Total
Less than 40	1980	7.3	0	10.2	17.4
	1990 no management	11.6	0	11.6	23.2
	1990 managed	11.6	0	0	11.6
	Removals	0	0	10.2	10.2
40 to 59	1980	102.2	293.6	51.1	446.8
	1990 no management	117.8	335.5	126.5	579.8
	1990 managed	117.8	137.5	57.3	312.6
	Removals	0	180.8	51.1	231.9
60 or Greater	1980	813.8	1,730.6	281.7	2,826.2
	1990 no management	613.9	2,237.6	736.8	3,588.3
	1990 managed	613.9	643.2	71.9	1,329.0
	Removals	322.4	1,440.3	281.7	2,044.5
Total	1980	923.3	2,024.2	343.0	3,290.4
	1990 no management	743.3	2,573.1	874.9	4,191.3
	1990 managed	743.3	780.7	129.2	1,653.2
	Removals	322.4	1,621.1	343.0	2,286.5

Table 2b.—*Acreage represented by each site index and age class combination for 10-year FREP growth projections*

Site index	Age class			
	35 and below	45–65	75 and above	Total
Less than 40	1,451	0	1,451	2,902
40 to 59	18,404	28,454	9,831	56,689
60 or greater	49,167	94,299	27,705	171,171
Total	69,022	122,753	38,987	230,762

229,000 cords annually. The available data for current removals on the same lands show roughly 64,000 cords for a 1-year period.[2] This indicates that current cutting levels of aspen type on state-owned land are approximately 165,000 cords short of the potential cut. Figure 3 shows the historical trend of aspen removals on all ownerships in comparison with birch and miscellaneous hardwood types. These non-aspen types are also acceptable in the manufacture of waferboard. This observation, coupled with the desirability of balancing age classes and the fact that the category here (aspen type, state ownership) is just a portion of the resource potential (see table 3), would indicate that opportunities do exist for more intensive management of the forest resource.

[2]*Timber sales data (by permits) during fiscal year 1977-1978, Region 1, State of Minnesota Department of Natural Resources, Division of Forestry, St. Paul, Minnesota.*

Sustainability Concerns

Sizeable investment in a business will not occur if availability of the required raw material cannot be ensured in the long run. One may ask in this example, then, whether an additional 165,000 cords of aspen type can be cut annually on state-owned land over a long enough period to sustain a given wood products industry and at the same time be acceptable to the public.

To enlarge the resource base, the test case was expanded to include aspen lands in county and private industry ownership. Again utilizing the 1977 inventory data for Survey Unit 1, a volume regulation model was chosen to determine a sustainable cutting level over time. Based on a method developed by Barnes (1951) and modified by Rose and Burk (1980) for determining an initial estimate of allowable cut, the iterative process (tabular check) was

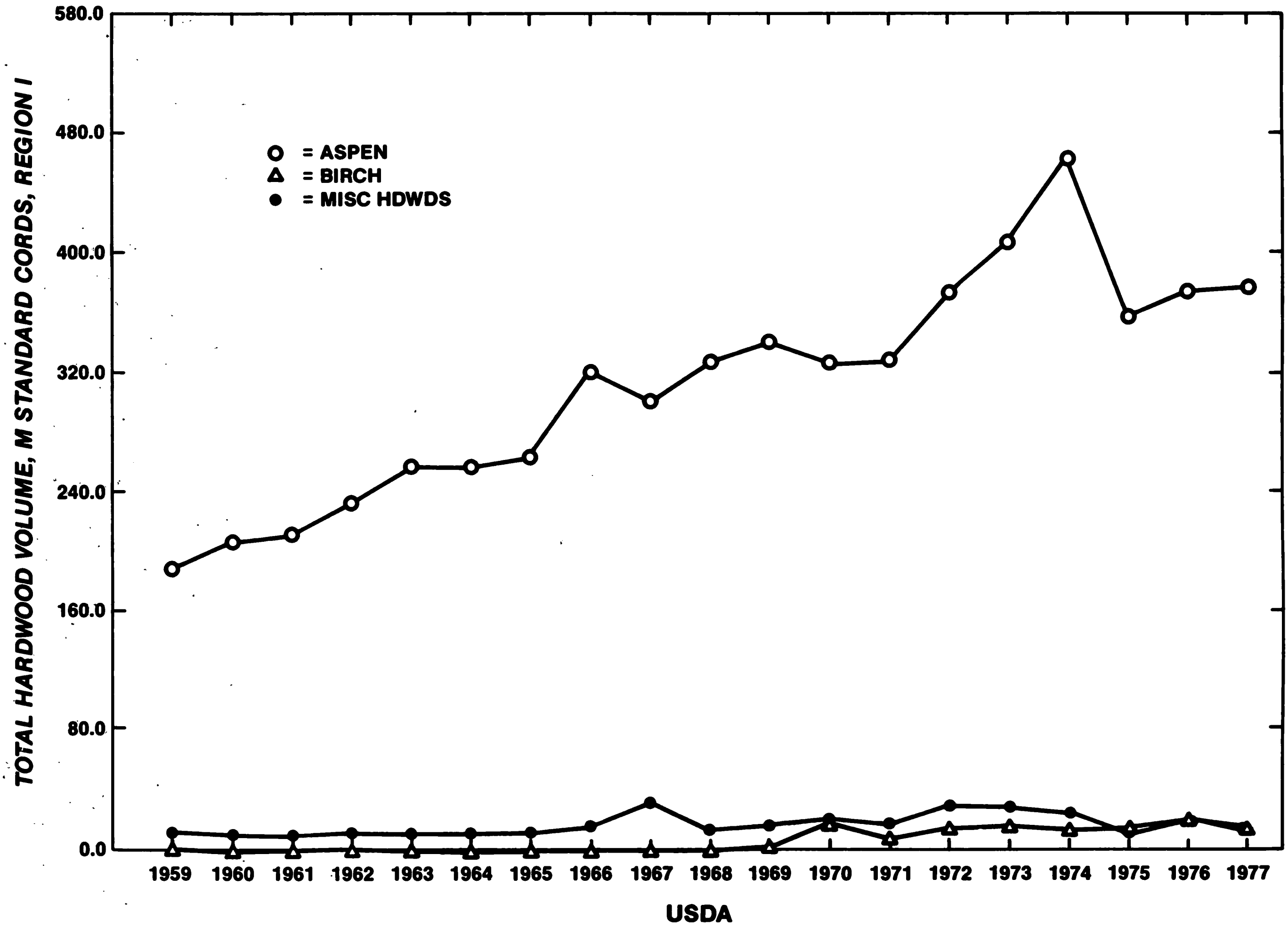

Figure 3. *Pulpwood production for USDA Forest Survey Region 1 from 1959 to 1977, all ownerships.*

carried out to the point where the entire inventory of a stand was cut once in one rotation. The model was applied to the aspen cover type, this time on State, county, and forest industry inventory plots. The allowable cut priorities in the model were the oldest stands first, with those on the best sites receiving top priority.

The imbalance of the age classes in the present aspen stands in northeastern Minnesota is obvious (fig. 4). This highlights the problems to be encountered in the future when set volumes are needed and deficits may occur. Through regulation, a gradual trend toward even-aged management can be achieved (figs. 4-6). Figure 5 shows this nearly accomplished after roughly one rotation (70 years). The simulation shows growing stock volume inventories (fig. 7) declining over the first 20 years and gradually rising to a higher, more stable equilibrium level. The allowable cut (fig. 8) rises rapidly over the first 30 years, eventually leveling off to greater than 550,000 cords per year on aspen cover type alone. This long-run sustainable yield level is more than 150,000 cords above current consumption (fig. 3).

Additional volumes are available from other hardwood cover types, such as birch (table 5), but lack of appropriate stand growth models prevented analysis of long-term sustainable yields of these hardwoods. Another estimate of their potential available volume can be obtained, however, from comparing current growth with current utilization. Net annual growth of all hardwoods excluding aspen is almost 290,000 cords annually (Spencer and Ostrom 1979), while only a fraction of this annual growth is currently being utilized (fig. 3).

All surplus volumes are based on conventional volume measurements. If total tree harvest were implemented, an additional 30 percent of volume could be added to all the stated surplus figures. The same percentage of extra biomass could potentially also

Table 3.—*Hardwood inventory summary for Region 1, by ownership*

	Cover type	State	County	Forest industry	All
Acreage	Aspen	257,065	475,222	209,078	1,562,053
	Aspen>50 yrs.	86,641	119,395	57,178	430,942
	Other hardwoods	168,839	313,718	110,298	1,031,746
	All hardwoods	425,904	788,940	319,376	2,593,799
Merchantable volume (Cords)	Aspen	3,089,183	5,267,157	2,384,874	16,517,283
	Aspen>50 yrs.	1,513,407	1,819,415	1,019,717	6,682,647
	Other hardwoods	1,997,062	3,641,195	1,138,346	11,388,416
	All hardwoods	5,086,245	8,908,352	3,523,220	27,905,699
Harvestable biomass (Green tons)	Aspen	9,574,338	16,659,387	7,484,716	52,258,621
	Aspen>50 yrs.	4,637,238	5,789,155	3,200,445	20,883,598
	Other hardwoods	6,532,225	12,156,842	3,900,162	37,997,587
	All hardwoods	16,106,593	28,816,229	11,384,878	90,256,208
BTU's x 10^6 Based on harvestable biomass	Aspen	92,200,874	160,429,899	72,077,817	503,250,522
	Aspen>50 yrs.	44,656,621	55,749,589	30,820,305	201,109,077
	Other hardwoods	69,856,622	133,762,229	42,264,839	416,687,217
	All hardwoods	162,057,496	294,192,128	114,342,656	919,937,739
Megawatt years Based on harvestable biomass	Aspen	832	1,449	651	4,421
	Aspen>50 yrs.	400	502	276	1,751
	Other hardwoods	632	1,208	382	3,689
	All hardwoods	1,464	2,657	1,033	8,110
Residual harvestable biomass (Green tons)	Aspen	2,623,676	4,808,284	2,118,750	15,094,734
	Aspen>50 yrs.	1,232,072	1,695,471	906,082	5,847,642
	Other hardwoods	1,739,307	3,417,974	1,168,132	10,665,389
	All hardwoods	3,899,605	7,436,184	2,929,150	23,282,530
BTU's x 10^6 Based on residual harvestable biomass	Aspen	25,271,247	46,313,392	20,407,800	145,392,478
	Aspen>50 yrs.	11,867,318	16,330,777	8,727,328	56,324,488
	Other hardwoods	18,262,713	35,888,727	12,265,386	111,986,679
	All hardwoods	85,805,247	78,079,932	30,756,075	244,466,565

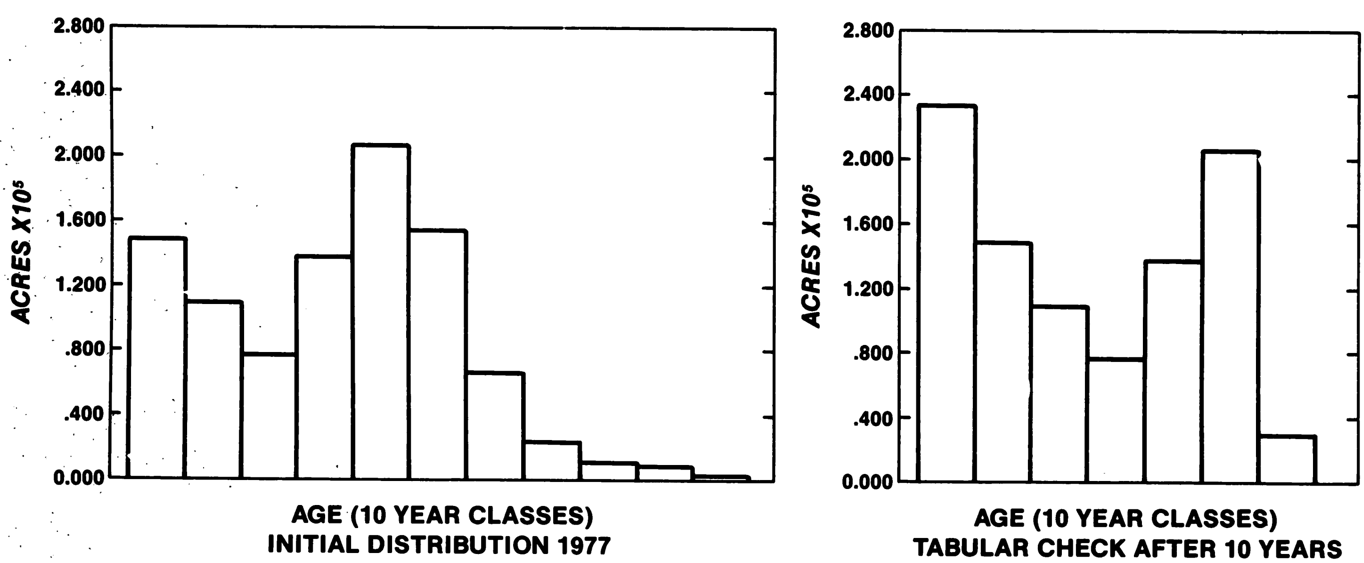

Figure 4.—*Initial (1977) age class distribution for the aspen cover type on State, county, and forest industry land in Region 1, and distribution after 10 years of volume regulation.*

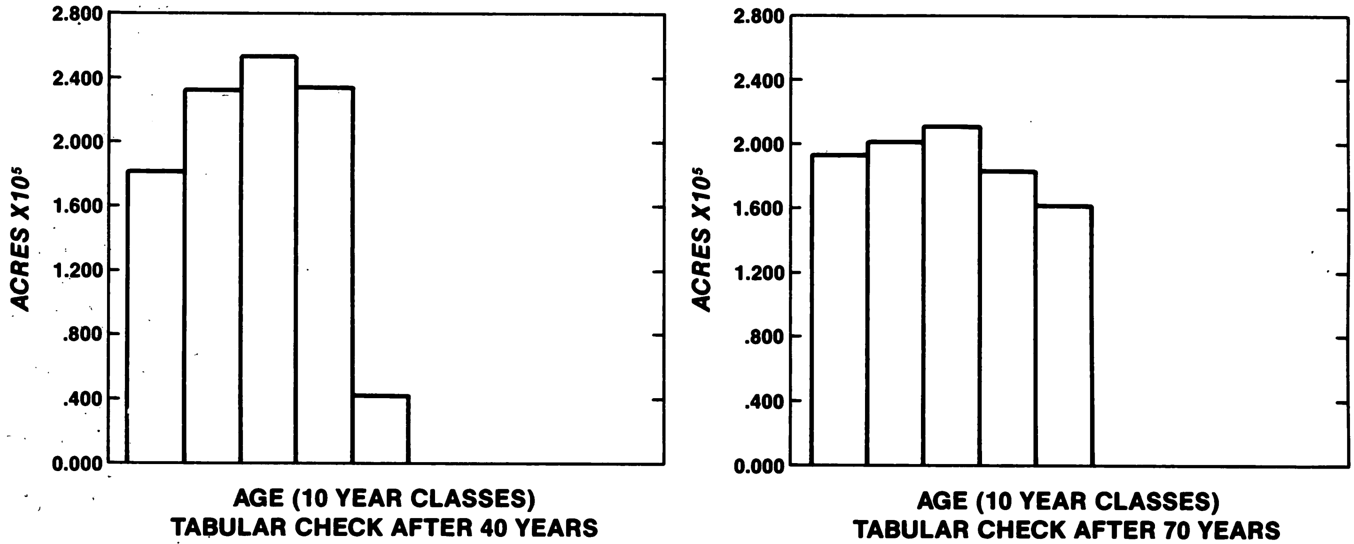

Figure 5.—*Age class distribution for the aspen cover type on State, county, and forest industry land in Region 1 after 40 and 70 years of volume regulation.*

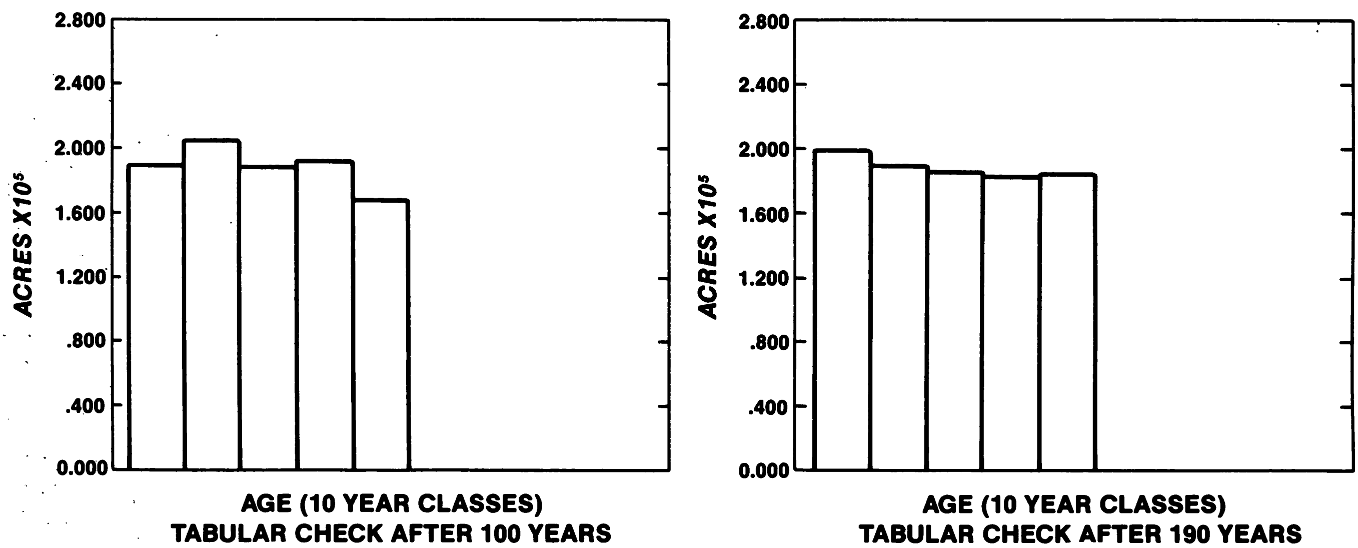

Figure 6.—*Age class distribution for the aspen cover type on State, county, and forest industry land in Region 1 after 100 and 190 years of volume regulation.*

be removed from timber stands currently being harvested and not considered surplus in our analysis. Thus, the potential for forest industry expansion in Survey Unit 1 appears to be substantial.

Linkage Between Models

At this point, the growth projection has indicated biological opportunities for increased timber harvests. The output is expressed in cord volumes by cover type. To determine the economic impacts of such increases on the region, these values must be incorporated into the regional economic impact forecasting system, which would show how an expanded timber industry based on these timber volumes would affect the various sectors of a region's economy. Lundgren and Essex (1979) have shown the interrelatedness of major components (fig. 9) of a timber resource evaluation program designed to investigate economic impacts. Based on management alternatives, these economic impacts are the basis for future plans and programs. A scenario of industrial expansion can be devised in which the timber harvest volume indicated by the resource evaluation system is

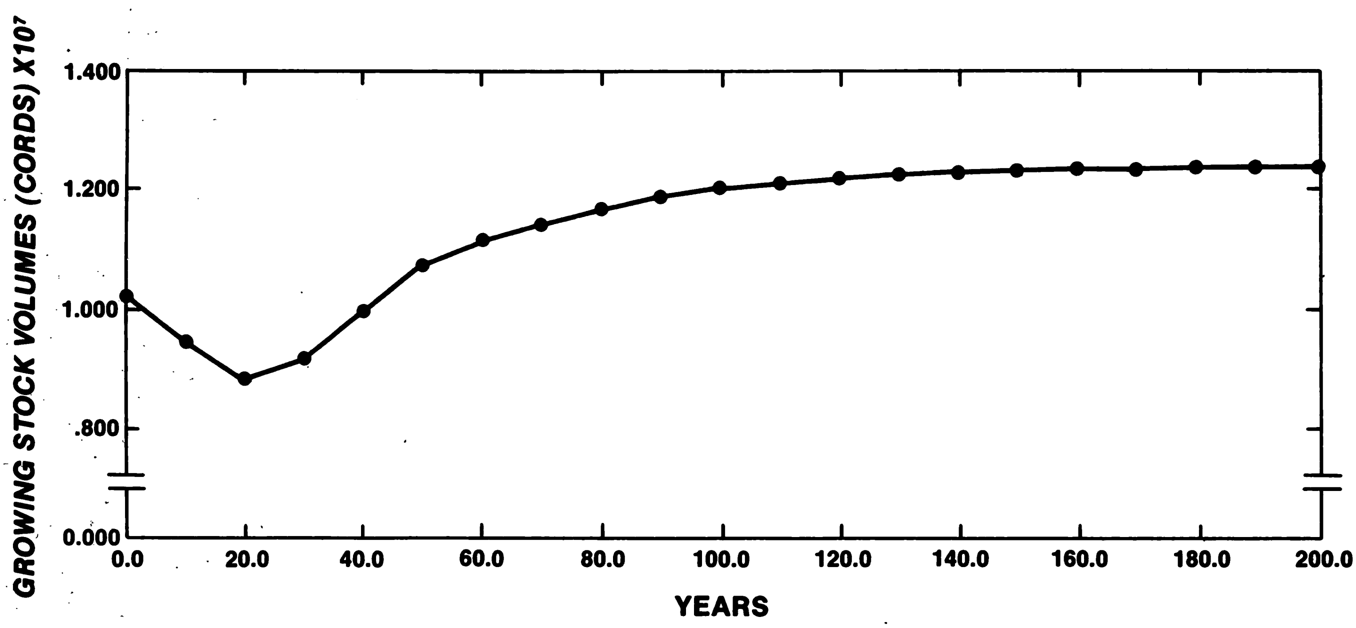

Figure 7.—*Total growing stock volumes for the aspen cover type on State, county, and forest industry land in Region 1 under volume regulation.*

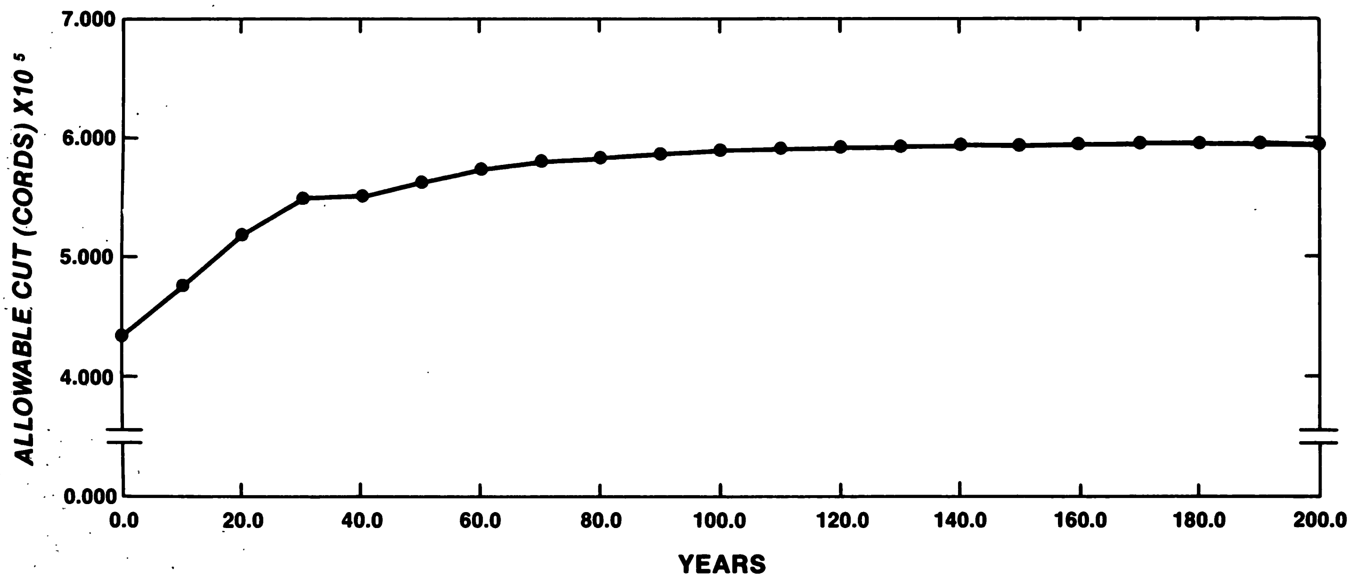

Figure 8.—*Allowable cut volumes for the aspen cover type on State, county, and forest industry land in Region 1 under volume regulation.*

utilized. The scenario is the link that transforms cord volumes into associated employment and sector expansion—the socioeconomic variables of interest.

Scenario Development

To maintain a realistic scenario of expanded industrial development, it was necessary to investigate potential markets. Although aspen is an important species for pulpwood in the Lake States, the aspen resource has suddenly found an expanded use in the waferboard industry. Largely coincidental to this study, announcements began cropping up of studies to determine plant locations and of planned groundbreaking ceremonies (Duluth News-Tribune 1978, 1979a; Minneapolis Tribune 1979). Even the one producing waferboard plant in the United States announced its expansion in Grand Rapids, Minnesota (Duluth News-Tribune 1979b).

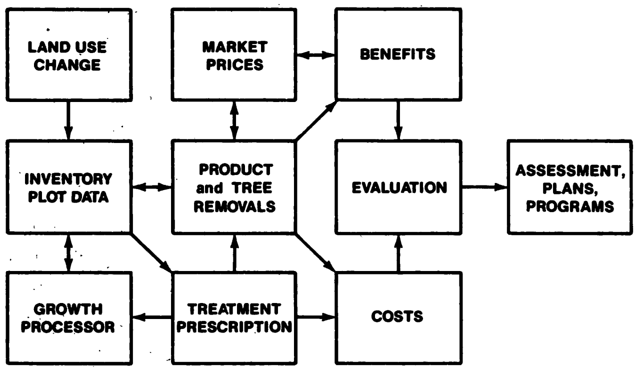

Figure 9.—*Major components of a timber resource evaluation system for economic analysis (Lundgren and Essex 1979).*

The logical industry had appeared and showed promise for the future. It has been predicted that the average variable costs of Minnesota waferboard, a product that competes favorably with plywood, will remain at 57 to 58 percent of southern plywood costs and 51 to 54 percent of western plywood costs through 1985 (Fuller and Veltkamp 1979). Another possible user of the harvested biomass could come in the form of a wood-fired electrical generation plant, an interim measure to help meet regional energy needs (Rose and Olson 1979).

The initial plan was to determine the economic impacts of just one new facility within the region. However, it was later determined that because the data base used for the economic projection included three counties outside of Survey Unit 1, the impact of one such facility would have a minor impact on an area of this size. Many land-use planners have observed political boundaries overlapping economic development boundaries, as is the case here. Douglas County, Wisconsin, is intimately associated economically with the Duluth area (St. Louis County, Minnesota); the other two Counties included in the regional impact study are Itasca and Aitkin in Minnesota.

To demonstrate economic impacts over a region of this size it was necessary to consider more than one new industrial facility. Thus, the scenario of development assumed introduction, over a 10-year period, of four waferboard plants and one electrical generation plant fired by wood. A facility would be introduced every 2 years, the first one beginning construction in 1980 and the last one opening on January 1, 1990. The plant locations are not site-specific; they must only lie within the economic development region boundaries. Each type of industrial facility has its own input requirements. These inputs include not only wood as a raw material, but also the construction, labor, and capital investment needed to bring the facility into operation. All must be addressed, as they may or may not influence the regional economy. The exact development schedule (fig. 10) and the specific input requirements for the economic evaluation simulated via SIMLAB are detailed in the following sections.

Year	Industrial activity	Facility opening
1980	Construction of waferboard plant #1—approximately 2 years	
1981		
1982	Construction of 25 MW wood-fired electrical generation plant—approximately 2 years	WAFERBOARD PLANT #1 opens January 1, 1982, averaging ½ of full production in 1982.
1983		Waferboard Plant #1 at full production in 1983.
1984	Construction of waferboard plant #2—approximately 2 years	POWER PLANT opens January 1, 1984.
1985		
1986	Construction of waferboard plant #3—approximately 2 years	WAFERBOARD PLANT #2 opens January 1, 1986, averaging ½ of full production in 1986.
1987		Waferboard Plant #2 at full production in 1987.
1988	Construction of waferboard plant #4—approximately 2 years	WAFERBOARD PLANT #3 opens January 1, 1988, averaging ½ of full production in 1988.
1989		Waferboard Plant #3 at full production in 1989.
1990	No further industrial expansion	WAFERBOARD PLANT #4 opens January 1, 1990, averaging ½ of full production in 1990.
2000	End of projection, December 31.	Waferboard Plant #4 at full production in 1991, as are others to year 2000.

Figure 10.—*Timetable for industry expansion over a 10-year period.*

Waferboard Plant

"Structural grade particle board," "flakeboard," or "waferboard," basically refer to the same type of product. The difference lies in the actual chip used in the manufacturing process and the grain direction in the chip—i.e., the way it is cut from the log. Waferboard uses a "wafer" that is large and square with the grain parallel to the plane of the cut. This is accomplished by feeding the log in sideways and chipping it from the side, rather than feeding the butt of the log into the chipping drum (Vajda 1978). Consequently, roundwood must be delivered to the plant and chipped, rather than being chipped at the landing. Hence, whole tree chipping in the woods for a waferboard product cannot be done with current technology.

With introduction of a new waferboard facility, construction activity, increased gross output in the wood products sector, increased transportation via truck freight to haul the product, and expanded output in the logging sector would all combine to create jobs and increase the cash flow in the region. Changes in these four sectors become inputs for the SIMLAB projection.

Construction

The announced costs of a plant producing 150 mm to 170 mm ft² (⅜-inch thick basis) range from $30 million to $37 million in current dollars (Minneapolis Tribune 1979). An average of $32.5 million was used in this example for the capital costs of a plant producing 150 mm ft² (⅜-inch thick basis) per year. This figure includes imported capital (equipment) not available in the region, in addition to the costs of construction. Because equipment must be purchased, in most cases, outside the State, it must be excluded from the economic impact assessment. The reason, of course, is that the money expended will not flow into northeastern Minnesota. The percentage of the total capital costs spent on equipment is sizeable—55 percent is used here (Stearns-Roger Corporation 1970). Hence, actual regional construction costs are:

Capital costs (1979 dollars)	$32.5 million
Less 55 percent supplied from outside northeastern Minnesota	$17.88 million
Regional construction costs	$14.63 million

All costs are expressed in 1970 dollars for the base year data in SIMLAB. Using the Consumer Price Index (CPI) as a deflator, this cost becomes $5.58 million in 1970. Plant construction proceeds over a 23-month period, hence this figure is divided equally to represent a yearly expenditure.

Wood products sector output

The new industry adds a gross output by selling its product in the marketplace. The gross value was estimated in this example by obtaining the current retail price per unit of the product in the Minneapolis-St. Paul market area, then stripping back to a wholesale price, FOB at the mill. This was done by using cost-of-doing-business ratios for retail and wholesale margin determination, and finally subtracting out an estimated cost per unit for transportation. The Appendix shows the procedure and calculations in detail. Again using the CPI as a deflator, the value of gross output becomes $2.34/ft³ in 1970 terms or $73.125/M ft² (3/8-inch thick basis).

The first year of operation for each plant assumes only 50 percent of full production. By the second year, efficiencies of manpower and equipment allow for full production at 150 MM ft².

Transportation sector output

With the advent of the new product, some sort of increased activity will occur in the freight sector. The only presently operating waferboard plant in Minnesota (Grand Rapids) utilizes contract trucking to deliver its product to market. The scenario devised here assumes the Twin Cities to be the delivery point (for further distribution). Estimates of trucking rates were based on those charged the current waferboard manufacturing company (Grand Rapids to the Twin Cities);[3] the rates were inflated linearly to roughly represent the distance from Virginia, Minnesota, to the Twin Cities. Because this study does not specify plant locations, Virginia, due to its central location in the region, was selected as an average.

The value, then, is expressed per unit output. In 1979 dollars, it equates to $0.28/ft³ of waferboard produced (1,000 ft³ = 32,000 ft² on a ⅜-inch thick basis). In the first year of operation (i.e., 50 percent of full production), output in the transportation sector is $347,867 in 1970 dollars and twice that amount when full production is reached.

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[3]*Personal communication, Mr. Eldon Keehr, Intrastate tariffs, Minnesota Department of Transportation, November 5, 1979.*

Logging sector output

Input requirements (i.e., cord volumes) per unit output had to be determined to get an estimate of gross output for the logging sector of the economy. By then assigning the average price for a delivered cord of aspen, a rough estimate could be made. The average price for aspen at the time of this simulation was \$26/cord, delivered (Minneapolis Tribune 1979). The input requirement, cords/M ft^2 (⅜-inch thick basis), was obtained two ways. Rough quoted estimates of cords consumed per year by a waferboard plant of the same size placed the figure around 780 cords/MM ft^2 (Fuller and Veltkamp 1979). Using a transformation formula for flakeboard (1,235 kg dry wood input per ton output), an estimate of 771 cords/MM ft^2 was obtained (Vajda 1975). For this study, then, 800 cords/MM ft^2 (⅜-inch thick basis) was used as the waferboard input requirement estimate.

25 MW Wood-fired Power Plant

The only differences in terms of sector changes for a new power facility versus a waferboard plant are a different intensity of construction, additional gross output in the electric utility sector, and a different wood requirement per unit output. The transportation sector is not noticeably influenced by the new plant, although nearly all sectors of the economy will reflect some change resulting from industrial expansion. This will be discussed further in the impact assessment section.

Construction

Plant construction costs for a 25 MW wood-fired power facility were estimated at \$8,611,000 in 1973 dollars (Stearns-Roger Corporation 1970). Equipment costs were estimated to be 57 percent of this figure, leaving \$2,814,790 in 1970 dollars. Based on a 20-month development schedule, this figure would be divided in half, as were the waferboard plant costs, to represent an annual expenditure over 2 years.

Electric utility sector output

Gross output was based on the assumption that the power plant would run 365 days a year, 24 hours a day. It was further assumed the plant would generate, on the average, at 80 percent of full capacity. Rates in effect in 1970 for residential usage were obtained from past records.[4] The gross output in 1970, then, is:

$$25 \text{ MW} \times 0.80 \text{ (percent load)} \times 8{,}760 \text{ hrs/yr} \times \$0.028 \text{ KWhr} \times 1{,}000 \frac{\text{KW}}{\text{MW}} = \$4{,}905{,}600.$$

Logging sector output

Wood requirements at full load were found to be 106,775 cords/year (Olson 1978). At 80 percent of capacity, roughly 85,000 cords are required. This is the input value used in this study. Actually, a plant could get by with less, as all biomass is burned (i.e., whole tree harvesting). This reduction could be as much as 45 percent.

In view of the development scenario, timber volume requirements are summarized by year through the projection period (table 4). Also shown is the value of the output in this sector, using the \$26/cord present worth deflated by the CPI to 1970. Although it is not input into the SIMLAB projection, man-hours per year required to carry out the corresponding annual harvest is also indicated. This is based on a 0.89 cords/man-hour estimate (Biltonen *et al.* 1976) that includes all workers involved in such a full-time harvesting system. It is included to indicate the magnitude by which jobs may be increased by accelerating timber harvest activities. The input-output model uses its own transaction coefficients to determine changes in the other sectors.

Adjustments to Transportation and Logging Sector Outputs

The wood products sector (gross output) and to a lesser extent the electrical products sector are the main driving forces for economic changes in this scenario. In both instances, these industries are relatively new. Because SIMLAB uses an input-output analysis based on historical industry transaction information, it is not as sensitive to inter-industry transactions given the new industry component. For example, the input-output ratio (i.e., transaction coefficient) representing the amount purchased from the logging sector in order to produce \$1 of product by the wood products industry was too low. The model did not adequately account for total purchases—timber input—required to make the waferboard or electrical products. This was also true of the transportation sector output. Consequently, the transportation

[4]*Personal communication, Ms. Elizabeth Dupay, Rates Department, Northern States Power. November 12, 1979.*

Table 4.—*Cord requirements for development scenario by year with associated gross output for the logging sector and man-hours/year required for harvest operation.*

Year	Timber requirements	Gross output in logging sector	Man-hours/year[1]
	Cords	*1970 million dollars*	*Thousand*
1980			
1981	120,000	1.65	107
1982	120,000	1.65	107
1983	205,000	2.83	183
1984	205,000	2.83	183
1985	325,000	4.48	290
1986	325,000	4.48	290
1987	445,000	6.13	397
1988	445,000	6.13	397
1989	565,000	7.79	505
1990	565,000	7.79	505
	yearly to 2000	yearly to 2000	yearly to 2000
2000			

[1]Assumed: 2,000 man-hours/year average, hence 1990 figure translates into approximately 253 man-years of employment.

and logging sector figures were adjusted to show those increases in gross output that the model did not account for internally.

The Appendix includes an example showing how these adjustments were made. Table 5 cites the values by sector and year used as inputs to modify the economy of the study region in the SIMLAB test projection.

Projection Results

According to the schedule, changes were made to the study area's economy corresponding to industrial development. Industrial classifications were broken down into sectors for the test projections (table 6). The baseline projection represents events as they would evolve in the absence of timber industry expansion. The development projection is compared against this and any deviation from the baseline noted. Based on the development scenario, the changes in final demand (table 5) were made in the appropriate years of the projection. The construction, logging, wood products, truck transportation, and electrical service sectors (i.e., sectors 12, 15, 16, 35, and 38, respectively) were those incurring the simulated direct economic activity. The total variable effect (e.g., employment), as represented in tables 7-11, is the sum of the values for the baseline and the development impact deviation. Five of the program output tables (total population, total employment, gross output, total earnings from wages and salaries, and totals in capital stock investment) were summarized and are discussed next.

Table 5.—*Scenario input to modify economy of test region by sector and year*

(In 1970 dollars)

Year	Activity	Construction costs	Wood products sector output	Electrical product sector output	Adjusted transportation sector output	Adjusted logging sector output
1970		(0)	(0)	(0)	(0)	(0)
1980	(Construction waferboard plant #1)	2,790,000				
1981		2,790,000	5,484,000			
1982	Waferboard plant #1 opens 1/1/82	1,407,000	10,969,000		332,283	616,590
1983	(Construction power plant)	1,407,000	10,969,000		664,568	762,991
1984	Power plant opens 1/1/84	2,790,000	10,969,000	4,906,000 yearly to 2000	664,568	762,991
1985	(Construction waferboard plant #2)	2,790,000	16,453,000		664,568	2,412,991
1986	Waferboard plant #2 opens 1/1/86	2,790,000	21,938,000		996,846	1,379,580
1987	(Construction waferboard plant #3)	2,790,000	27,422,000		1,328,126	1,995,981
1988	Waferboard plant #3 opens 1/1/88	2,790,000	32,906,000		1,660,409	962,571
1989	(Construction waferboard plant #4)	2,790,000	38,391,000		1,992,691	1,589,161
1990	Waferboard plant #4 opens 1/1/90	(0)	43,875,000		2,324,971	555,562
1991	No additional industrial development		(43,875,000 yearly to 2000)		(2,657,254 yearly to 2000)	(0 yearly to 2000)
2000	End projection					

Table 6.—*Breakdown of test region economic sectors, SIMLAB*

Sector number	Sector names
1	Livestock and livestock production
2	Other agricultural production
3	Peatland production (empty)
4	Agricultural services, forestry[1] and fisheries services and products
5	Iron and ferrous alloy ores
6	Other metal ores except copper
7	Copper ore mining except Minnesota
8	Open-pit copper ore mining, Minnesota
9	Deep shaft copper ore, Minnesota
10	Nonmetal mining
11	Agricultural chemicals
12	Contract construction
13	Food and kindred products
14	Apparel and miscellaneous fabrics, textiles
15	Logging camps, sawmills
16	Other lumber and wood products
17	Paper and allied products
18	Printing, publishing, and allied industries
19	Chemicals
20	Peat-chemicals (empty)
21	Petroleum refining and related industries
22	Rubber and miscellaneous plastic products
23	Stone and clay products
24	Primary iron and steel industries
25	Primary copper industries
26	Copper rolling and drawing industries
27	Other 1° metals rolling and drawing industries
28	Fabricated metal products
29	Machinery, except electrical
30	Electrical machinery
31	Miscellaneous manufacturing
32	Transportation, except following
33	Railroad transportation
34	Highway passenger transportation
35	Truck transportation and warehousing
36	Air transportation
37	Communication
38	Electric service
39	Gas service
40	Water service
41	Wholesale trade
42	Retail trade
43	Finance and insurance
44	Real estate and rental
45	Hotels, personal and repair services
46	Business services
47	Automobile repair and service
48	Amusements
49	Medical, educational, and nonprofit organizations
50	Federal government enterprises
51	State and local enterprises
52	Other industry
53	Other government (public goods and services)

[1]Industries engaged primarily in operation of timber tracts, nurseries, and forest services (fire protection).

Total population

Table 7 shows the total population by age groups through year 2000. The development impact on population in 1985, 1992, and 2000 is positive, as would be expected. The largest impact falls in the group between 25 and 34 years of age. It should be pointed out, though, that these population projections reflect more than the result of industrial expansion. They also reflect a decreasing population, which can be seen by viewing only the baseline projection. The reason for this downward trend is decreasing employment in taconite mining and manufacturing beyond the mid-1980's (Meagher *et al.* 1979). The "increase" in population due to the timber-based expansion only slightly offsets this baseline decrease. Population in the study area for the year 2000 is estimated at 334,071 for the development projection, compared with 325,571 for the baseline case.

Total employment

Neither of the two new industries involved in the development scenario is particularly labor-intensive. Nevertheless, they have far-reaching effects throughout the economy. Table 8 represents the status quo employment projections in the baseline run, in addition to employment effects, by sector, as a result of increased economic activity. As expected, employment in the logging and wood products sectors (15 and 16) shows noticeable increases with respect to the other sectors. This is especially true in 1985 and 1992. Even more interesting, though, are the sizeable increases in the service sectors of wholesale and retail trade (41 and 42), and the medical, educational, and nonprofit organizations (49). Combined with the "other government" sector (53), which represents the traditional bureaucratic levels of Federal, State, and local agencies, these four groups constitute nearly 59 percent of the total employment increases attributed to the industrial development in year 2000. In that year, the four sectors that were altered in the development case only contribute approximately 24 percent to the total employment increase of 4,495 persons. Additionally, they also show a decline in total numbers from 1992. Compared with the base year of 1977, total employment decreased 4.6 percent by 2000 in the development case, compared with 7.8 percent in the baseline projection. It is more likely that industrial growth picked up unemployed personnel in the region, rather than causing an immigration of workers from outside the study area.

Table 7.—*Estimated and projected total population by age groups, northeastern Minnesota and Douglas County, Wisconsin, 1977-2000*

		1985		1992		2000	
Age group	**1977 Baseline**	**Baseline**	**Development impact**	**Baseline**	**Development impact**	**Baseline**	**Development impact**
1-5	36,110	39,894	35	33,043	476	25,069	1,238
6-11	45,743	44,767	97	49,233	383	39,472	1,020
14-17	32,776	17,918	56	19,852	270	23,089	391
18-24	49,776	36,783	193	25,163	715	30,509	922
25-34	53,275	66,518	180	53,192	1,260	30,569	2,409
35-54	81,672	81,302	112	95,550	606	106,817	1,770
55-64	40,880	35,220	36	31,357	188	31,427	368
65+	43,721	43,816	42	41,875	207	38,620	383
Column total	383,954	366,218	749	349,266	4,104	325,571	8,500
Grand total	383,954	366,967		353,370		334,071	

Table 8.—*Estimated and projected total employment, northeastern Minnesota and Douglas County, Wisconsin, 1977-2000*

(In number of persons employed)

			1985		1992		2000	
Number	**Industry title**[1]	**1977 Baseline**	**Baseline**	**Development impact**	**Baseline**	**Development impact**	**Baseline**	**Development impact**
1	Livestock	2,116	1,593	—	1,657	15	1,442	17
2	Other agric.	1,503	1,226	—	1,144	19	996	19
4	Agric., for., fish. serv.	775	930	24	1,069	74	1,264	74
12	Construction	3,992	4,222	84	4,025	43	4,163	45
13	Food, kindred products	3,464	3,132	—	2,849	15	2,646	23
15	Logging, sawmills	1,273	1,206	46	1,158	104	1,128	87
16	Other lumb., wood prod.	833	841	259	837	874	859	747
17	Paper, allied prod.	5,599	5,753	8	5,749	26	5,942	26
21	Petroleum refin.	399	320	—	257	6	212	7
29	Machinery, exc. elect.	608	683	15	687	27	784	17
32	Transport, except:	1,947	1,679	6	1,312	14	1,052	11
33	Rail transport	2,326	2,091	17	1,857	39	1,684	35
35	Truck transport	838	838	39	848	136	885	129
37	Communication	1,215	995	52	795	22	652	26
38	Electric	1,145	981	66	864	59	789	49
41	Wholesale trade	7,587	7,481	79	6,952	218	6,721	237
42	Retail trade	30,573	30,167	174	27,787	733	26,434	1,144
49	Medical, educ. org.	13,876	13,207	21	11,940	96	10,727	178
50	Fed. enterprises	918	967	13	985	28	1,031	39
53	Other government	22,993	23,571	146	23,436	592	23,372	1,079
Column total		103,980	101,883	1,049	96,208	3,140	92,783	3,989
Total (all 53 sectors)		138,750	136,580	1,183	130,908	3,504	127,920	4,495
Grand total		138,750	137,763		134,412		132,415	

[1]See table 6 for complete titles.

Gross output

The value of production in producer's prices—gross output—is used as a measure of region's business volume. Industries within the region buy goods and services from other industries to stay in operation. Workers spend their payrolls also to buy goods and services. Table 9 shows the value of gross output by sector for the baseline and the development cases. In the year 2000, timber-based sectors 15 and 16 together represent 35 percent of the total increase in gross output (above the baseline), valued at $178,970,000. Compared with 1977, the baseline projection to year 2000 indicates a 53 percent increase in gross output. With industrial growth, the

Table 9.—*Estimated and projected value of gross output, northeastern Minnesota and Douglas County, Wisconsin, 1977-2000*

(In thousands of 1970 dollars)

			1985		1992		2000	
Number	Industry title[1]	1977 Baseline	Baseline	Development impact	Baseline	Development impact	Baseline	Development impact
1	Livestock	48,153	48,153	—	63,904	569	70,865	855
2	Other agric.	24,049	25,364	—	29,995	503	33,067	634
4	Agric., for., fish. serv.	20,151	24,520	636	27,788	1,909	32,342	1,876
12	Construction	132,037	153,861	3,035	156,896	1,676	172,901	1,849
13	Food, kindred products	319,507	364,048	340	401,311	2,041	450,968	3,987
15	Logging, sawmills	92,349	115,057	4,395	133,363	12,828	158,370	12,221
16	Other lumb., wood prod.	34,954	42,318	13,539	48,359	50,478	56,857	49,494
17	Paper, allied prod.	227,799	297,191	437	361,938	1,596	455,133	2,018
21	Petroleum refin.	58,860	64,805	525	69,792	1,621	77,136	
29	Machinery, exc. elect.	21,397	28,799	637	33,479	1,313	44,071	962
32	Transport, except:	94,416	111,900	411	128,656	1,385	151,717	1,568
33	Rail transport	67,859	79,115	638	87,223	1,866	98,091	2,032
35	Truck transport	15,988	18,161	860	20,076	3,205	22,822	3,330
37	Communication	31,784	34,891	274	36,729	1,034	39,640	1,566
38	Electric	85,765	95,938	6,522	109,840	7,563	130,141	8,193
41	Wholesale trade	160,085	185,601	1,935	204,699	6,408	233,364	8,232
42	Retail trade	260,396	294,282	1,698	310,907	8,210	338,318	14,648
49	Medical, educ. org.	187,782	197,238	316	193,561	1,545	188,376	3,130
50	Fed. enterprises	14,259	15,430	218	16,298	460	17,607	660
53	Other government	539,017	662,565	4,105	760,922	19,205	874,976	40,385
Column total		2,436,608	2,859,239	40,522	3,195,736	125,414	3,646,765	160,002
Total (all 53 sectors)		3,626,672	4,220,464	46,138	4,782,795	139,009	5,561,805	178,970
Grand total		3,626,672	4,266,602		4,921,805		5,740,775	

[1]See table 6 for complete titles.

development impact would reflect a 58 percent increase over the same period. Once again, wholesale and retail trade increases are high (13 percent of total) in year 2000, spurred by consumer spending. Government growth, in response to increased economic activity, takes second place to the wood products sector gross output (23 percent of total).

Total earnings

The trend in total earnings from wages and salaries paid (table 10) follows that of gross output. With development, total earnings increase 32 percent from 1977 to year 2000, compared with a 28 percent increase in the baseline projection over the same period. Once again, the wood products sector shows the largest increase, followed by the governmental sector and the wholesale-retail trades. Construction earnings fall off by nearly 50 percent after the development of new industrial facilities is completed in 1990. The construction of residential housing, service facilities, etc., constitutes earnings thereafter.

Capital stock

The totals of all annual investments, both for output increases and pollution abatement (less depreciation), are shown in table 11. Industries that are less labor-intensive show higher values of capital stock, representing heavy investment in machinery and pollution abatement equipment. This can be seen in the development run, year 2000, where the electrical sector has the greatest increase, due to extremely costly air pollution control equipment for the new electrical plant. The baseline projection indicates a 54 percent increase in total capital stock over the period, valued at $3,695,819,500 in the year 2000. This is in contrast to a 57 percent increase, totaling $3,763,305,200 at the end of the projection, for the industry expansion projection. It should be noted that the government (public) sector (53) is not viewed as one that accumulates capital stock in the same sense that the private industrial sectors do.

Table 10.—*Estimated and projected total earnings from wages and salaries of employed work force, northeastern Minnesota and Douglas County, Wisconsin, 1977-2000*

(In thousands of 1970 dollars)

Number	Industry title[1]	1977 Baseline	1985 Baseline	1985 Development impact	1992 Baseline	1992 Development impact	2000 Baseline	2000 Development impact
1	Livestock	15,483	11,653	—	12,122	108	10,551	127
2	Other agric.	10,248	9,742	—	9,086	152	7,911	152
4	Agric., for., fish. serv.	6,144	7,597	—	8,731	600	10,326	599
12	Construction	55,028	68,626	1,354	66,798	713	73,363	784
13	Food, kindred products	22,227	23,849	—	25,507	128	28,321	250
15	Logging, sawmills	6,766	8,064	308	9,626	926	11,897	918
16	Other lumb., wood prod.	4,430	5,621	1,798	6,997	7,304	9,058	7,885
17	Paper, allied prod.	41,811	51,281	75	60,414	266	74,514	330
21	Petroleum refin.	5,843	5,967	48	5,670	132	5,451	167
29	Machinery, exc. elect.	4,535	5,721	126	6,499	254	8,454	184
32	Transport, except:	18,112	19,068	70	17,969	193	17,570	181
33	Rail transport	28,599	34,883	281	41,809	894	51,595	1,069
35	Truck transport	7,792	9,511	451	11,618	1,855	14,784	2,157
37	Communication	14,350	16,291	128	17,499	493	19,408	767
38	Electric	11,143	10,465	711	10,012	689	10,115	637
41	Wholesale trade	52,127	56,212	586	56,720	1,776	60,664	2,140
42	Retail trade	122,732	132,427	764	132,454	3,498	139,392	6,035
49	Medical, educ. org.	91,170	93,854	150	84,857	677	76,231	1,267
50	Fed. enterprises	8,373	9,533	135	9,716	275	10,169	381
53	Other government	164,643	168,785	1,046	166,999	4,215	166,542	7,687
Column total		691,558	749,152	8,033	761,105	25,151	806,316	33,718
Total (all 53 sectors)		943,668	1,038,015	9,331	1,093,128	27,510	1,203,574	37,331
Grand total		943,668	1,047,345		1,120,639		1,240,905	

[1]See table 6 for complete titles.

SUMMARY

Minnesota's Survey Unit 1 (fig. 2) was chosen as the study area for determining the potential for increased forest management activities. A 10-year projection of state-owned lands in aspen cover type was made. Management options with and without timber harvesting were used to: (1) compare the effects of no timber harvesting versus appropriate harvesting treatments on age class distributions; and (2) obtain an idea of the timber volumes that could be harvested above current levels.

The no-harvest run showed a perpetuation of unbalanced age class distributions, making the situation even worse in terms of overmature timber. Stand volume decreases in some age classes were attributed to natural losses from such things as insect and disease infestation. The management run called for heavy removals, especially in the older age classes, in an attempt to balance the distribution of age classes. Simulated harvest was approximately 229,000 cords/year, roughly 165,000 cords/year above current levels in this ownership-cover type category. With the inclusion of other underutilized hardwood cover types, such as birch and balsam poplar, the potential harvest opportunity is high.

Sustainability of such an increased harvest was investigated, expanded to state, county, and forest industry ownerships (aspen cover type). The simulation showed that not only could highly unbalanced

Table 11.—*Estimated and projected totals in capital stock, northeastern Minnesota and Douglas County, Wisconsin, 1977-2000*

(In thousands of 1970 dollars)

			1985		1992		2000	
Number	Industry title[1]	1977 Baseline	Baseline	Development impact	Baseline	Development impact	Baseline	Development impact
1	Livestock	42,243.8	42,243.8	—	57,289.3	450.3	62,110.0	749.7
2	Other agric.	21,098.0	22,251.2	—	26,481.5	439.7	29,008.6	556.4
4	Agric., for., fish. serv.	17,677.8	21,510.4	557.8	24,377.5	1,674.5	28,372.5	1,646.1
12	Construction	145,036.8	145,036.8	—	145,036.8	1,528.9	159,634.0	1,685.9
13	Food, kindred products	68,154.9	77,656.1	—	85,604.8	435.3	96,197.3	850.5
15	Logging, sawmills	29,485.4	36,735.6	1,403.1	42,580.1	4,095.7	50,564.4	3,901.9
16	Other lumb., wood prod.	7,296.6	8,833.8	2,826.2	10,094.9	10,537.1	11,868.8	10,331.9
17	Paper, allied prod.	169,914.6	221,674.0	325.9	269,968.6	1,190.2	339,483.2	1,505.2
21	Petroleum refin.	11;276.0	12,414.9	100.6	13,370.5	310.4	14,777.4	452.6
29	Machinery, exc. elect.	9,247.4	9,247.4	—	9,971.6	391.0	13,126.6	286.4
32	Transport, except:	171,111.6	202,799.4	744.9	233,166.5	2,510.1	274,960.3	2,841.3
33	Rail transport	102,038.0	118,963.0	958.8	131,155.9	2,806.1	147,497.6	3,056.1
35	Truck transport	4,181.1	4,749.4	225.0	5,250.2	838.0	5,968.2	870.9
37	Communication	67,269.0	73,845.2	579.3	77,733.5	2,187.9	83,895.7	3,313.9
38	Electric	133,676.0	149,533.2	10,166.2	171,201.0	11,788.3	202,842.2	12,770.4
41	Wholesale trade	135,570.5	157,180.0	1,639.1	173,352.7	5,426.9	197,628.7	6,971.5
42	Retail trade	149,653.1	169,128.0	975.7	178,682.2	4,718.2	194,436.0	8,418.2
49	Medical, educ. org.	75,658.4	80,459.1	—	80,459.1	—	80,459.1	—
50	Fed. enterprises	5,745.5	6,217.2	88.0	6,567.1	185.6	7,094.5	265.8
53	Other government	—	—	—	—	—	—	—
Column total		1,366,334.5	1,560,478.5	20,590.6	1,742,343.8	51,514.2	1,999,925.1	60,474.7
Total (all 53 sectors)		2,401,176.4	2,712,023.4	22,261.5	3,115,099.8	56,118.2	3,695,819.5	67,485.7
Grand total		2,401,176.4	2,734,284.9		3,171,218.0		3,763,305.2	

[1]See table 6 for complete titles.

age-class distributions be brought into full regulation after nearly one rotation, but allowable cut could be substantially increased over time. This would level off to greater than 550,000 cords/year on aspen cover type alone. Considering the other hardwood types (but still ignoring nonindustrial private ownerships), the magnitude of the potential resource becomes evident.

A composite scenario of industrial development was devised to utilize the large potential increase in hardwood harvests available from state, county, and forest industry lands. Development of four waferboard plants and a wood-fired electrical generation plant between 1980 and 1990 was assumed in the hypothetical expansion. This was the linking element between the output of the biological model, FREP, and the socioeconomic model, REIFS. Input requirements were determined for all facilities in terms of wood and construction costs. Their associated final output, valued approximately as they would be sold in the region, were calculated. Direct effects on other sectors of the economy as a result (e.g., truck transport to haul final waferboard product), were also determined.

The waferboard plants and 25 MW wood-burning electrical plant caused noticeable impacts to the study area economy. Expansion in the construction, wood products, logging, electrical, and truck transport sectors were shown to influence numerous variables, some more than others. Tables 7-11 highlight the more noticeable impacts on total population, employment, gross output, earnings, and capital stock. A predicted decline of 58,383 in regional population from 1977 to year 2000 was lessened to a decline of

49,883. Moreover, significant increases, or perhaps offset of decreases, in preschool and school age children occurred by the end of the projection period. The importance of such figures could weigh heavily in educational planning, especially if school closures and/or reductions in educational staffs loom ahead.

As a result of industrial expansion, employment expanded substantially by the year 1992. Over 1,000 jobs were created in the timber-based sectors alone. By the year 2000, the wholesale-retail trade sectors indicated an increase of 1,381 jobs to offset the predicted decrease in employment for that sector. But the more striking trend was in a sector that showed a predicted employment increase even in the absence of development. Over the period 1977 to 2000, employment in the government services sector increased nearly 4.7 percent in response to development. In relative terms, the wood products sector increased most significantly; but retail trade had a larger absolute increase in jobs in this scenario.

Without development, gross output, based on historical worker productivity, was predicted to increase from 1977 to the year 2000 by better than 53 percent. With development, this increase was boosted to nearly 58 percent. The government sector showed the second largest increase in gross output. Investments in capital stock showed greater increases with development than without. The electrical service sector showed the greatest investment increase, valued at $12.77 million (in 1970 dollars) for the year 2000. The wood products sector was close behind at $10.3 million. Pollution abatement equipment weighed heavily in these increases, especially in the electrical service case.

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APPENDIX

Determination of Waferboard Price, Wholesale, FOB at Mill

This was accomplished by starting with the retail price of the product and working backwards to strip off the cost of doing business margins for retail, wholesale, and transportation. Published by Dun and Bradstreet, Inc. for 185 lines of business,[4] these ratios represent a percentage of business receipts as reported by a representative sample of the total of all Federal income tax returns for 1969-1970. Total business receipts for each sector (i.e., retail, wholesale) equal the cost of goods sold plus the gross margin. It is this gross margin that is stripped off for each sector.

Retail price 8′ x 4′ (3/8″) or 1 ft³ = \$7.39 (1979[5])

• less retail gross margin for building materials, hardware, farm equipment (24.35 percent)	− 1.80
	\$5.59/ft³
• less wholesale gross margin for lumber and construction materials (16.39 percent)	− .92
	\$4.67/ft³
• less transportation cost (see next section)	− .25
Wholesale, FOB, at mill	\$4.42/ft³ (1979 \$'s)
Deflated by Consumer Price Index to 1970	\$2.34/ft³

Determination of Transportation Costs for Waferboard

The quoted price currently charged by the State of Minnesota, Department of Transportation, from Grand Rapids to St. Paul-Minneapolis is 63¢ per 100 weight (40,000 lb minimum). Transport cost per ft³ follows from:

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[4]*Dun & Bradstreet, Inc. 1973. Cost of doing business: corporations. Key business ratios for 1969-1970. New York, New York.*

[5]*Knox Lumber Co., St. Paul, Minnesota, as of November 1979.*

$$\frac{\$0.63}{100 \text{ lb}} \times \frac{40 \text{ lb}}{\text{ft}^3} \text{ (approximate waferboard density)}$$
$$= \$0.25/\text{ft}^3.$$

Because this value is based on the Grand Rapids-Twin Cities highway distance, it was changed to a per-mile rate and expanded to estimate the rate to Virginia, Minnesota. This hypothetical regional center resulted in a 70¢/100 weight rate, or 28¢ per ft^3 in 1979 terms. During the first year of a waferboard plant's operation, the transportation sector would haul one-half the amount it would the following year:

Full production 150 mm ft^2 (3/8″)	= 4,687,500 ft^3,
4,687,500 ft^3 x \$0.28/ft^3	= \$1,312,500 (1979),
\$1,312,500 deflated by CPI	= \$695,733 (1970) in full production for transportation sector,
First year of waferboard plant operation	= \$348,000 (1970) for transportation sector.

Determination of Cord-input Requirements (volume)

Based on the 1,235 kg dry wood input per 1 ton output conversion factor for flakeboard (Vajda 1975), the cord-aspen per mm ft^2 (3/8-inch thick basis) equivalent was determined as follows:

Assuming 83 ft^3/cord for aspen,

then $$\frac{83 \text{ ft}^3}{\text{cord}} \times \frac{26.6 \text{ lbs}}{\text{ft}^3} \text{ (12 percent m.c.)}$$
$$= \frac{2{,}208 \text{ lbs}}{\text{cord}} \left(\frac{1{,}001 \text{ kg}}{\text{cord}}\right),$$
and 1,235 kg "dry" wood input translates into
$$\frac{1{,}235 \text{ kg}}{1{,}001 \text{ kg/cord}} = 1.2338 \text{ cords input for 1 ton output.}$$

Assuming density of waferboard is approximately $\frac{40 \text{ lbs}}{\text{ft}^3}$, then input of 1.2338 cords for 2,000 lbs output (1 ton) yields

$$2{,}000 \text{ lbs} \times \frac{\text{ft}^3}{40 \text{ lbs}} = 50 \text{ ft}^3 \text{ output.}$$

Now, 1.2338 cords input yields 50 ft^3 output,
or $$\frac{50 \text{ ft}^3}{0.03125 \text{ ft (3/8 in.)}}$$
$$= 1{,}600 \text{ ft}^2 \text{ on 3/8-inch thick basis.}$$

Then 1.2338 cords yields 1,600 ft^2 (3/8 in.) or 7.71125 x 10^{B4} cords/ft^2 (3/8-inch thick), equalling approximately 771 cords input/mm ft^2 (3/8 in.).

Adjustments of Transportation and Logging Sector Inputs

As referred to earlier, the table of technical coefficients (i.e., input-output ratios) in SIMLAB were not fine-tuned adequately for the new industries proposed in the scenario. Consequently, adjustments were made to the values of final demand that were inputs in the SIMLAB development case projection (table 4 in text). The following example shows how this was done.

For the year 1985, the wood products sector final demand (output) was \$10,969,000. This represented one 150 MM ft^2 (3/8-inch thick) waferboard plant at full production (150 MM ft^2 x \$73.125/M ft^2). The corresponding transportation output was, as shown earlier, \$696,000 (rounded). The technical coefficient to be checked in the input-output table reflected a value of 0.002866. That is, to produce \$1 of output in wood products, \$0.002866 was purchased from sector No. 35, motor freight. But the 1985 final demands indicated:

$$\frac{\$ \quad 696{,}000 \text{ (transport output)}}{\$10{,}969{,}000 \text{ (wood prod. output)}} = \$0.063452$$

The scenario shows that slightly more than \$0.06 is purchased in motor freight for every \$1 of waferboard sold. The model, then, is not accounting for \$0.060586 (\$0.063452–\$0.002866) in transportation per \$1 of wood product. Hence, the transportation final demand is increased to pick up only that portion that the model will not account for:

$$\$0.060586 = \frac{\text{adjusted transportation final demand}}{\$10{,}969{,}000}.$$

Adjusted transportation final demand = \$664,568. The value of \$664,568 for year 1985, in the transportation sector, is what is shown in table 4 and is used to modify the SIMLAB development case projection. This was done, similarly, for the logging sector and both were modified each year as necessary. In year 1991, the model adequately accounted for final demand in the logging sector, hence no final demand (output) was added.

Erkkila, Daniel L.; Rose, Dietmar W.; Lundgren, Allen L.
Estimating economic impacts of timber-based industry expansion in northeastern Minnesota. Gen. Tech. Rep. NC-82. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1982. 21 p.

Analysis of current and projected timber supplies in northeastern Minnesota indicates that expanded timber-based industrial activity could be supported. The impacts of a hypothetical industrial development scenario, including construction of waferboard plants and a wood-fueled power plant, were estimated using an input-output model. Development had noticeable impacts on the study area economy, e.g., regional employment and gross output.

KEY WORDS: Input-output model, development scenarios, timber supply, inventory projection.

U.S. GOVERNMENT PRINTING OFFICE:1983-666-018/248