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Private Investment in Forest Management and the Long-Term Supply of Timber

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Timber supply behavior of private forest owners is a major uncertainty in long-term forest product market projections. A model of private supply is developed that explains both harvest and forest management investment decisions. Comparison of two fifty-year projections, one assuming constant management intensity and a second using the harvest-investment model, indicates that projected levels of investment would (*a*) have little impact on markets prior to the year 2000, (*b*) stabilize real wood product prices after 2000, (*c*) eliminate softwood lumber imports by 2030, and (*d*) expand the dominant role of southern forest regions in wood product markets.

Key words: forest management, timber supply, wood prices.

Since the first national assessment of U.S. timber supply prospects more than a century ago (Hough), one of the principal uncertainties in projecting future harvest levels and inventories has been the supply behavior of private forest owners. Two aspects of private supply behavior are important: (*a*) the volume of timber private owners will harvest from existing inventories under various price and market conditions, and (*b*) the investments private landowners will make in forest management (planting, thinning, and fertilization) that will influence the growth of inventory and future harvest levels. Some empirical work exists on the "short-term" harvest question, and there is a substantial body of theory about the "long-term" investment question. There has been little effort, however, to combine available empirical and theoretical structures in a comprehensive model of timber supply and forest management investment over time.

This paper presents an integrated model of private timber supply that incorporates both harvest and investment behavior. The implications of this supply model are explored by combining it with a model of final product markets. The combined model was used for two fifty-year projections of U.S. timber prices, harvest, and consumption. In the first simulation, only the short-term harvest mechanism is used. Investment and intensity of private management are assumed to remain constant at recent levels. The second simulation considered both short- and long-term aspects.

Results suggest that investment behavior of private owners will have a major impact on anticipated long-term price and consumption behavior in forest products markets. With the investment levels projected by the model, simulated prices of forest products are stabilized by the first decade of the next century, while stumpage prices rise at first but then return to near current levels at the end of the simulation period. Ignoring investment, simulated prices continue to rise at rates at least as high as those observed in the past two decades. Results also confirm that intensified management will have little impact on product or stumpage markets in any region prior to the year 2000. Thus, public policies designed to augment timber supply in regions currently experiencing declining harvest must rely on expanded harvest from public lands rather than accelerated investment on private lands if they are to be effective in the short term. Finally, investment behavior as depicted by the model will lead to further concentration of both timber and product output in the South.

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Simulated production in the West increases, but the South's investment potential is so much greater that it will expand its dominant role in U.S. markets by the year 2030.

Previous Studies

Two distinct approaches have been employed in previous studies of private timber supply. The first uses mathematical programming to schedule short-term private harvests consistent with maximization of some objective (Berck, Rahm). Investment in intensive management occurs at a prespecified rate external to the model. Typically, the rate has not depended on prices, costs, or other financial considerations. The second approach is to estimate the relationship between current period harvest, stumpage price, and some proxy for the costs of holding timber inventory (McKillop, Robinson, and Adams). This approach concentrates on short-term supply response, ignoring intertemporal linkages of harvest decisions and long-term investment decisions.

An Integrated Supply Model

The integrated private supply model proposed here consists of three elements:

(*a*) A set of short-term, regional stumpage supply or harvest relations which interact with stumpage demand relations to determine current harvest and stumpage price. There is one supply relation for each of two classes of private owners, industrial and nonindustrial, in each of eight U.S. supply regions. The stumpage supply relations depend on price and on timber inventories held by each owner group.

(*b*) An inventory projection model that updates the inventory volumes used in the stumpage supply equations. At the start of each simulation period, inventory volume equals the lagged inventory plus growth, less natural mortality and harvest during the previous period.

(*c*) A model that determines investment in forest management practices and adjusts the parameters of the inventory projection model. In general, higher rates of investment mean higher rates of forest growth and lower rates of natural mortality. The decision to invest depends on the prospective present net worth of each investment alternative and, hence, on anticipated physical yields, investment costs, and stumpage prices.

The private harvest-investment model is embedded in a larger model of U.S. forest products and stumpage markets developed by Adams and Haynes. The market model is spatially disaggregated, with six domestic consuming regions and eight domestic supplying regions plus Canada. Each region has either demand or supply equations (as appropriate) for each final product. The regional supply equations for each final product, e.g., lumber or plywood, depend on the stumpage sector by means of a stumpage price (factor cost) term. Aggregate stumpage demand is derived from the supply processes for all products. The short-term stumpage supply relations from the harvest-investment model reflect the harvest response of private owners, while harvests from public lands (which are not price sensitive) enter as exogenous additions to total supply. Spatial equilibrium is computed in the final product sector by means of a reactive programming algorithm (King and Ho). Associated equilibria in the eight regional stumpage markets are found by equating aggregate stumpage demand and total stumpage supply. Investment affects market activity and prices by augmenting growth, increasing inventories, and thereby shifting the short-term private stumpage supply equations to the right. Market activity and prices influence investment via the price expectation mechanism in the investment model. The following sections describe the harvest-investment model in further detail.

Short-Term Private Stumpage Supply

Private stumpage supply equations were patterned after those developed by Adams and take one of two forms depending on region and owner group:

(1) $h_{r,t}{}^{o} = \alpha + \beta\, p_{r,t} + \gamma\, I_{r,t-1}{}^{o}$, or

(2) $h_{r,t}{}^{o}/I_{r,t-1}{}^{o} = \delta + \epsilon\, p_{r,t}$,

where $h_{r,t}{}^{o}$ is timber harvest in period t, region r, owner o; $p_{r,t}$, stumpage price in period t, region r; $I_{r,t-1}{}^{o}$, timber inventory volume at the end of period $t-1$ (start of period t), region r, owner o; and α, β, γ, δ, ϵ are parameters. Selection of either form (1) or (2) was based on goodness-of-fit and residuals characteristics for each region/owner group. In general, form (2) was adopted for industrial owners in the West, while form (1) was employed for nonindustrial owners in the West and all owners in the East. One basic distinction between these groups is that western industrial owners generally hold large inventories of old-growth timber which fell in volume over the sample period (1950–76), while western nonindustrial and eastern owners held generally smaller inventories of young-growth timber that have been increasing in volume.

Price and inventory elasticity estimates derived from equations (1) and (2) show consistent differences among regions and between owner groups. Comparing western and southern regions, price elasticities are generally higher in the South (.41 versus .17) while inventory elasticities are higher in the West (1.10 versus .57). Across all regions, price elasticities for industrial ownerships average 67% greater than those for nonindustrial owners.[1] The West-South differences in price elasticities reflect markedly different land ownership patterns in the two regions and the more active private stumpage markets in the South. In the West, timber ownership is heavily concentrated in industrial ownerships. The bulk of this timber flows from woods to mill without entering a stumpage market. Nonindustrial lands are a minor wood source and procurement efforts by processors are limited. In contrast, industrial lands are of minor importance in the South. The bulk of the timber consumed in this region is purchased through various marketing arrangements from nonindustrial owners. Causes of the differences in inventory elasticities are less clear. One conjecture is that inventory-holding costs (taxes, protection, and annual operation) are higher in the West than in the South because western rotations are longer. Hence, a given inventory change leads to a greater cost change and supply response in the West.

Higher price elasticities for industrial owners, regardless of region, are consistent with variations in ownership objectives. Ownership studies and surveys of owner intentions suggest that nonindustrial owners often do not retain woodlands for reasons of profitability or as a source of income. In many western regions, nonindustrial harvest has actually fallen in some periods, while price and inventory have been increasing. In contrast, profitability and sensitivity to short-term movements are important to industrial owners. Thus, it is reasonable to observe greater price responsiveness in industrial supply.

[1] All elasticity differences are significant at the .05 level.

Inventory Projection Model

The model of forest growth used to project timber inventories over time was derived from the TRAS system developed by Larson and Goforth. The inventory of each region/owner group is characterized by its distribution of number of trees per acre by diameter class. Over time, growth is simulated by the advancement of trees from smaller to larger diameter classes depending on diameter growth, loss due to natural causes, and removals from each class with harvesting. Growth of trees into the smallest diameter class is estimated by an "ingrowth" rate.

Investment in intensive management involves using some mix of intensive forestry treatments. A recent study by the Forest Industries Council provides the basic data on treatment alternatives, their financial and yield characteristics, and the acreage suitable for treatment in the timber-producing regions of the United States. Treatments were identified as those growth-augmentating practices currently available for existing conditions on commercial timberlands. They include planting, thinning, fertilization, and species conversion (from hardwoods to softwoods).

The investment model determines the treatment mix to be adopted in a given region/owner group and the number of acres to be treated over time. Using the Forest Industries Council data, it was then possible to compute the prospective increase in growth per acre on the treated acres beyond that from current management. By combining treated and untreated acres, an estimate of total increase in growth was then obtained. It was assumed that the growth per acre simulated by the inventory projection model with initial parameters (initial diameter growth, mortality, and ingrowth rates) was an accurate estimate of the growth under continued current management. The effects of management intensification were then simulated by changing model parameters to yield a per acre growth rate equal to the sum of current growth plus an increment resulting from adoption of the specific treatment mix.

The adoption of a particular treatment mix does not immediately increase forest growth by the full potential increment. Land is gradually shifted into intensive management. Also, the growth impacts of any given treatment are realized gradually after its initiation. Thus, changing growth parameters in the inventory projection model does not involve a one-time shift at the time of investment. Details of this calibration process are given in a paper by Barber.

Long-Term Investment Model

Private owners are assumed to be economically rational in their investment activities. Forest management practices are adopted only if they promise to yield a positive present net worth, given expected stumpage prices, investment costs, yields, and owners' discount rates.[2] A real discount rate of 4% was assumed for all owners. Other owner objectives are ignored. However, constraints on the rate of investment imposed by limited availability of capital are recognized. Private owners also are assumed to recognize the effects of current investment on future stumpage supplies and prices. That is, their price expectations are rational.

The model works as follows. In each year of the projection period, private owners survey a list of potential investments, analyzing their present net worths. For each treatment with positive present net worth and for which some untreated acreage remains, a fraction of the untreated acreage (termed the "enrollment rate") receives that treatment. In this process, the treatment mix adopted over time can vary. For example, treatment i in a particular region/owner group may have a positive present net worth in year t, leading to some investment. In year $t + k$, however, expected future prices may have changed or all treatable acres may have been previously enrolled so that treatment i may not appear in year $t + k$'s investment mix.

Price expectations. As investment proceeds over time, forest growth gradually will increase and with it the inventory level. This will in turn shift the short-term private supply relations, changing future harvests and stumpage prices. Owners are assumed to recognize this interrelation between current investment and future prices. The mechanism adopted for adjusting price expectations was to replicate the entire projection process several times, using as expected prices in iteration k the prices projected in iteration $k - 1$. The process was stopped when the differences between prices in succeeding iterations were less than a small, fixed tolerance. For treatments with investment lifetimes longer than fifty years or adopted so late that some or all of their returns occur after the end of the projection, expected prices were held at the level of the projection period's last year.

Enrollment rate. Assuming economic gain to be the sole objective and ignoring any investment constraints, all treatments with positive present net worth would be undertaken immediately by private owners. However, the investment capital required for immediate implementation of all treatments in the Forest Industries Council study would be about $12 billion at current prices, far exceeding the capabilities of industrial and particularly nonindustrial owners. Investments likely would be made gradually over time as funds became available, with only some fraction of the treatable acreage enrolled each year. Because there is little data on actual investment, it was assumed that if a treatment had a positive present net worth in a given year, the enrollment rate in that year would be A_i/d_i acres, where A_i is the treatable acreage identified in the Forest Industries Council study, and d_i is the investment lifetime of alternative treatment i expressed in years.

Investment rates are commonly assumed to be directly proportional to profitability in natural resource development models. The A_i/d_i rule is partially consistent with such profitability rules. Within a given region/owner group, the rule yields higher enrollment rates for investments with shorter durations (this approximates a "payback period" criterion). Within any given category of treatments, duration is inversely related to site quality, while profitability is positively related. Thus, for a given treatment which may be practiced on a range of site qualities, the A_i/d_i rule leads to more rapid enrollment of high quality lands and hence of alternatives with higher present net worths.

Across regions, the A_i/d_i rule yields higher enrollment rates in regions with shorter average investment duration and larger treatable acreage. This involves potentially higher enrollment rates in the South than in the West, because durations are longer and treatable acreage is smaller in the West. Historically, this is generally what has occurred. Over the past two decades, annual area planted or seeded in the South has averaged more than three times that on the Pacific Coast. In some specific years, it has been more than six times

[2] All prices and costs are in real terms deflated by the all commodity producer price index (1967 = 1.0).

larger. Per acre of commercial forest land, southern regeneration is 21% higher than in the West. Annual area given intermediate stand treatments (thinning) has averaged about 2.5 times larger in the South than in the West and in some years has been nearly six times larger (USDA Forest Service 1980, pp. 462–6).

Simulation Results

Using the models described in the preceding sections, two contrasting projections were developed for the U.S. forest products economy over the next five decades. In the first "baseline" simulation, the product and stumpage markets were projected assuming that the intensity of management on private lands is held at current levels. Given historical trends toward increased intensity, the baseline simulation is a conservative view of potential timber supply. The second simulation, termed the intensive management projection, employs the private harvest-investment process and allows private management intensity to vary as determined by the model.

In the intensive management simulation, land enrollment in intensive treatment programs was substantial. Table 1 indicates the acreage enrollment and number of treatments utilized for four critical southern and western regions. In the South, all available treatments are employed, and nearly 87% of the treatable acreage was enrolled (acreage treated/acreage treatable). Investments remain profitable in the South despite declining stumpage prices because of the high physical growth rates of southern forests. In the West, on the other hand, many treatments are noneconomic even with real price growth. This is particularly true in the California region, where only thirty of forty-five available treatments are employed. However, the extent of enrollment in the West (Douglas-fir and California regions) at 81% of treatable acreage is almost as large as in the South.

The initial impact of management intensification is to increase the growth of the private forest inventory relative to the baseline. As growth expands, the inventory also increases. Figure 1 displays growth and inventory characteristics for three critical region/owner groups, Douglas-fir industry, California industry, and southcentral other private. By 2030, growth under intensive management is about twice baseline levels in the West and nearly three times baseline levels in the South. By 2010, increased management intensity has stemmed the long-term decline in industrial inventories in the Douglas-fir region and led to increases in inventories in the California industry and southcentral other private groups.

Larger private inventories shift the short-term private supply relations, depressing stumpage prices and expanding cut relative to baseline levels. Figure 2 shows stumpage price paths for the Douglas-fir, California, and southcentral regions. By 2030, prices in the Douglas-fir region have returned to approximately their 1980 levels, while California prices are about $20 higher. The greatest price reductions occur in the southern regions because of the large increases in growth and inventory. Table 2 gives harvest volumes by region and major owner group. Management intensification in the South leads to substantially larger and earlier relative growth, inventory, and harvest increments than in the West.

Table 1. Summary of Treatment Characteristics under Intensive Management for Selected Region-Owner Groups

Region/Owner	Number of Treatments	2030 Growth Increase from Intensive Management	2030 Growth under Constant Management Intensity	Acreage Treated	Acreage Treatable	Total Ownership Acreage
	(utilized/available)	(CF/acre/year)	(CF/acre/year)	(thousand acres)		
Southeast industrial	11/11	33.1	38.9	5,841	7,707	15,870
Nonindustrial	12/12	49.6	32.8	30,107	43,029	57,010
Southcentral industrial	13/13	50.5	24.7	15,938	16,025	23,820
Nonindustrial	13/13	61.5	20.9	45,752	46,029	58,330
Douglas-fir industrial	10/12	50.8	67.8	2,049	2,644	7,380
Nonindustrial	10/12	53.2	67.5	878	1,288	3,250
California industrial	30/43	81.7	60.2	1,551	1,871	2,890
Nonindustrial	30/43	69.8	64.5	3,063	3,488	4,220

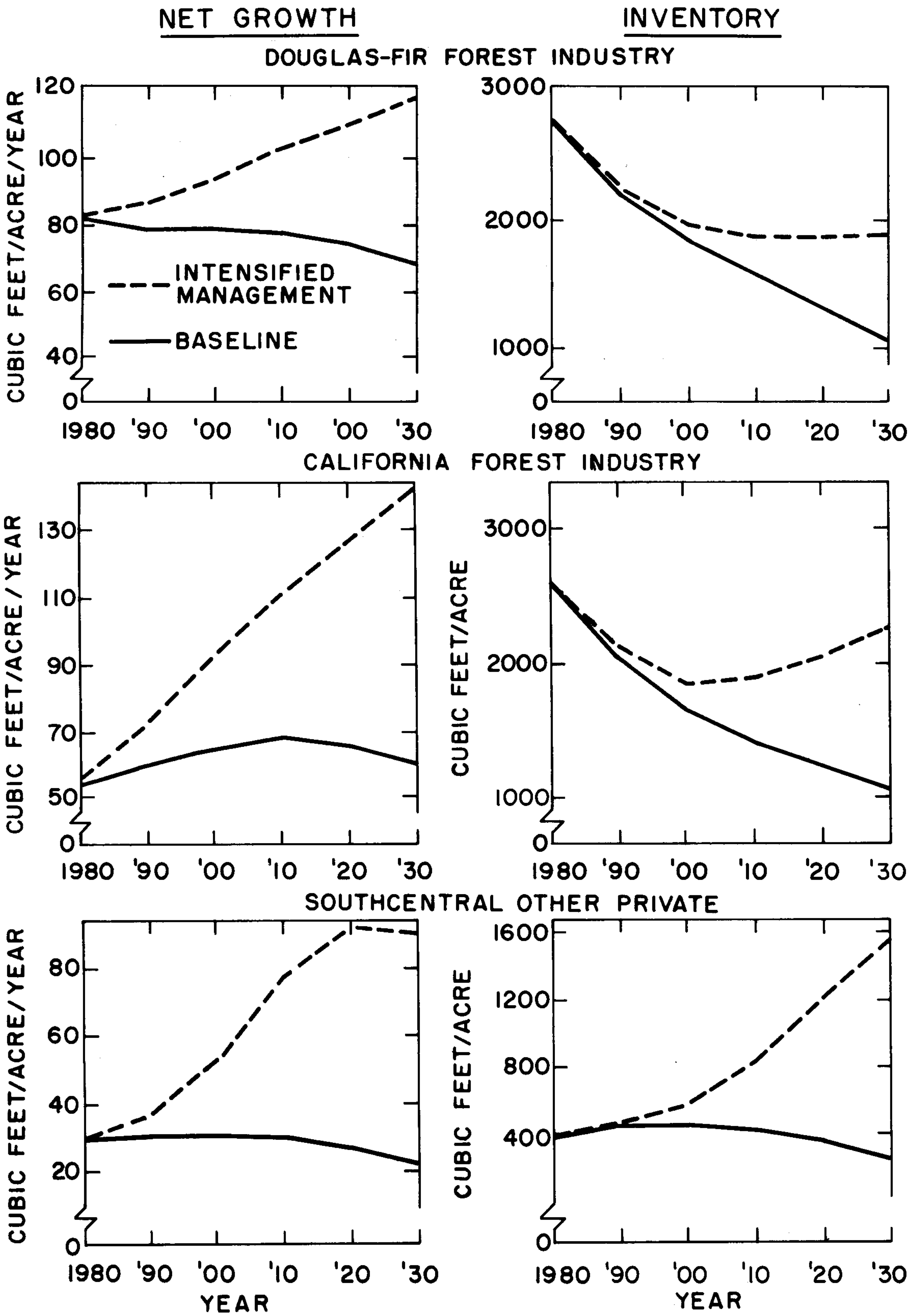

Figure 1. Net growth and inventory from baseline and intensive management simulations for selected region-owner groups

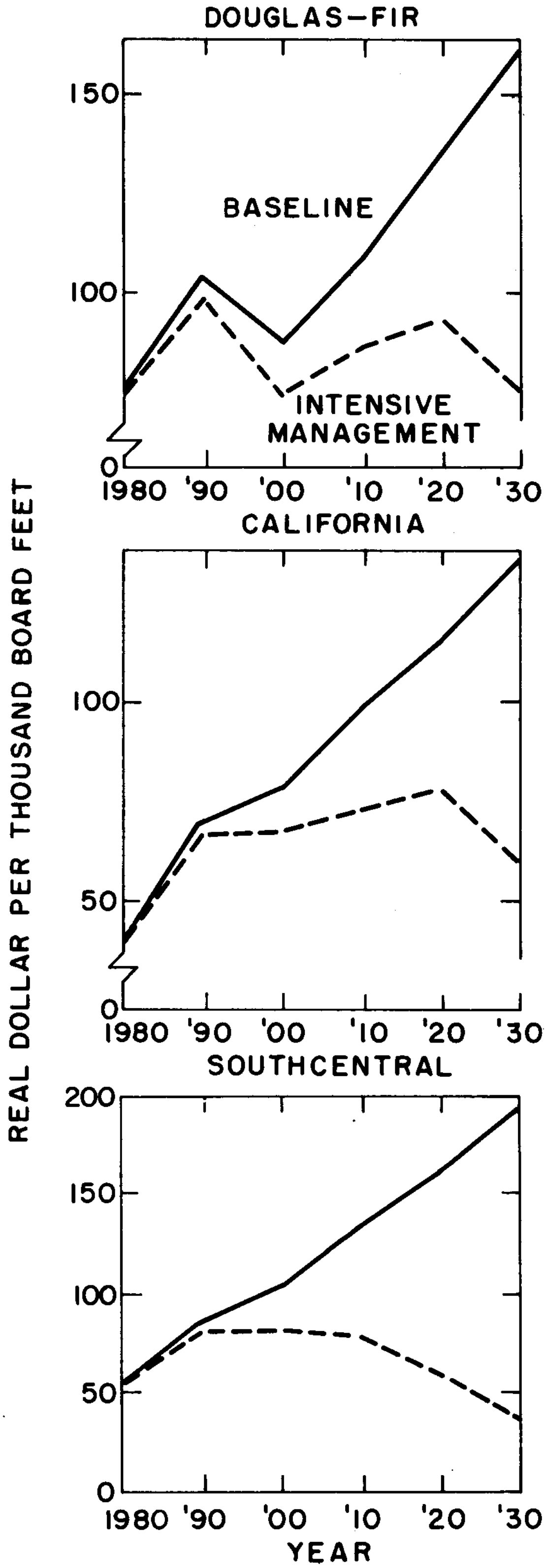

Figure 2. Stumpage prices from baseline and intensive management simulations for selected regions

Lower stumpage prices yield lower production costs for all final products (nonwood costs were assumed to remain at their baseline levels) and alter regional patterns of comparative advantage in final product markets. The greatest shift in costs occurs in the southern regions which, as a result, realize the greatest gains in product output and in harvest. These effects are clearest for the softwood lumber market. As indicated in table 3, levels and trends in regional shares of U.S. new supply (domestic production plus imports) are not markedly altered from the baseline simulation prior to 2000. After 2000, modest gains in market share are realized in the Douglas-fir region, but the greatest expansion occurs in the South. Total U.S. new supply increases by about 6 billion board feet by 2030, accounting for some of the market share gains. Major gains also occur because of domestic substitution for lumber imports from Canada. By 2030, the intensive management simulation indicates that Canadian lumber would no longer be competitive in U.S. markets.

Nationally, intensified management leads to expanded domestic production of wood products, lower prices, increased consumption, and reduced dependence on imports. Table 4 summarizes these impacts for softwood lumber and plywood. Prices of softwood lumber and plywood grow rapidly in both simulations from 1980 to 2000. Rates of price growth fall sharply after 2000, averaging 0.1% or less in the intensive management simulation. Domestic lumber production is 16.3 billion board feet higher by 2030, while domestic consumption is up only 6.3 billion board feet. The 10.0 billion board foot difference is replacement of Canadian lumber imports. Softwood plywood production and consumption rise by identical, modest amounts.

Conclusion

The U.S. Forest Service has consistently identified rising real forest products prices as a key forest policy issue (USDA Forest Service 1965, 1973, 1980). Over the past several decades, real prices of lumber have risen steadily at an average rate of about 1.5% per year. Plywood prices have risen at least as fast since the early 1960s. Rising prices have led to expanded use of nonwood products, causing market losses for forest products producers. The Forest Service also has argued that substitution may entail additional environmental

Table 2. Total and Private Timber Harvest from Baseline and Intensive Management Simulations

Region/Simulation		1990 Total	1990 Private	2000 Total	2000 Private	2030 Total	2030 Private
		(million cubic feet)					
Douglas-fir	Baseline	2,468	1,442	2,230	1,154	2,140	997
	Intensive	2,462	1,436	2,247	1,171	2,283	1,139
California	Baseline	905	553	875	518	932	554
	Intensive	903	551	890	533	1,023	645
Rockies[a]	Baseline	1,626	652	1,711	646	2,166	719
	Intensive	1,623	649	1,694	633	1,315	1,044
North	Baseline	890	715	1,011	799	1,322	1,051
	Intensive	890	715	1,010	798	1,315	1,044
South	Baseline	5,687	5,344	6,238	5,854	7,515	7,007
	Intensive	5,730	5,387	6,462	6,078	9,649	9,168
Total U.S.	Baseline	11,576	8,706	12,065	8,971	14,075	10,328
	Intensive	11,608	8,738	12,303	9,213	16,115	12,608

[a] Includes eastern Oregon and Washington and Rocky Mountain states.

and social burdens because many nonwood products are derived from nonrenewable resources, are more energy-intensive in production, and generate greater pollution in both manufacture and consumption (USDA Forest Service 1980).

Results of the intensive management simulation suggest that there is sufficient potential for expanding timber growth across the several forest regions of the United States to stabilize wood product prices by the year 2000. Under the assumptions of the harvest-investment model, these results are obtained through the actions of private, profit-seeking investors. Alternatively, the results may be viewed as indicating the extent of management intensification that would have to be stimulated by some combination of private profit-seeking and public incentive, assistance, and/or regulatory programs if achievement of stable wood products prices in the next century were an objective of public policy.

The future of various forest regions would be significantly altered by the widespread adoption of intensive management practices. In the baseline simulation, the eastern and Rocky Mountain regions appear to have major opportunities for harvest and product output expansion, while the Douglas-fir and California regions do not. Both of the latter are nearing the end of liquidation of old-growth timber stocks on private lands. They face problems of transition to young-growth. Declining harvest will cause employment and income losses. These will be major shocks to some local economies. Understandably, there is intense interest in public policy measures to modify or eliminate these economic problems.

A commonly suggested policy is to subsidize, encourage, or regulate intensified management. Results of this simulation do indicate that the declining trends in inventory (fig. 1) and harvest (table 2) may be stabilized or even reversed by increased investment in the Douglas-fir and California regions. In neither area, however, can any major impact be expected prior to the year 2000. Although some short-duration treatment opportunities (such as commercial thinning) do exist, the bulk of available investments produce results only after forty or more years. Thus, investment appears to solve long-term problems, but some means must be found to bridge the gap between current (declining) and future (stable to rising) harvests after 2000. The most likely sources of additional short-term supply in the

Table 3. Shares of Total U.S. New Supply of Softwood Lumber by Region from Baseline and Intensive Management Simulations

Region/Simulation		Percentage of Total U.S. New-Supply of Softwood Lumber 1990	2000	2030
Douglas-fir	Baseline	12.6	9.5	15.2
	Intensive	12.5	9.9	15.6
California	Baseline	12.6	12.7	14.3
	Intensive	12.6	12.7	13.7
Rockies	Baseline	18.9	20.4	27.4
	Intensive	18.9	19.7	19.1
North	Baseline	2.9	2.2	3.9
	Intensive	2.9	2.2	3.4
South	Baseline	24.2	22.4	16.3
	Intensive	24.9	26.1	48.2
Canada	Baseline	28.7	31.8	23.0
	Intensive	28.2	28.5	0

Table 4. Prices, Consumption, and Production of Softwood Lumber and Plywood from the Baseline and Intensive Management Simulations

		1990	2000	2030
Producer price index	Baseline	200.0	225.2	296.2
softwood lumber	Intensive	195.8	217.5	225.6
(1967 = 100.0)				
Producer price index	Baseline	193.7	200.7	231.3
softwood plywood	Intensive	192.7	196.2	198.4
(1967 = 100.0)				
U.S. consumption	Baseline	42.6	41.7	42.4
softwood lumber	Intensive	42.6	42.5	48.7
(billion bd. ft.)				
U.S. consumption	Baseline	21.8	22.0	22.1
softwood plywood	Intensive	21.9	22.3	24.8
(billion sq. ft.)				
U.S. production	Baseline	31.4	29.4	33.6
softwood lumber	Intensive	31.7	31.4	49.9
(billion bd. ft.)				
U.S. production	Baseline	22.7	22.8	22.7
softwood plywood	Intensive	22.8	23.1	25.4
(billion sq. ft.)				
U.S. lumber imports	Baseline	12.7	13.7	10.9
from Canada	Intensive	12.4	12.5	0.0
(billion bd. ft.)				

two regions are national forest lands, through so-called "departures" from current nondeclining, even-flow harvest policies. Departures allow a temporary increase in national forest harvest without jeopardizing the forest's ability to sustain their base even-flow harvest level. While departures may be technically feasible, they have been the focus of considerable controversy among industrial and environmental groups.

Another consequence of management intensification is to shift more productive capacity to the South. In 1950, the South produced no softwood plywood and about 46% of total U.S. woodpulp. By 1980 the South produced roughly 38% of U.S. softwood plywood and 60% of U.S. woodpulp. Southern expansion has been possible primarily because of lower labor and stumpage costs and, because of its proximity to major markets, lower transportation costs. The baseline simulation projects a continuation of past trends with the South's share of total softwood harvest rising from roughly 45% in 1980 to 53% by 2030. However, the investment trends depicted in the simulation accelerate production concentration in the South, leading to a 60% share of softwood harvest by 2030.

This result is a direct consequence of the many potentially treatable acres in the South and of the specific enrollment rule employed in the simulation. From the Forest Industries Council study, only the South and the Douglas-fir and California regions have significant opportunities for increasing growth through intensive management. The South has roughly nine times the commercial forest acreage of the Douglas-fir and California regions combined but nearly twelve times the treatable area. Thus, even by halving or quartering the South's enrollment rate and acreage treated, the region would continue to expand output relative to the West.

Recently, some forestry interest groups have advocated the adoption of a national policy seeking a net surplus in U.S. international forest products trade. Intensification of forest management at the levels discussed in this paper appears to offer the only means of achieving this ambitious goal. In the baseline simulation, the United States is a net importer throughout the projection period. By 2030 net imports are 2.3 billion cubic feet. Intensive management increases total U.S. supply in 2030 by 2.1 billion cubic feet, reducing lumber imports by 1.7 billion cubic feet. The remaining supply increment expands U.S. domestic lumber and plywood markets and reduces domestic prices. International trade other than lumber imports was held constant in both the baseline and intensive simulations. However, lower U.S. product prices would improve the competitive position of U.S. producers relative to world producers, leading to improvements in the net trade position beyond that shown in the simulations.

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References

Adams, Darius M. *Effects of National Forest Timber Harvest on Softwood Stumpage, Lumber, and Plywood Markets: An Econometric Analysis.* Oregon State University Forest Res. Lab. Res. Bull. 15, 1977.

Adams, Darius M., and Richard W. Haynes. "The 1980 Softwood Timber Assessment Market Model: Structure, Projections, and Policy Simulations." *Forest Science Monograph* 22(1980):1–64.

Barber, Richard L. "A Methodology for Evaluation of RPA Timber Production Enhancement Programs Using the RPA Assessment Model." M.F. thesis, Oregon State University, 1979.

Berck, Peter. "The Economics of Timber: A Renewable Resource in the Long Run." *Bell J. Econ.* 10(1979):447–62.

Forest Industries Council. *Forest Productivity Report.* Washington DC: National Forest Products Association, 1980.

Hough, Franklin B. *Report upon Forestry, vol. 1.* Washington DC: U.S. Department of Agriculture, 1878.

King, R. A., and F. S. Ho. *Reactive Programming: A Market Simulation Spatial Equilibrium Algorithm.* Dep. Econ. Res. Rep. 21, North Carolina State University, 1972.

Larson, R. W., and M. H. Goforth. *TRAS: A Timber Volume Projection Model.* Washington DC: USDA For. Serv. Tech. Bull. 1508, 1974.

McKillop, William L. "Supply and Demand for Forest Products, An Econometric Study." *Hilgardia* 38(1967):1–132.

Rahm, Michael. *Forest Policy Project, Module III-A, Timber Supply Baseline,* Renton WA: Boeing Computer Services, 1980.

Robinson, Vernon L. "An Econometric Model of Softwood Lumber and Stumpage Markets, 1949–67." *Forest Sci.* 20(1974):171–9.

U.S. Department of Agriculture, Forest Service. *Review Draft: An Analysis of the Timber Situation in the United States.* Washington DC, 1980.

———. *The Outlook for Timber in the United States.* Washington DC: Forest Resource Rep. 20, 1973.

———. *Timber Trends in the United States.* Washington DC: Forest Resource Rep. 17, 1965.