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Private forest investment and long-run sustainable harvest volumes

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Abstract. Private timberlands in the United States have the biological potential to provide larger quantities of timber on a sustainable basis than they do today. Most opportunities for increasing growth and harvest lie on nonindustrial private lands in the South. Past studies, based on fixed scenarios of future prices, also suggest that many of these opportunities for intensified management can be undertaken with positive economic returns. Translation of these physical and apparent economic potentials into projections of future management and harvest requires a model of private timber management investment behavior. This study examines the dynamics of investment in private forest management according to a model of timber markets and timber supply in which intertemporal levels of private investment, harvest, and timber prices are all endogenous. The results of this model are used to examine the extent and types of possible future private management investments and how these will affect timber supply. In addition, the sensitivity of these projections to variations in key market and behavioral determinants is examined through simulation of alternative scenarios involving reduced public timber harvest and constraints on planting investment of nonindustrial private owners.

The base case illustrates the substantial potential of timberlands for increased growth and harvest. This requires, however, investments in planting well beyond those observed in recent years. Given this, the area in planted forests would almost triple within the next 30 years. Expanded investment would allow immediate increases in timber harvest and sustained increases in timber inventory, with virtually no trend in softwood log prices. Projected increases in plantation area would concentrate timber production on fewer hectares, with more hectares managed passively. Naturally regenerated forests in the future would cover at least three-quarters of the private timberland area, with hardwoods continuing to dominate. Restricting nonindustrial private plantation investment to levels observed in the recent past markedly alters projections for softwoods, thus raising prices and reducing timber harvest relative to the base case across the full projection period. In contrast, reductions in public timber harvest alone result in increased prices and reduced total cut in the near term, but have limited impact on the outlook three-five decades hence, because private investment effectively compensates for public timber harvest reductions.

Introduction

Private timberland in the United States comprises 145 million ha and supplies the largest part of the country's wood requirements (Powell et al. 1993). Despite increased substitution and slower economic and population growth, the long-term demand for wood products is not expected to decline (Haynes et al. 1995). At the same time, timber harvest reductions on public lands are likely to continue, as will the conversion of forest land in all ownerships to nonforest or non-timber uses. As a consequence, private timberlands will become increasingly important in the nation's timber supply, and there will be some incentive to expand long-term growth and harvest from these private lands.

Previous studies have identified large areas of private timberland with biological potential for increased net growth through more intensive management. On the basis of static investment analyses with fixed prices, these studies suggest as well that substantial portions of these investments could provide an attractive financial return (USDA Forest Service 1990; Alig and Wear 1992). Translation of these physical and apparent economic potentials into projections of future management and harvest requires some model of private timber management investment behavior. With few exceptions, however, past analyses of private timber supply have simply used one or more sets of fixed assumptions for future investment activity in which planting and other investment actions occur in a preset and invariant sequence over time (see, for example, USDA Forest Service 1990). Although this approach provides a general picture of the impacts of various investment levels, it may significantly misrepresent future time paths of timber management and harvests by ignoring any interaction or feedback between investment decisions and current or future timber market conditions.

This study examines the dynamics of investment in private forest management by using a model of timber markets and timber supply in which intertemporal levels of private investment, harvest, and timber prices are all endogenous. We developed projections of the extent and types of possible future private management investments and how these will affect timber supply. Could private investment significantly modify the future timber supply outlook? Would this conclusion change if the public cut continues to fall, and are sustainable nonfederal harvest volumes possible without large timber price changes? How important are the contributions of forest industry and nonindustrial private lands in this process? For each scenario, we report projections of plantation area for forest industry (FI) and nonindustrial private forest (NIPF) owners, timber management intensity, timber inventory levels, and log prices.

Extent and management of planted forests

Changing forest product market and policy conditions in recent years have been associated with marked intensification of timber management on some private lands and with an increasing share of total harvest from private lands. Total private timber inventory volume has increased by 37 percent, although the private U.S. timberland[1] base currently is 3 percent smaller than in 1962. Rising timber prices induced investment to enhance timber yields, primarily through the use of planting stock.

Changes in planted forest area

Prior to the 1930s, only a few thousand hectares of NIPF land were planted annually. The area of NIPF tree planting increased sharply to over 400,000 ha/yr during the peak of the Soil Bank Program in the late 1950s (Alig et al. 1990). Spikes in NIPF planting have typically been associated with government programs, including those that followed the Soil Bank Program: the Forestry Incentives Program begun in the 1970s and the Conservation Reserve Program (CRP) in the late 1980s and early 1990s (Figure 1). The CRP was part of the 1985 and 1990 USDA Farm Bills, and subsidized the afforestation of about 1 million ha of highly erodible cropland, mostly in the South. Annual planting rates in the United States have fluctuated notably since the early 1960s (USDA Forest Service 1995). The area of FI tree planting increased steadily between the early 1960s and the mid-1980s, and peaked in about the same year as NIPF planting during the CRP period.

The area of plantations in the South and Pacific Northwest Westside (PNWW) regions[2] of the United States has grown over the last several decades. Expansion of plantation area is consistent with broad trends in other key timber-growing regions of the world, where plantations increasingly are the source of industrial wood. Plantations in many cases offer timber supply advantages in terms of location, accessibility, operability, wood type, and wood quality. The vast majority of tree planting on private timberland consists of softwood species, mainly because they produce larger volumes of higher value sawtimber in less time, relative to hardwoods.

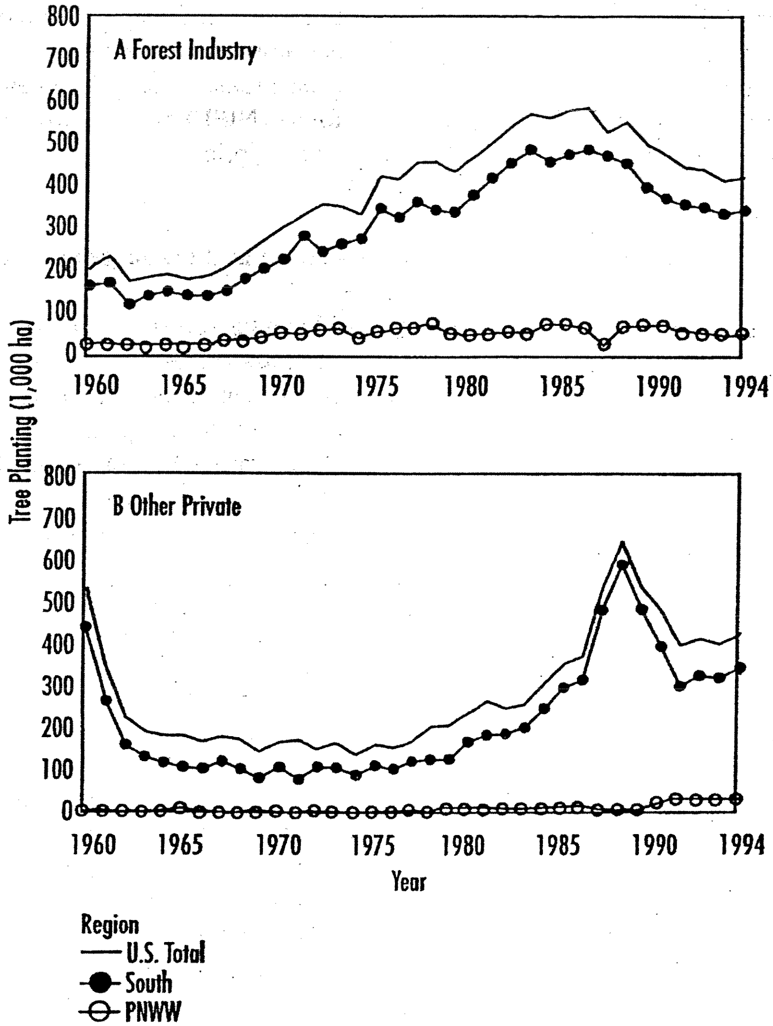

Figure 1. Historical tree planting levels for forest industry and other private landowners, 1960–1994.

The South has about two-thirds of the fast-growing coniferous plantations in the world (Sedjo 1995), equal to about 12 million ha of southern pine plantations. The South contains two-thirds of the plantation[3] area of the United States (Brooks 1993), with planted pine area in the South increasing more than 10-fold since 1952 (USDA Forest Service 1988). In 1994, more than 80 percent of the area planted to trees in the United States was in the South (USDA Forest Service 1995). Within the South, a proportionately larger amount of FI timberland (32 percent) is planted compared to NIPF timberland (6 percent). In 1994, the FI planted slightly more than half of new private plantations in the United States, on a timberland base about one-quarter the size of that of the NIPF. The next highest level of private tree planting in 1994 was in the PNWW region, equal to about one-tenth of private plantings. In contrast to the South, most of the PNWW private tree planting was on FI lands. The area of private tree planting in the PNWW region has also increased since 1962 (Figure 1), but at a slower rate than in the South.

Several studies have found a positive relationship between available timber growing stock and timber harvested, thereby indicating that tree planting may have an effect on short-term as well as long-term timber supply (Alig et al. 1990). Research examining NIPF tree planting decisions has indicated a weak response to stumpage prices (Newman and Wear 1993). Reforestation decisions by NIPF owners were correlated with reforestation costs and availability of cost-sharing (e.g., Brooks 1985; Royer 1987). Forest industry planting decisions have not been researched as much as their NIPF counterparts, but available evidence suggests that FI planting decisions in the South are positively influenced by increases in stumpage prices and land prices (where land is a substitute for plantations), and negatively influenced by increases in interest rates (Lee et al. 1992).

Changes in intensity of plantation management

Estimates of timber management are based on expert opinion in most cases, but indicate that the large NIPF timberland base is generally managed in a custodial or low-intensity mode (e.g., USDA Forest Service 1988; Adams et al. 1992). In contrast, the FI base has a much higher percentage of plantations and receives a higher proportion of intermediate treatments (e.g., thinning). Activities associated with intensive management (e.g., fertilization, weeding, and thinning) can effectively reduce time to reach a minimum merchantable standard by increasing incremental volume growth on each stem. However, even short rotations (20–30 years in the South) represent a long time horizon filled with considerable uncertainty, so that noncorporate forest owners are sometimes reluctant to undertake such investments.

Past studies of investment opportunities and behavior

A number of regional and national studies have examined and inventoried the area of private timberland on which timber management could be intensified (see, as examples, USDA Forest Service 1973, 1988, 1990; Alig and Adams 1995). These studies have consistently shown a large potential for intensification on NIPF lands and, to a lesser extent, on forest industry ownerships. For example, in the 1989 RPA Timber Assessment by the USDA Forest Service (1990), more than 24 million ha of NIPF land were identified as having potential for increased growth through intensified management, while returning a real rate of return of at least 4 percent. These opportunities are concentrated in the South and include more than 8 million ha of timberland that offer attractive rates of return if regenerated to plantations. If these investments were undertaken and sustained, they would result in a timber volume increment of some 19.8 million m^3 at harvest.

Past studies of private investment behavior, which have treated investment as endogenous, can be grouped according to their modeling methodology. Vaux (1954, 1970), USDA Forest Service (1963), and Hyde (1980) use a relatively simple model in which levels of management and steady-state timber harvest are linked to stumpage price for various strata of the inventory in a schedule that might be interpreted as a long-term timber supply function. Optimal long-term supply, price, and timber management intensity are found where this function intersects long-run demand. In a short-term, dynamic context, Adams et al. (1982) employ TAMM, the Timber Assessment Market Model (Adams and Haynes 1996), together with a price-linked ranking of investment opportunities, to identify the equilibrium level of management investment. Assuming a fixed temporal pattern of investment implementation, they make price projections with TAMM at various investment levels in an iterative fashion until solutions stabilize. Newman and Wear's (1993) econometric model of long-term timber production decisions by private owners in the South includes timber management investment in the form of a planting input. Although the model is not used to make projections, it does provide estimates of the sensitivity of planting to changes in timber and other input prices. Sedjo and Lyon (1990), in a global study, and Adams et al. (1996a), in an analysis of the United States, employ intertemporal, spatial equilibrium market models of the forest sector in which investment decisions are determined together with harvest timing. Although their respective approaches are conceptually similar, Sedjo and Lyon use a continuous, real-dollar measure of management input, whereas Adams et al. use a range of discrete classes or groups of management practices.

Forest sector model

This study employs the forest sector portion of the Forest and Agricultural Sector Optimization Model (FASOM) to project future levels of private management investment and timber harvest in the United States. The Forest and Agricultural Sector Optimization Model is a multiperiod, price-endogenous, spatial equilibrium market model of the U.S. forest and agricultural sectors (for a detailed discussion, see Adams et al. 1996a,b). The model operates on a decadal time step, with projections made for ten decades to accommodate treatment of terminal inventories. Policy analysis is limited to results for the 50 years from 1990 to 2040. Exogenous model elements in the forest sector component are held constant after the fifth decade. Terminal inventories (at the end of the finite projection period) are valued, with the assumption of perpetual, steady-state timber management following the last year of the time horizon.

The Forest and Agricultural Sector Optimization Model treats only the log market portion of the forest sector. Log demand is derived from the markets for processed products such as lumber, plywood, and paper. Logs are differentiated by six product classes: hardwood and softwood sawlogs, pulpwood, and fuelwood. A single national demand region for forest products is used, and markets for logs are assumed to be competitive. The demand functions for softwood and hardwood sawtimber and pulpwood are derived from solutions of the TAMM (Adams and Haynes 1996) and NAPAP (Ince 1994) models by summing derived regional demands for logs from manufacturing at higher market levels (sawlogs from TAMM, pulpwood from NAPAP). Sawlog and pulpwood processing facilities have some maximum capacity to produce output in any given period, and, hence, log demand has some upper bound. Decisions to purchase additional capacity in each period to augment current and future log consumption are endogenous. "Downward" substitution is permitted in the model from sawlogs to pulpwood to fuelwood. Log trade with regions outside the United States was treated by including price-sensitive, product-specific demand (export) or supply (import) functions for each region as appropriate, based on historical or anticipated offshore trading patterns. Public timber harvests, differentiated by national forest and other public lands, are treated as exogenous. Land use changes (shifts from forest to other uses) are also exogenous. For the present study, these projections were drawn from Alig and Wear (1992), and portray a continued net loss of NIPF timberland area, mostly to urban and developed uses.

The Forest and Agricultural Sector Optimization Model describes private timberland in terms of strata differentiated by region (nine), class of ownership (forest industry and nonindustrial), forest type (four classes describing species composition, either softwoods or hardwoods, in the current and immediately preceding rotation), site productivity (three levels of potential for wood volume growth), management intensity (four discrete types of timber management regime applied to the area), and 10-year age class (ten). Central to examining potential changes in private forest management are the four timber management intensity classes, from which FASOM endogenously selects the optimal form for both softwood and hardwood hectares: passive – no management intervention of any kind between harvests of naturally regenerated aggregates; low – custodial management of naturally regenerated aggregates; medium – minimal management in planted aggregates; and high – genetically improved stock, fertilization, or other intermediate stand treatments in planted aggregates. Specific practices differ by region, site quality, and forest type.

Growth of existing and regenerated stands is simulated by means of timber yield tables that give the net wood (growing stock) volume/ha in unharvested stands by age class for each stratum (a similar approach is described by Mills and Kincaid 1992). Harvest of a hectare of timberland involves, in general, the simultaneous production of some mix of softwood and hardwood timber volume.

Forestry budgets for private timberland include costs for establishment, growing (e.g., fertilization), timber harvest, and delivery to a mill. Costs differ by region, species, and timber management practice. A constraint reflects limits on the extent of hardwood area that is biologically suitable for conversion to softwood timber types.

Base projections and scenarios

As a datum for comparison, we develop a base case (BASE) that assumes a continuation of current levels of public harvest and no limitations on the extent of private management investment. Base case assumptions for demand and other market conditions derive from the USDA Forest Service's 1993 RPA Update (Haynes et al. 1995). To partially examine the sensitivity of the BASE results to changes in conditions, we modified assumptions in three additional scenarios: reduced public timber harvest but no private investment limits (RPH), constrained private investment with current public timber cut (CPI), and a combination of reduced public harvest and constrained private investment (R + C). We discuss five aspects of the BASE projections in some detail – plantation area, forest type changes, intensity of plantation management, timber prices, and harvest levels – and then contrast the alternative scenarios.

Base case

Plantation area

Table 1 shows the FASOM BASE projections of private plantation areas from 1990 to 2040. We restrict our attention to the South and Pacific Northwest

Table 1. Forest and Agricultural Sector Optimization Model projections of plantation areas on private timberland in the U.S. south (South) and the Pacific northwest westside (PNWW) regions, for the base case and three scenarios, 1990–2040.

Decade	Projected plantation area (1,000 ha)							
	BASE		RPH[a]		CPI[b]		R + C[c]	
	South	PNWW	South	PNWW	South	PNWW	South	PNWW
	Forest industry							
1990	5.267	1.191	5.267	1.191	5.267	1.191	5.267	1.191
2000	6.794	1.827	7.437	1.802	12.375	1.860	12.412	1.774
2010	10.820	2.091	11.638	2.110	13.551	2.126	13.565	2.126
2020	11.350	2.282	12.198	2.282	14.224	2.317	14.224	2.316
2030	11.302	2.446	10.797	2.446	14.224	2.468	14.224	2.468
2040	11.311	2.579	10.797	2.579	14.224	2.579	14.224	2.579
	Nonindustrial private forest							
1990	4.051	0.277	4.051	0.277	4.051	0.277	4.051	0.277
2000	14.290	0.926	16.954	0.869	5.696	0.469	5.306	0.473
2010	22.115	1.149	27.370	1.149	6.803	0.637	6.389	0.641
2020	23.381	1.250	29.296	1.250	6.433	0.800	6.818	0.800
2030	23.684	1.364	29.707	1.364	5.412	0.949	5.332	0.949
2040	23.650	1.432	29.633	1.432	5.428	0.981	5.102	0.981

[a]Reduced public timber harvest, but no private investment limits.
[b]Constrained private investment with current public timber cut.
[c]A combination of reduced public harvest and constrained private investment.

Westside (PNWW) regions, as the two regions with greatest forest investment activity. In the BASE, about 28 million ha of forest plantations are added in those two regions, with about half of that area added during the first decade.

The area of FI plantations is projected to more than double by 2040 in both regions. Nonindustrial private forest plantation area is projected to increase more than 5-fold in both regions, growing from 4.3 million ha in 1990 to 25.1 million ha in 2040. The amount of overall plantation area increases rapidly in the initial decades, and then stabilizes toward the end of the projection period.

In the South, where timber rotations are shorter, plantation area peaks in 2020 for FI lands and in 2030 for NIPF lands. The area of FI plantations in the South expands the most during the 2000–2009 period, whereas NIPF owners in that region add the largest proportion of their plantations (over 40 percent) during the 1990–1999 period. In the PNWW, additions to both FI and NIPF plantation areas are projected throughout the period 1990–2040, but are largest during the 1990–1999 period.

Potential increments in private plantation area are consistent with investment opportunities identified in earlier studies (e.g., Alig and Wear 1992; Alig et al. 1992). When FASOM projections of planted areas were compared to TAMM projections prepared for the 1993 RPA Assessment Update (Haynes et al. 1995), base case results for FASOM generally differed more in degree than in form. This may reflect, in part, the consideration of data on "economic opportunities" for silvicultural investments by Forest Service analysts as part of the assumptions made regarding intensity shifting for the Update. The tendency would be to assume that more area moves to higher management intensity classes (MICs) in regions and ownerships where such opportunities are abundant (see, for example, USDA Forest Service 1990, Chapter 9). Our BASE showed similar movements, but, lacking any limits on investable funds or other constraints, the FASOM model selects much higher levels (larger areas) of plantation investment.

Forest type changes

Projected plantation activity includes conversion of substantial areas of hardwood types to softwoods, especially in the South and less so in the PNWW region (Figure 2). Type conversion in the first several decades is fueled by a relative shortage of softwoods. This contributes in turn to declining hardwood harvest volumes and rising hardwood prices in later periods (beginning about 2020).

Although plantation areas expand markedly in the BASE relative to current levels, future private forests would still be predominantly of natural origin. By 2040, U.S. private timberland would include, at a maximum, about one-quarter softwood plantations, with somewhat higher proportions in the South and PNWW regions. About four-fifths of the NIPF timberland area in the United States would still be concentrated in the lowest two management intensity classes that involve naturally regenerated stands, in contrast to about one-half for the forest industry. The growing area of plantations effectively reduces pressure on naturally regenerated forests as a source of industrial wood (Sedjo 1995).

Intensity of plantation management

Figure 3 shows the projected distribution of planted FI and NIPF softwood timberland area by medium and high MIC classes. Industry owners are projected to apply a higher proportion of relatively intensive plantation management (e.g., precommercial thinning, fertilization, and commercial

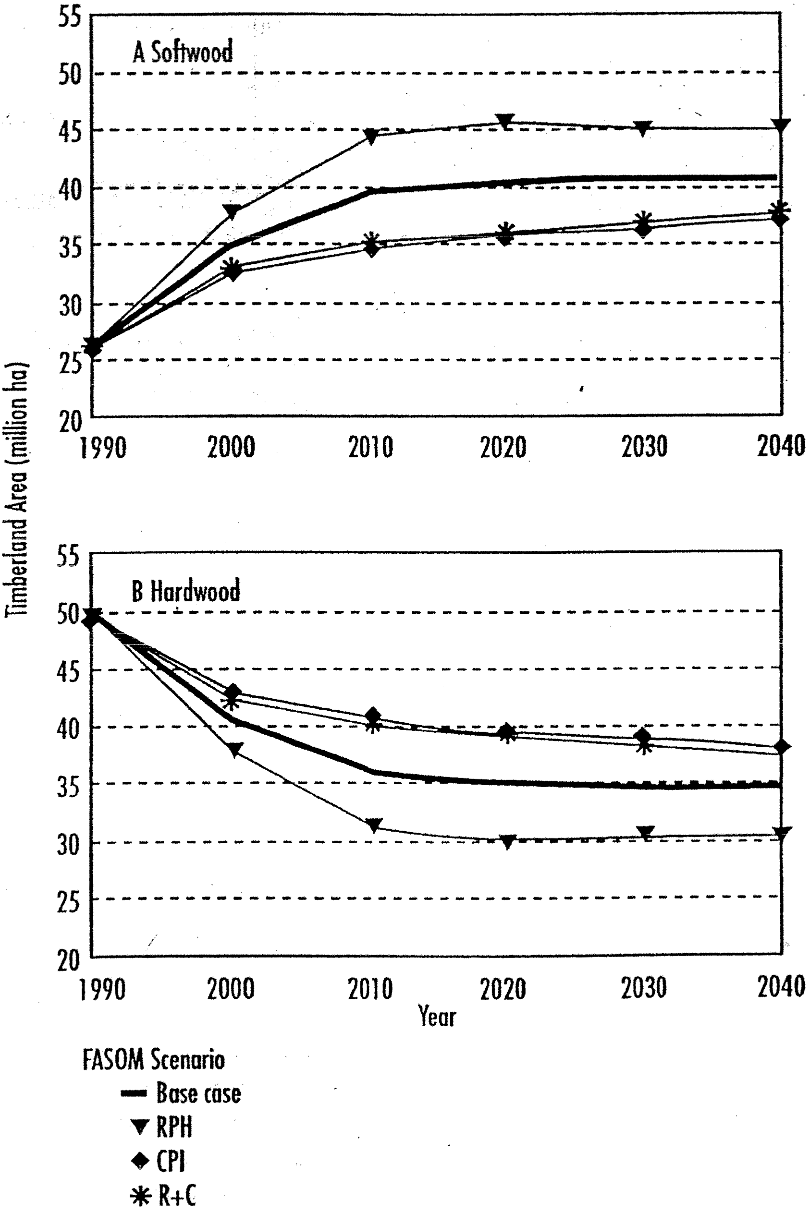

Figure 2. Total private softwood and hardwood timberland area for the base case and three alternative scenarios (RPH – Reduced Public Harvest; CPI – Constrained Private Investment; R + C – Reduced Public Harvest and Constrained Private Investment) for the U.S. south and Pacific northwest westside, 1990–2039.

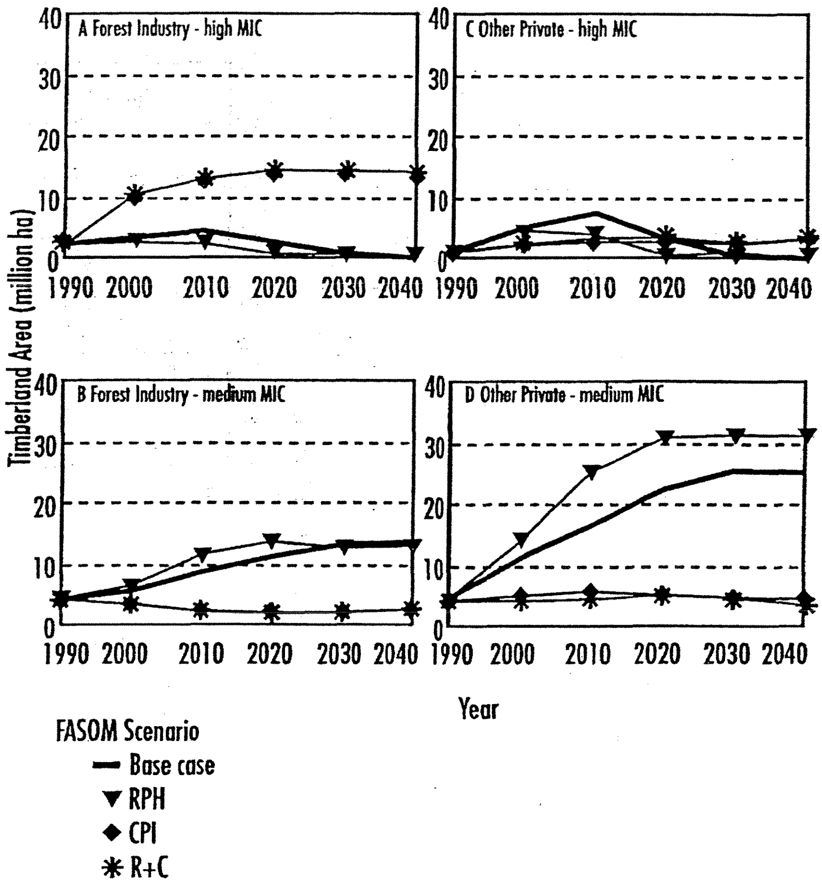

Figure 3. Projected forest industry timberland area for (A) high and (B) medium management intensity classes, and projected other private timberland area for (C) high and (D) medium management intensity classes for the base case and three alternative scenarios (RPH – Reduced Public Harvest; CPI – Constrained Private Investment; R + C – Reduced Public Harvest and Constrained Private Investment) for the U.S. south and Pacific northwest westside, 1990–2039.

thinning) than are NIPF owners. This does not mean that the bulk of private lands will be more intensively managed than at present. Indeed, averaged over all private lands, most plantations would receive less intensive treatments. Scarce investment funds are allocated to the most productive lands that receive a significant increase in management intensity. Other areas receive less investment. For example, some lands in the low management intensity class (not shown in the figures) are shifted into the lowest (passive) class.

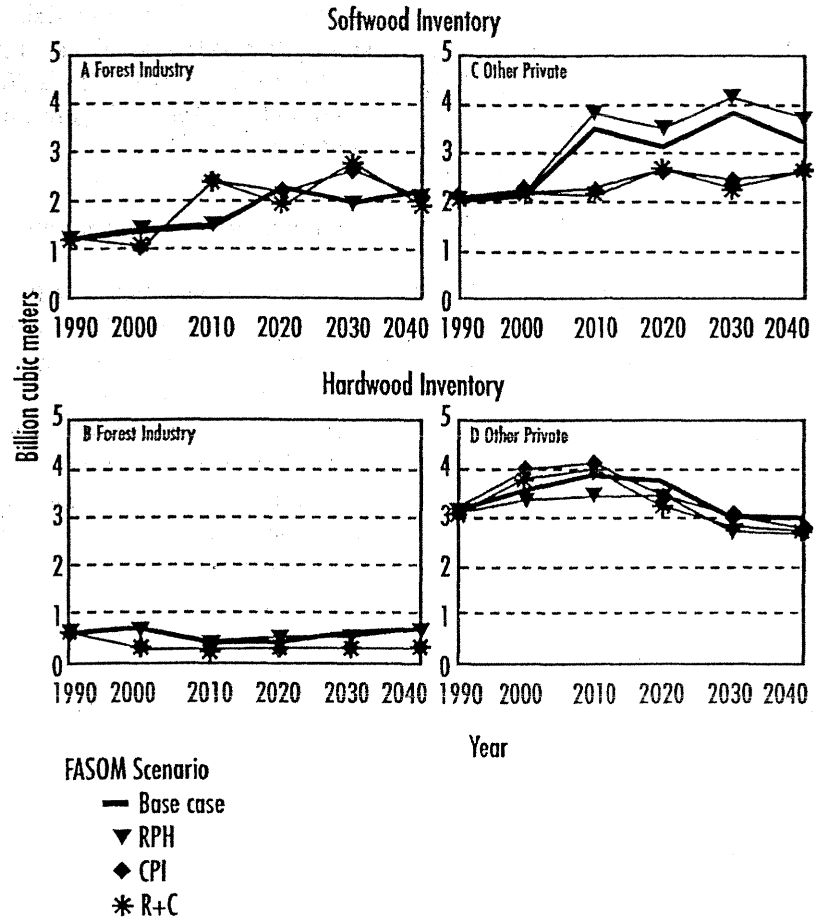

Figure 4. Projected forest industry (A) softwood and (B) hardwood inventory and other private (C) softwood and (D) hardwood inventory for the base case and three alternative scenarios (RPH – Reduced Public Harvest; CPI – Constrained Private Investment; R + C – Reduced Public Harvest and Constrained Private Investment) for the U.S. south and Pacific northwest Westside, 1990–2039.

Timber volumes

Projected softwood and hardwood inventory levels, combined for the South and PNWW regions, are shown in Figure 4. Softwood growing stock inventories on both ownerships are projected to increase through the 2000–2009 decade, and then to roughly level off at amounts at least 50 percent higher than initial 1990 levels. Projected levels of hardwood growing stock rise slightly in the 1990s for both owner groups. The FI level drops after 2000, as a large area of hardwoods is converted to softwood plantations, then rises later in the projection. Nonindustrial private forest hardwood inventories follow a similar but somewhat delayed pattern, declining after 2010 and then turning up slightly after 2030. The 2040 FI hardwood inventory level is back up above the initial 1990 level, whereas the 2040 NIPF level is slightly lower than the 1990 level.

Price and harvest projections

Given the investment activity described above, harvests can expand readily to meet growing demand and softwood product prices differ little over the course of the projection (Figure 5). In contrast to previous studies that used fixed investment schedules and market models with only a single period's scope, the BASE softwood price projections are far less volatile and exhibit little growth. Within FASOM's highly flexible structure, private timber producers can anticipate future price movements and plan current investment and harvest accordingly.

The BASE timber harvest rises for both softwoods and hardwoods over the full projection. As indicated in Figure 5, softwood harvest is larger in all decades than the BASE projection in Haynes et al. (1995), whereas softwood sawtimber prices are lower. This same general relationship holds for hardwood projections as well. In the present model, unrestricted management investment allows larger harvests in all periods, including the 1990 and 2000 decades, in anticipation of future growth increases.

Alternative scenarios

Our model of private investment decision presumes that owners pursue, in effect, an objective of land value maximization, limited only by conditions of the market and of their initial inventories of land and timber. There are, of course, many conditions that act to restrict investment behavior. We examined one class of these constraints – availability of investable funds – in scenarios limiting nonindustrial investment expenditures to levels observed in the recent past. Also, because changes in volumes of public harvest represent shifts in demand for private timber, and because these volumes are highly uncertain, we examined both "current" and "reduced timber cut" scenarios for public ownerships. The nature of the alternative scenarios and expectations regarding results are as follows:

Reduced public timber harvest (RPH). Harvests from most classes of public lands in the United States are established by mechanisms independent of

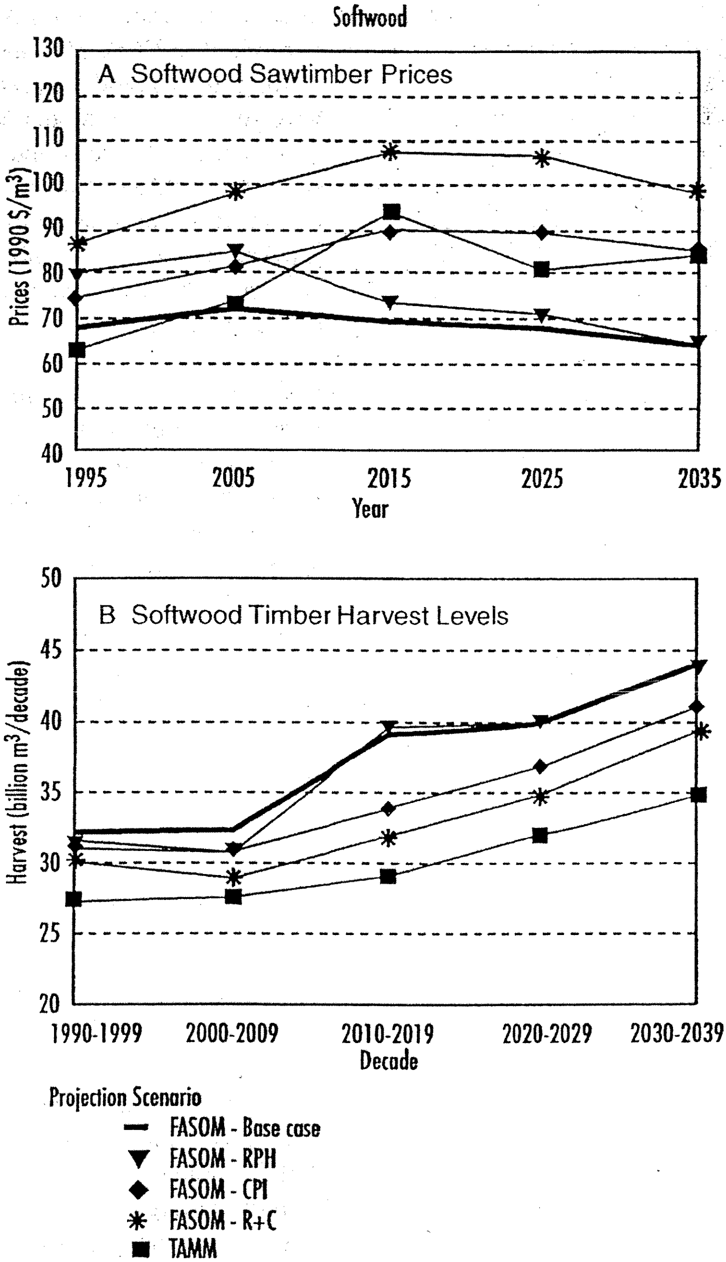

Figure 5. Projected softwood prices for the FASOM base case and three alternative scenarios (RPH – Reduced Public Harvest; CPI – Constrained Private Investment; R + C – Reduced Public Harvest and Constrained Private Investment), and projected U.S. softwood (sawtimber and pulpwood) timber harvest levels for the FASOM base case, three alternative scenarios, and TAMM, 1990–2039.

markets and prices for forest products. Thus, public cut is treated as an exogenous input to FASOM. Changes in public harvests have the partial effects of shifting the demand for private timber and, because forest owners in FASOM have perfect foresight, of changing the extent and timing of current and future private timber harvests and forest management investments. In this modification of the BASE scenario, we eliminated national forest timber harvests, but left those on other public lands unchanged (Adams et al. 1996a). These restrictions on public timber production should lead to higher timber prices, at least in the near term, and more incentives for private owners to intensify timber management.

Constrained private investment (CPI). In FASOM any change in future conditions is optimally anticipated (from a net social welfare viewpoint) and investment is freely flexible to range over time. A representation of "real world" behavior would doubtless be somewhat less adaptable, in recognition of the limitations of the decision maker. In this modification of the BASE scenario, we limited the future annual expenditures for NIPF tree planting investments to the level observed in 1993 (USDA Forest Service 1995). The constraints were imposed by region. We would expect that restricted NIPF capability to invest will lead to higher log prices, less area in softwoods on NIPF lands, and increased forest investment by forest industry owners, although their capability to respond is limited by the smaller size of their land base.

Combined: reduced public harvest and constrained private investment (R + C). Under this scenario, we combined the assumptions of less public timber harvest and the restricted capability of NIPF owners to invest in management.

Plantation area

Projected areas of planted private timberland differed widely among the three alternative scenarios and in comparison to the BASE (Table 1). In all scenarios, planted area increases at least through 2009. The largest increase is for NIPF planted timberland in the South under the RPH scenario, which is 6 million ha larger than the BASE by 2040. In contrast, NIPF planted timberland area in the higher-cost PNWW region changes little between the BASE and the RPH scenario.

Constraining the level of plantation investment by NIPF owners in the CPI scenario substantially lowered NIPF plantation area. This is especially important in the South, where the 2040 area is less than one-quarter of the BASE level. In response, FI planting in the South is one-quarter larger by

2029. Any further increases in southern FI softwood plantations in the CPI scenario are constrained by a limit on the area of convertible hardwood.

Projected areas of planted private timberland were similar between the CPI scenario and the combined scenario (R + C), where the reduced public harvest condition is imposed as well. The investment constraint is clearly the controlling condition for the projection, and is binding in all periods. The effects of the public cut restriction are to further raise demand for private timber, this leading to markedly higher log prices than in the CPI scenario (Figure 5).

Adjustments across policy scenarios, especially over the next 10–20 years, reflect the strong influence of the age class distribution and limited merchantable timber volumes available for harvest in the current timber inventory. For example, there is an interaction between projected increases in private plantation area under the RPH scenario and the lower near-term supply of timber and lower total U.S. harvest. The lower short-term harvest causes prices to rise. This exacerbates conditions of limited merchantable private inventory during the first three decades of the projection, which amplifies the very modest price increases observed in the BASE in this period. In the RPH scenario, higher prices elicit more private investment, and gradually force prices back toward BASE levels.

Forest type changes

All scenarios involved significant conversion of hardwood areas to softwood types (Figure 2). Higher softwood log prices elicit more investment in conversion of hardwood types to softwoods. Reduced public cut stimulates this process in the first two decades, and restrictions on NIPF investment reduce it by nearly equal amounts. After 2020 there is little incentive to continue conversions in any of the scenarios. Type conversion constraints were binding after 2020 for the amount of hardwood land available for conversion to softwoods on FI lands in the South under the CPI scenario. The FI steps in to plant more area when the level of NIPF plantation investment is constrained to recent historical levels. The hardwood conversion constraint also is binding in that period for the combined R + C scenario.

Intensity of plantation management

Timber management intensity on planted lands appears to be somewhat more sensitive to scenario changes than to type conversion, particularly in the long term. Limiting NIPF investment raises log prices across the full projection span (Figure 5). As a result, more land could be enrolled in the higher (and more costly) plantation intensity class (high MIC class in Figure 4). A significantly larger proportion of these limited regeneration expenditures by NIPF owners are for planting high site lands. The range of adjustment is insufficient, however, to bring log prices back to BASE levels. Restriction of NIPF investment clearly dominates behavior in the combined R + C scenario.

Reduced public cut without an investment constraint, in contrast, stimulates substantially more hardwood site conversion. Although this additional land remains primarily in the lower plantation intensity category (medium MIC), private investment increases enough to return prices to BASE levels. Under the RPH scenario, inventory is managed more intensively than in the BASE because of higher product prices and timberland values. With lower supplies of stumpage available from the public sector, product and timberland prices increase and private landowners expand their inventory holdings in line with product demands.

Price and harvest projections

All scenarios acted to raise softwood sawtimber prices above the BASE (Figure 5a). Increases under the RPH scenario were limited to the first two decades for reasons noted. Limiting private investment prevents owners from fully exploiting future gains, and prices remain higher than in the BASE. Reducing public cut, in the face of an NIPF investment restriction, ratchets prices still further upward, because there are few additional investment options accessible (FI lands are already at hardwood conversion limits).

Softwood harvests in all scenarios are below BASE levels (with the exception of the 2010 decade for the reduced public cut case), and, similar to the BASE, show steady growth after 2000. Restricting either public cut or NIPF investment forces some decline in total softwood cut between the first and second decades of the projections. This reflects more rapid depletion of initial stocks in the first decade of these scenarios, and the lag between investment and harvest. The addition of reduced public timber cut to investment limits leads to a nearly constant downward shift in softwood harvest throughout the projection (Figure 5b), because private owners are left with very limited means of response in the face of the investment restriction.

Discussion and conclusions

Our base case suggested that U.S. private timberlands have considerable potential for sustainable wood production under intensified management. Indeed, investment at the levels envisioned here could lead to substantially greater harvest volumes and lower prices than those projected in the 1993 RPA Timber Assessment (Haynes et al. 1995). Under assumptions of perfect foresight and perfect capital markets and no constraints on investable funds in our model, harvest could potentially expand to meet growing demand such that softwood log prices would vary little over the projection. The requisite levels of aggregate private investment were, however, well beyond those observed in recent years. The area in planted forests would almost triple within the next 30 years, with the bulk of this increment in the South where plantation investments are less costly. On industrial ownerships, projected plantation rates would differ little from recent historical activity. For NIPF lands, however, our projections involved a substantial increase over current levels, despite the rising trend of investment in recent decades. This reflected in part the small portion of that ownership currently devoted to plantations, the site quality and growth potential of its lands, and its overall size.

Private harvest in the United States over the next two decades will be strongly influenced by current timber inventory characteristics, particularly the limited areas and timber volumes in older merchantable age classes in virtually all regions. Despite these conditions, our projections indicate that expanded investment would allow some immediate increments in timber harvest, sustained increases in timber inventory, and virtually no long-term trend in softwood log prices. In the longer term, continued conversion of rural land to urban and developed uses will act to reduce the timberland base, in some cases removing the most productive lands. Our results suggest, however, that great potential for expanding sustained production levels would still exist.

At the same time, these results do not necessarily portend a future forest comprising solely planted stands. Projected increases in plantation area would concentrate timber production on fewer hectares, with more timberland passively managed and with less harvest pressure on naturally regenerated forests. Naturally regenerated forests would cover three-quarters of the future private timberland base, with hardwoods continuing to dominate.

Under the assumptions of perfect foresight and perfect capital markets in our model, changes in prices and profitability stimulated changes in investment that acted to counter the effects of the various policies examined, and to limit the movement of prices and quantities away from the base case results. In the reduced public harvest case, for example, investment rose in response to higher prices and largely offset public losses within two decades. Because the source of this flexibility was management intensification, however, any restrictions on private investment have significant impacts. Thus, the scenario limiting NIPF investment to recent historical levels yielded higher log prices and reduced aggregate cut. Combining any other supply restriction or demand expansion (such as the reduction in public harvest) with the investment limit only served to exacerbate the market impacts.

Notes

1. Timberland is forest land that is not reserved for other uses and is capable of producing 1.4 m^3 of industrial wood/ha/yr.
2. The U.S. South consists of thirteen states, from Virginia to Texas; the PNWW region consists of the portions of Oregon and Washington that are west of the crest of the Cascade Mountains (Haynes et al. 1995).
3. Planted area and plantation are synonymous in this paper.

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