15 Private Forest Management and Investment in the US South: Alternative Future Scenarios

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Introduction

During the 20th century, private forest lands provided the bulk of the output of forest products in the USA. The share of US softwood timber harvests from public forests dropped by more than half, from 26 to 12%, between 1986 and 1996. With increasing demands for wood products in the future a high likelihood, and a smaller share coming from public lands, private timberlands will need to provide larger volumes of profitable timber production in an environmentally responsible manner.[1] Part of this growth in wood volume will come from yield-enhancing investments induced by attractive financial returns, primarily through the use of planting stock and site preparation.

This paper examines the impact of changes in private management investment on future harvest and price levels in the US forest sector, emphasizing the South of the USA because of its importance in US wood supply. We employ modelling systems developed as part of the USDA Forest Service's Resources Planning Act (RPA) Timber Assessment to simulate a series of scenarios on future private investment and timber management.[2] Understanding the timber supply prospects from private lands in the near term turns heavily on knowledge of the owners' responses to prices. In the long term, however, forest management and associated investment in silvicultural practices are the key concerns, including consideration of different trends by owner and forest cover types.

We use computer simulations to project a base case, and then consider two variations due to changes in decisions to hold higher levels of inventories (reduced hardwood harvest) and in direct investment in softwood plantations. These specific scenarios were chosen because of their pertinence to some of the key issues in prospective future timber supply: changing ownership objectives on the non-industrial private forest (NIPF) lands and the importance of plantations in the provision of future supply. The following section outlines the base case projection, which serves as our starting point. We then give a brief overview of the computer simulation model and a detailed description of the elements of the two scenarios. Final sections present simulation results and discuss their implications.

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Projected Demands for Wood Products and the Role of US Private Lands

Timber demand

The primary drivers of long-term wood products consumption and timber harvest in the USA are changes in population and income. In the draft 2000 RPA Timber Assessment, the 'base case' projection envisions slower growth and a marked ageing of the US population over the next five decades. While the total population will rise by 123.3 million people between 1998 and 2050, the number of people aged 65 and older will increase by 44 million, more than one-third of the total increase. Population ageing will have effects on the rate of output growth in the US economy and on types of goods and services demanded. Income growth will also be slower than in the past at about 2% per year, compared to growth in excess of 3% since World War II. Despite this slowing growth trend, there will be ample pressure on demand, and wood products consumption will probably rise to record levels. The USA currently relies on imports for about 20% of wood consumption; at the same time, exports account for about 12% of US production (Haynes, 2001). In recent years, US consumption of roundwood[3] in all timber products was 561 million m^3 (20 billion ft^3), of which 515 million m^3 came from domestic forests. Private forests provided 89.3% of this domestic harvest, up from 75.9% in 1970. By 2050 roundwood consumption is projected to increase some 34% to 750 million m^3 (26.5 billion ft^3) in the 'base case' projection, of which 665 million m^3 comes from US forests. The share from private forests in this projection rises to 91.0%.[4]

Land-use changes

In meeting the rising demand and harvests projected in the draft Timber Assessment's 'base case', private timberlands will undergo significant changes in area, inventory, growth and management intensity. The US population is projected to increase by more than 120 million people by 2050, with above average increases in the southern and western regions. Increases in population and income will increase consumption of timber products but will also increase demands for land for residential and infrastructure uses, further shrinking the timberland base. Rising population, expansion of urban and suburban areas, and construction of new housing will continue to erode the timberland base (see e.g. Mauldin *et al.*, 1999). From 144.7 million ha (357.7 million acres) in 1997, the US private timberland base is projected to drop by 4.1%, or approximately 6.0 million ha, by 2050, with timberland *per capita* projected to decline from about 0.73 ha per person in 1997 to 0.49 ha in 2050. Most of the projected US timberland area reduction is on NIPF ownerships.[5] Area change projections vary by region however and, for example, total private timberland area in the South Central region is projected to increase slightly by 2050 (Ahn *et al.*, 2001) based on assumed future increases in forestry land rents relative to agriculture.

Forest cover changes

Over the last 50 years, the largest timberland area changes in the USA have involved forest cover changes in the South, with a decrease in the area of natural pine and a substantial increase in planted pine area. Planted pine area increased by more than 10 million ha between 1952 and 1997, more than a tenfold increase. Plantations occupy only about 16 million ha, 5% of US forest land area and 8% of the timberland area, while naturally regenerated stands occur on the remainder (Smith *et al.*, 2001). Even in the South, which has the largest share of plantations, they still represent only 15% of the total private timberland. Private area of pine plantations in the South is projected to increase 62% by 2050 (Alig *et al.*, 2002). Tree planting has increased quite steadily from 40,000 ha in 1930 to the planting of 1 million ha in 1997 (Moulton and Hernandez, 1999). Three major federal programmes have created large peaks in tree planting activity: the Civilian Conservation Corps programme caused total planting to approach 200,000 ha per year during the late 1930s; the Soil Bank Programme propelled annual tree planting over the 400,000 ha mark in the late 1950s; and the Conservation Reserve Programme contributed largely to setting an all-time record high of 1.4 million ha planted in 1988 (see Fig. 15.1 for trends since 1950) (Alig *et al.*, 1999).

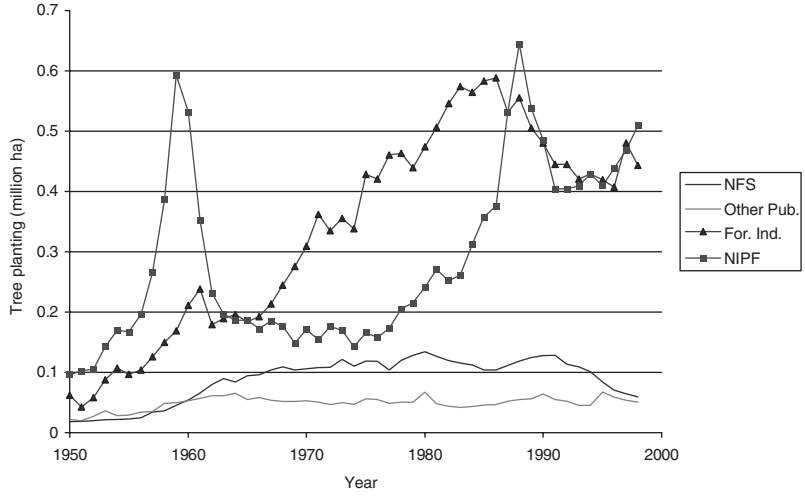

Fig. 15.1. Tree planting in the USA by forest ownership, 1950–1998. NFS, National Forest; Other Pub., other public; For. Ind., forest industry; NIPF, non-industrial private forest.

Projected future shifts in areas of natural pine and upland hardwoods in the South differ from long-term historical trends. Between 1952 and 1997, natural pine area declined by about 58%, due in part to conversion of some areas after harvest to pine plantations and other harvested stands reverting to hardwood types. Total private area in natural pine is projected to decline at a slower rate, with only a slight (1%) further reduction by 2050. The case of uplands hardwoods is somewhat the reverse. Between 1952 and 1997, upland hardwood area in the South increased by about 27%. Future area is projected to decline by 26%, due to conversion to residential and urban/developed uses such as around the Atlanta area, conversion to pine plantations, and some transitions to other forest types (e.g. oak–pine).

These projections are based on forest type transition rates computed from recent FIA plot re-measurement data and use of surveys of private forest owner intentions from Moffat *et al.* (1998) for NIPF timberlands and from the American Forest and Paper Association for industrial timberlands (Butler and Alig, 2001). Another key input is harvest projections from the RPA modelling system (see endnote 2). The amount of hardwood harvest in the South has been increasing in recent decades, and that trend is projected to continue. At the same time, aggregate investment in hardwood silviculture and management in the South has not kept pace with that for softwoods. The forest type projections are based on the assumption that such behaviour will largely continue. However, the use of short-rotation woody crops (SRWC) (e.g. hybrid poplar) is projected to increase, with most in latter decades of the projection and represent about 6% of total hardwood roundwood harvest in 2050.

The outlook for a limited harvest trend for hardwoods represents a marked change from the outlook in the 1970s and 1980s of a relative abundance of commercial hardwoods. For example, earlier observers such as Knight (1973) pointed to the pine regeneration problem in the South, with concern for hardwoods limited to the difficulty of finding markets for lower quality hardwoods. Since the early 1970s, the addition of more than 6 million ha of pine plantations in the South has contributed to a significant increase in pine plantations as a source of harvested timber in the USA. The potential also exists for emergence of hardwood SRWCs to supplement hardwoods from forests (e.g. Alig *et al.*, 2000a), but at present the volumes anticipated are relatively small.

Timber harvests and inventories

At the same time, the inventories of private forests will continue to evolve. Although changes will occur in all regions, the key areas for future private supply are the South and the Douglas-fir region of the Pacific Northwest.

The South will experience some limitations in softwood harvest over the next decade, but in the long term should see significant expansion in both softwood harvest and inventory. The source of near-term restrictions lies in the inventory structures of two groups: South Central (SC) NIPF and Southeast (SE) industry. In both ownerships, volumes will be stable to declining in the age classes where harvest is primarily concentrated and volumes available for harvest (unreserved and above minimum harvest age) will decline. After 2010, however, maturation of large areas of immature timber (the legacy of regeneration activities in the 1980s and early 1990s) will produce large shifts in the age structures of these timberlands, increase growth, and allow major expansion in harvest. For the companion private groups in the South, SC industry and SE NIPF, volumes in merchantable ages have already begun to rise and no near-term limitations are foreseen. Softwood harvest and inventory projections for the South are summarized in Table 15.1. Aggregate industrial harvest is expected to roughly double by 2050. Harvest will exceed growth after 2030, but by 2050 inventory is still 64% higher than 1997 levels. NIPF ownerships will realize a nearly 40% increase in harvest and inventory will rise steadily (growth exceeds harvest) to 50% above current levels. The limitations in near-term harvest on NIPF lands are also clearly shown in Table 15.1.

Management intensities

Changes in management practices and rising management investment have contributed to growth in Southern harvests and inventories in the past and will continue to do so in the future. As illustrated in Table 15.2, industrial owners will increase their plantation area to more than three-quarters of their timberland base, and

Table 15.1. Timber harvest and inventory for private ownerships in key US supply regions, with projections to 2050.

	1997	2010	2030	2050
	(Million m^3)			
Softwoods				
Southern Industry				
Harvest	63	77	117	122
Inventory	693	984	1293	1135
Southern NIPF				
Harvest	110	88	110	153
Inventory	1829	2180	2641	2742
Douglas-fir				
Harvest	19	28	28	26
Inventory	500	512	507	579
Hardwoods				
Southern Industry				
Harvest	21	21	17	15
Inventory	463	387	340	279
Southern NIPF				
Harvest	78	114	117	116
Inventory	3260	3453	3135	2702
Northern Industry				
Harvest	7	5	5	5
Inventory	339	368	428	493
Northern NIPF				
Harvest	42	53	65	78
Inventory	3436	4115	4701	4962

Source: Historical data and projections, USDA, Forest Service, RPA Timber Assessment. Projections were made using the Assessment models (see note 2 for source of model documentation).

Table 15.2. Indicators of management intensity on private lands in key supply regions, with projections to 2050.

Region	Management class	Measured	1995 (%)	2010 (%)	2030 (%)	2050 (%)
Softwoods						
Southern Industry	Plantations	as % of all softwood area	58.6	68.9	75.4	77.6
	High intensity plantations	as % of plantations	21.5	49.3	52.7	52.1
	Low–medium intensity natural and oak–pine	as % of natural and oak–pine	76.9	80.0	82.4	86.5
Southern NIPF	Plantations	as % of all softwood area	23.8	26.0	29.7	31.3
	High intensity plantations	as % of plantations	26.5	30.2	30.2	27.7
	Low–medium intensity natural and oak–pine	as % of natural and oak–pine	48.9	36.6	27.8	21.8
	Unavailable (for harvest) lands	as % of all softwood area	4.8	6.7	8.4	10.9
Douglas-fir Industry			1990 (%)	2010 (%)	2030 (%)	2050 (%)
	Plantations	as % of all softwood area	56.6	75.9	82.0	87.6
	High intensity plantations	as % of plantations	49.4	53.2	53.1	52.9
Hardwoods						
Southern Industry	Low intensity, including partial cutting	as % of all hardwood area[a]	87.1	81.6	74.4	69.4
	Unavailable (for harvest) lands	as % of all hardwood area[a]	7.5	11.6	16.9	21.4
Southern NIPF	Low intensity, including partial cutting	as % of all hardwood area[a]	81.1	75.0	63.1	55.9
	Unavailable (for harvest) lands	as % of all hardwood area[a]	9.5	12.6	18.0	21.0

Source: Historical data and projections, USDA, Forest Service, RPA Timber Assessment.
[a]Excludes non-stocked areas.

employ more intensive regimes (e.g. substitution of capital for land) on more than half of the plantation area by 2050. In natural pine and oak–pine areas, however, management will remain largely of the least intensive forms (including partial cutting). NIPF owners will also add more plantations, but to a much smaller relative extent than industrial owners (plantations rise from 24 to 31% of the NIPF total softwood area between 1997 and 2050). There will be little change in the application by NIPF owners of more intensive regimes within plantations and a significant number are not planted back to pine after harvest (Fig. 15.2), but management intensity will increase in natural pine and oak–pine types. In addition, NIPF owners are projected to increase the areas unavailable for timber harvesting and management (Moffat *et al.*, 1998), with the fraction of unavailable softwood area alone rising from an estimated 5% at present to 11% by 2050 (Table 15.2).

In the Douglas-fir region, industrial owners also face near-term harvest limitations for the same reasons as SC NIPF and SE industrial owners. After nearly five decades of gradual reduction in inventory and harvest as old-growth stands were converted to managed young-growth, there are large areas of timberland just below the minimum merchantability threshold. As this timber begins to mature over the next few decades, harvest and inventory will stabilize at levels near those in the late 1980s (see Table 15.1). Unlike the South, however, there does not appear to be much opportunity for harvest expansion. Increasing management intensity will act to sustain growth and harvests in the future. Plantations are expected to move from roughly 57% of the industrial timberland base to nearly 88% by 2050. The proportion of plantations in more intensive management forms (fertilization, genetically improved stock and/or enhanced site preparation, and commercial thinning) is expected to rise only slightly above the current level of 49%.

Hardwoods are often overlooked in discussions of wood consumption, but they remain a critical part of US timber supply. In 1996, hardwoods accounted for 37% of total roundwood consumption and are expected to remain at that share in the 'base case' projection through to 2050. Hardwood consumption is projected to rise from 207 million m^3 in recent years to 276 million m^3 by 2050. Harvests from domestic hardwood forests slightly exceed US consumption, due to a small volume of exports, and this condition, too, is expected to continue through to 2050. Private forests, mostly in the eastern states, provide 90% of the hardwood harvest currently, and this fraction is projected to rise to 92% by 2050.

Hardwood inventory exceeds softwood on private lands in the USA. At present this volume is split roughly evenly between northern and southern regions (see Table 15.1). In the 'base case' projection, harvests on private lands in the South expand more rapidly than those in the North, exceeding growth in all years on Southern industrial ownerships and after 2010 on Southern NIPF lands. Inventories by 2050 in these cases fall below current levels. In the North, in contrast, growth

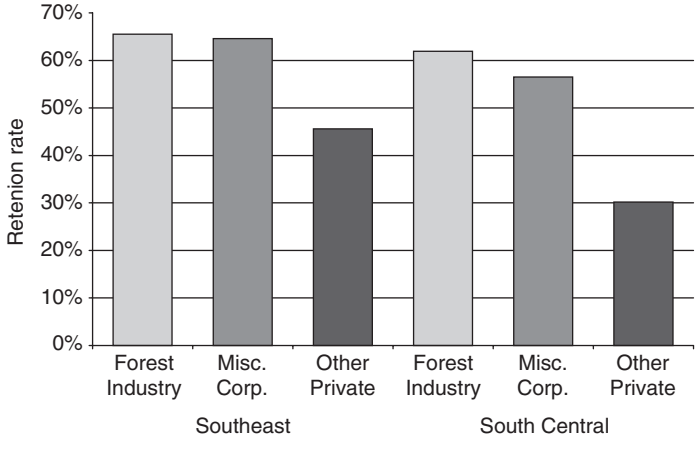

Fig. 15.2. Retention or replanting of pine plantations after final harvest on private ownerships by subregion in the US South, for the most recent forest survey period.

exceeds harvest on both private ownerships, and inventories rise sharply over the projection. The marked difference between regions reflects the current and expected future concentration of processing industry in the South.

Although there is not a full set of reliable statistics, management investment on private hardwood timberlands is certainly far lower than for softwood types. As indicated in Table 15.2 for private timberlands in the South, most hardwood timberland has not been planted and is managed with the least intensive methods (partial cutting, natural regeneration). A substantial amount of the hardwood timberland is in older age classes (45 years and older) (Haynes, 2001). A sizeable area on both industrial and NIPF ownerships is not available for harvest according to regional surveys (e.g. Moffat *et al.*, 1998). In the 'base case' projection, both private owner groups are projected to shift a large fraction of their remaining hardwood hectares into unavailable status over time. For both owner groups, this class holds roughly 20% of their hardwood timberland by 2050. Meanwhile, industrial owners will shift a small portion into more intensive modes of management, while NIPF owners are projected to shift a larger area into more intensive forms of hardwood silviculture. For perspective, the shift of NIPF hardwood hectares to more intensive management is comparable to the amount that industry is assumed to put into the unavailable reserves.

Simulation Methods

The TNAA system of models[6] was developed to support the RPA Timber Assessments and Assessment Updates conducted every 5 years by the USDA Forest Service. TNAA is a price endogenous, spatial equilibrium system (Adams and Haynes, 1996). Market solutions for both solid wood and fibre products are obtained one period at a time using direct optimization of market surplus objective functions. TNAA projects prices, consumption, and production of softwood and hardwood solid wood and fibre products, and harvest of timber from private lands and associated timber prices using an annual time step. Exogenous projections of land allocation and forest cover changes are provided by regional area change models (e.g. Alig *et al.*, 2001; Butler and Alig, 2001), and timber growth and yield projections by the area-based Aggregate Timber-Land Assessment System (ATLAS) (Mills and Kincaid, 1992). Exogenous projections of forest management investment have been based on single-hectare analyses and expert opinion. On the resource side, the TNAA system uses parameters for most behavioural equations (e.g. timber harvest by private owners) that are estimated from historical data. Private timber supply functions are derived from explicit hypotheses of intertemporal harvest behaviour for industrial and non-industrial owner classes. The resulting relations link harvest to prices, inventory levels, interest rates and, for non-industrial owners, income from non-forest sources.

Total timber harvest in TNAA is divided between 'sawtimber' and 'non-sawtimber' classes based on the product for which the harvested timber is used. Sawtimber includes timber harvested for lumber, plywood, miscellaneous products and saw/veneer log trade; non-sawtimber includes fibre for reconstituted panels, pulpwood and fuelwood. TNAA includes models of public and private sawtimber stumpage supply in the USA and delivered sawlog costs in Canada. Pulpwood supply equations for the USA and Canada and behavioural relations for fuelwood harvest from standing timber are included in the pulpwood and fuelwood models. The supply relations are linked to the sawtimber relations in TNAA by means of timber inventories and prices. Trade-related assumptions include the continuation of the importance of Canada as a source of some softwood lumber and a gradual increase in the importance of non-Canadian sources of forest products, an increasing importance of hardwood product exports, and a continuing shift in the composition of trade toward value-added products (Haynes, 2001).

Timber inventories on private ownerships only are projected in TNAA using a modified version of the ATLAS model. Basic inventory data are derived from the Forest Service's periodic forest surveys. Because dates of these inventories differ by region, the simulation structure allows staggered 'starting' times in the projection process. Lands include only those classed as 'timberland', meeting a minimum standard of productivity and not reserved from timber harvesting. Timberland is stratified by region, owner, (representative) age class, site productivity group, management intensity class and forest cover type.

A management intensity class is defined by a combination of silvicultural activities including, but not limited to, regeneration, pre-commercial and commercial thinning, and fertilization. These actions are depicted in ATLAS through the use of a specific age-dependent yield function for even-aged strata (or yield process for partial cutting) that reflects the growth and yield impacts of the regime. Lands classified under even-aged management can shift among management intensity classes over time to reflect changes in timber management investment. At present the extent and timing of these shifts are determined outside of the TNAA system and occur only after a hectare has been harvested.

Over time the timberland base is adjusted in ATLAS for the movement of land between forest (timber production) and non-forest (including, agricultural, urban and reserved) uses. Projections of these shifts are developed outside of the model, based on regional models of area changes (e.g. Alig and Wear, 1992). When land shifts to a non-forest use, a portion of its volume at the time of shifting is assumed to be harvested and is counted in the current aggregate cut from its stratum. This reflects the process of land clearing or volume reduction associated with most land-use changes in the private sector.

Scenarios

Overview

The major US forest regions have widely different potentials to attract private investments in forest production. Rapid tree growth generally translates into higher potential economic returns to investors, and tree growth is fastest in the South and the wetter areas of the Pacific Northwest. In this chapter we focus on the South because it accounts for about 80% of US tree planting, has large areas of marginal agricultural land that could be planted to trees, and is proximate to major wood-processing facilities and the large concentration of the consumers in the East. The South contains more than ten times as much private timberland as the Pacific Northwest. The South is a key supplier of fibre for papermaking and contains about two-thirds of the fast-growing coniferous plantations in the world, equal to about 12 million ha of southern pine plantations; however, hardwood forest types cover a large majority of its regional landscape.

To investigate the impacts of variation in future forest investment in the South, we simulate two alternative scenarios – one examines maintenance of higher hardwood inventory levels and a second involves a lower investment in pine plantations – and a base case (BASE) developed as a baseline for comparison. The BASE assumptions were taken in early 2001 from the USDA Forest Service's 2000 draft Timber Assessment for the Resources Planning Act (Haynes, 2001). The BASE assumptions, including supply side aspects such as timberland area projections (e.g. Alig *et al.*, 2001), were reviewed in a series of meetings around the USA. In the future, trends in the demand for forest products will continue to be determined largely by growth in US population, income and economic activity. Projections of future levels for these key demand determinants were taken from government projections, including some by USDA (Haynes, 2001). For example, the macroeconomic outlook underlying these projections is based in part on the US Bureau of Census 1996 middle series projection of the US population, with demographic changes resulting in an ageing population and a slowing of labour force growth. The alternative scenarios pertain to the dynamics of private forest investment and associated uncertainties, suggested by recent trends and developments as described below.

Description of scenarios

Maintaining hardwood inventories (LOHARD)

A key forest investment decision is the volume of growing stock allowed to accumulate in the stand under management. This, in turn, is regulated by the harvest decision: the rotation age in the case of even-aged management and the removal volume in the selection case. Where management is guided by a consideration of the present value of future net returns, higher stocking levels can be induced by lower discount rates *and* by the realization of returns (either monetary or intellective) derived directly from the standing inventory (e.g. non-timber products such as hunting leases or the owner's enjoyment of larger trees). Recent surveys

(see, for example, Moffat *et al.*, 1998) suggest that the recognition of such benefits may be on the rise for some Southern NIPF ownerships. This scenario considers a case where NIPF owners opt to maintain inventories in their hardwood stands at near current levels by reducing harvest over the next five decades, avoiding the decline projected in the BASE case.

Total hardwood inventory volumes in the South decline by nearly 17% by 2050 in the BASE case, even though hardwood harvest shows little growth after 2005. In this scenario we restrict harvests on Southern NIPF lands so as to maintain hardwood inventory volumes at or above levels in the late 1990s. This scenario would be consistent with a trend towards greater emphasis on non-timber forest values on the part of NIPF owners and a concomitant disinclination to harvest timber. This scenario will have its greatest impacts in the large SC NIPF ownership.

Less investment in pine plantations (LOSOFT)

As described above, growth in the area of pine plantations has been a major feature of Southern forest practice over the past two decades. However, the longer-term history suggests that some volatility in plantation levels is possible. This scenario explores a case where the rate of plantation establishment falls below the level projected in the BASE case. This provides an opportunity to gauge how important Southern pine plantations are in the future supply projection.

The area of private pine plantations is projected to increase by 62% in the BASE, with about 7 million ha of plantations added between 1997 and 2050. The projected increase is in line with historical trends, where more than 10 million ha of plantations were added between 1952 and 1997. In this scenario, we reduce projected Southern pine plantation area by about 2.7 million ha compared with the BASE projection.

Results

For each scenario, we report projections of Southern plantation area for forest industry and non-industrial private owners, timber management intensity, timber inventory levels, timber harvest levels and prices.

Base projection

The BASE case projects, over the next 50 years, the likelihood of increasing abundance of softwoods and decreasing abundance of hardwoods in the South. These trends in supply, along with contributions from the North and West, will adequately meet US consumption needs in the longer term without significant increases in most softwood product prices over the next 50 years. However, the adequacy of timber supplies is dependent on continued expansion of softwood plantations with increased management intensity in the South, moderation of hardwood use in the South, and continued improvement in technology to grow trees and to obtain more wood and paper product output per unit of timber input.

Total roundwood harvest in the USA is projected to be 0.68 billion m^3 in 2050. Comparing 1996 and 2050, softwood harvest is projected to increase 38% to 0.40 billion m^3 and hardwoods 37%, to 0.25 billion m^3. In addition, the consumption of hardwood short-rotation woody crops (e.g. hybrid poplar) for pulpwood grows to about 0.02 billion m^3 by 2050. While softwood timber harvest increases 38%, US softwood inventories are projected to increase by 58%. While US hardwood harvest increases 37%, hardwood inventories are projected to increase by 25%. Although the increases are similar for softwoods across regions, hardwood inventories decline moderately in the South but rise in the North.

The proportion of the roundwood harvest consumed in the USA and used to manufacture wood pulp is expected to remain relatively constant at 30%. However, the use of short-rotation woody crop fibre and recycled fibre is expected to increase. The bulk of the nation's timber harvest will occur in the East (79% in 1996 and 83% in 2050) and in the South (55% in 1996 and 60% in 2050). Most of the projected short-rotation woody crop fibre supply is in the East. By 2050, roughly two-thirds of the softwood timber harvest comes from plantations that will occupy less than 20% of the timberland base.

Sawtimber prices are expected to stabilize somewhat after increasing in the 1990s. Market-based adjustments mostly on private timberlands are able to meet expected increases in US consumption. Stumpage markets in the West will continue to be weak for small diameter logs. Pulpwood prices rise as a result of limitations in

harvestable hardwoods on non-industrial private timberlands in the South. Product prices are expected to be stable at roughly current levels.

Outcomes under scenarios

Reduced rates of pine plantation establishment in the LOSOFT scenario lower growth on Southern timberlands and ultimately lead to lower softwood inventories and lower softwood timber harvest. The softwood inventory impacts are clearly shown in Fig. 15.3 and are particularly large on NIPF lands because the largest plantation reductions occur on this ownership in the scenario. By 2050, LOSOFT NIPF inventories are some 0.28 billion m^3, about 10%, lower than in the BASE, but they are still 0.42 billion m^3 higher than the levels of the late 1990s. Industrial inventories are also modestly lower, but this reflects increased harvest in response to the higher prices stimulated by the NIPF harvest reduction. The LOHARD scenario has limited impacts on the softwood inventory and continues to show a considerable gain in inventory on both owner groups by the end of the projection.

Hardwood inventories, in contrast, are largely unaffected by all but the LOHARD scenario (see Fig. 15.4). NIPF inventories rise at first in the LOHARD case but eventually return to late 1990s levels. This is a gain of nearly 0.57 billion m^3 relative to the BASE. Forest industry hardwood inventories in the LOHARD case fall more rapidly than the BASE, again because of higher cut in response to higher prices. The decline is small in absolute terms relative to the NIPF gain, but in percentage terms is nearly equivalent. Unlike Southern private softwood inventories, hardwood stocks on both ownerships are projected to be stable to declining over the projections. The drop in industrial inventories is largely a reflection of conversions to softwood plantations. Type conversions are also important in holding down NIPF inventories and these losses are augmented by land-use changes into urban/suburban and agricultural uses.

Impacts of the scenarios are visible at the national level in terms of growing stock removals (see Figs 15.5 and 15.6). The reduction in softwood volume of 11 million m^3 (Fig. 15.5) in the LOSOFT case is 3% of BASE removals by 2050. The LOHARD scenario also affects softwood removals. Restricting hardwood harvests on Southern NIPF lands to maintain hardwood inventory volumes raises softwood removals at first, due to substitution of softwoods for hardwoods in Southern pulping. Later the impact due to hardwood harvest restrictions is reduced as SRWC fibre is introduced in sizeable quantities, replacing both hardwoods and softwoods. Peak changes for this scenario in the 2030s amount to 1–1.5% of US total softwood removals.

US hardwood growing stock removals rise modestly for the LOSOFT scenario (Fig. 15.6), reflecting substitution responses in Southern pulping. Hardwood removals fall sharply in the LOHARD case after 2020, dropping some

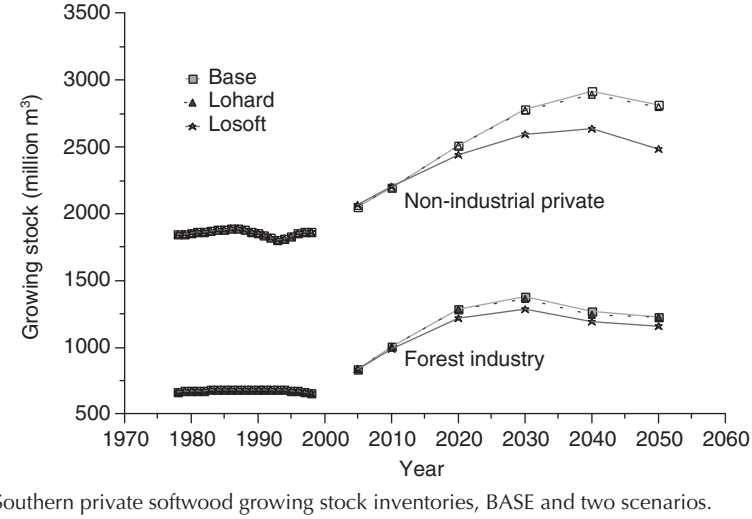

Fig. 15.3. Southern private softwood growing stock inventories, BASE and two scenarios.

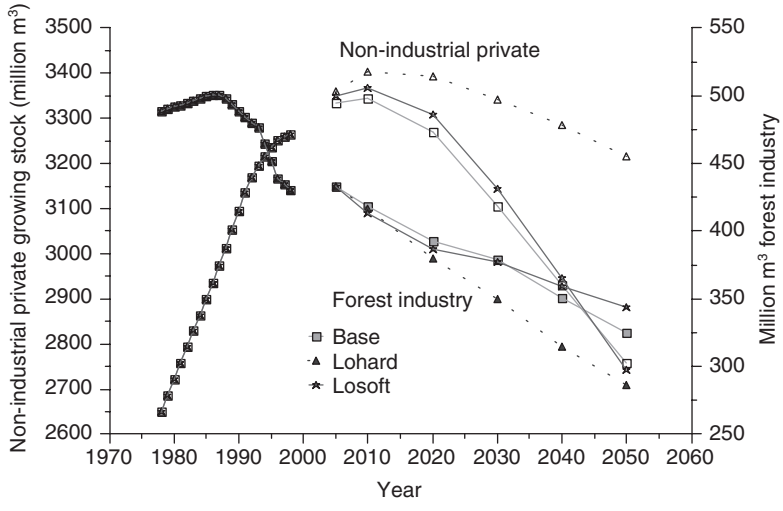

Fig. 15.4. Southern private hardwood growing stock inventories, BASE and two scenarios.

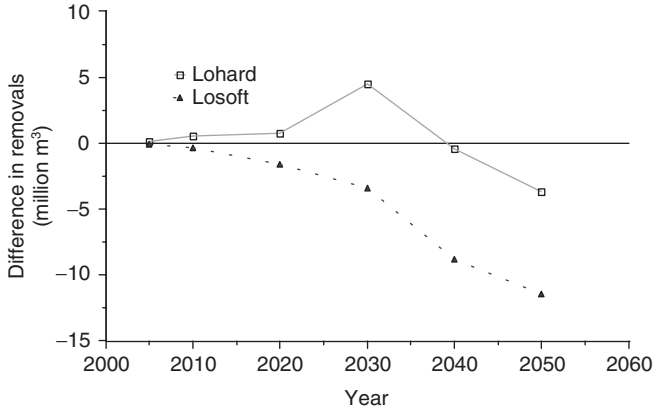

Fig. 15.5. US softwood growing stock removals, differences from the BASE case, for two scenarios.

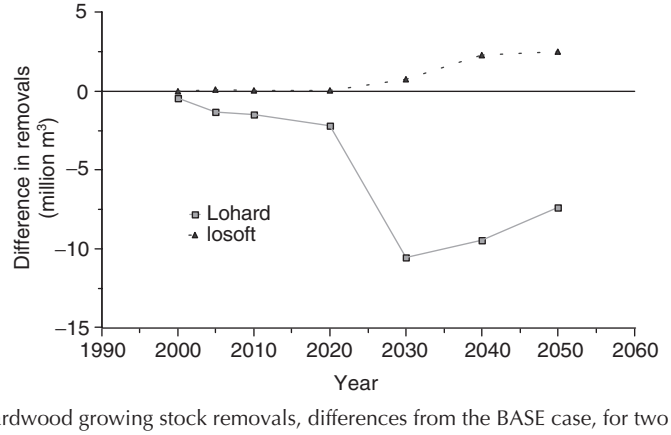

Fig. 15.6. US hardwood growing stock removals, differences from the BASE case, for two scenarios.

11 million m^3 by the late 2020s, about 5.5% below the BASE.

Market responses to these several shifts are reflected as well in the prices of sawtimber. Figures 15.7 and 15.8 show Southern sawtimber stumpage prices in deflated (1982) dollars. The harvest restrictions in the LOSOFT scenario push softwood sawtimber prices above the BASE, but at their largest departure they are only some 3–4% higher. Hardwood sawtimber prices (Fig. 15.8) respond sharply to the LOHARD case, rising nearly \$6 m^{-3} above the BASE by 2050 (an increase of more than 25%), while the LOSOFT scenario has little impact.

Summary and Discussion

Simulation results for the alternative future scenarios pertaining to investment in forestry have several policy implications, especially given the outlook for softwood versus hardwood markets. First, the majority of forest investment in the South has been directed at establishment and management of softwood plantations, in contrast to hardwood management intensification. In effect these more productive softwood plantations act to take pressure off the remainder of the land base. So it may be reasonable public policy to allow or even promote some expansion in these areas, recognizing that if we do not there will be still more extensive harvesting in other areas and associated loss of non-timber goods and services.

In the longer term, more timberland area is projected to shift to higher softwood management intensity classes in regions and ownerships where such opportunities are abundant, especially in the South (see, for example, USDA Forest Service, 1988, 1990: Chapter 9). For example, planted pine area in the South is projected to increase by 62% by 2050. At the same time, the investment projections

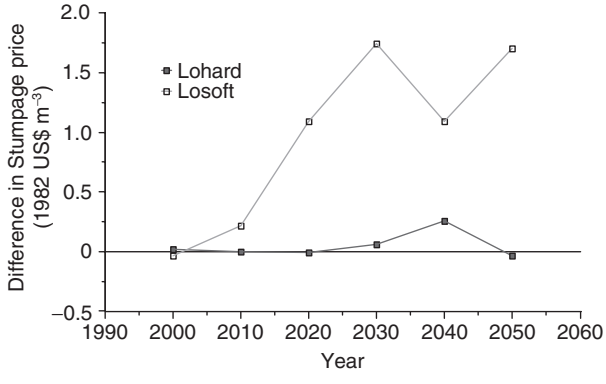

Fig. 15.7. Southern softwood sawtimber stumpage prices, differences from the BASE case, for two scenarios

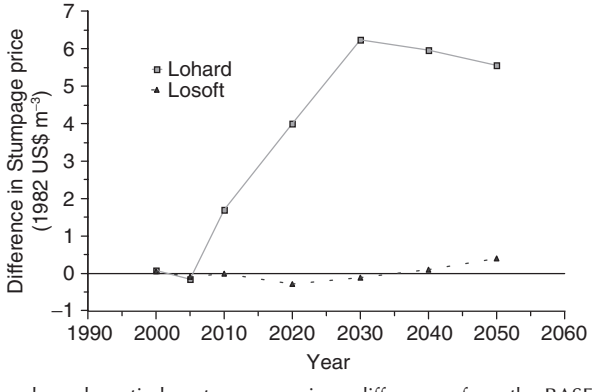

Fig. 15.8. Southern hardwood sawtimber stumpage prices, differences from the BASE case, for two scenarios.

do not necessarily portend a future forest comprised solely of planted stands and unidirectional transitions to plantations. 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. Dynamics of forest cover changes include some pine plantations that are lost to other land-uses and a significant number of plantations not planted back to pine after harvest. A sizeable number of such harvested plantations revert to hardwood stands, especially on NIPF lands. Only a small fraction of the private land base is projected to end up in 'intensive' management – and the largest part of intensification is just insuring adequate regeneration after harvesting, not adoption of high-tech/high-cost practices. Intensification on that relatively small part of the timberland base may allow more of an emphasis on non-timber goods and services on other portions of the timberland base. At the same time, plantations have come under increasing scrutiny in the South and other regions in recent years. Owing to their simplified species and size composition, they provide a different (less complex) wildlife habitat, supporting for the most part early successional wildlife species. Plantation management also involves more frequent harvesting disturbances due to generally shorter rotations and, some argue, plantations that are more susceptible to disease and insect losses.

The LOSOFT simulation involves a reduction of just 14% in the 2050 level of softwood plantations in the South, representing a change of 4% in total Southern private timberland, yet total US softwood removals fall by 3% by 2050. So, a very small change in the management of a special portion of the land base leads to a quite noticeable shift in overall harvest. This suggests that plantations do matter in the bigger picture, and past research (see Alig *et al.*, 1990, for a summary) shows that policy instruments such as cost-sharing programmes do matter when it comes to bolstering plantation area. Moulton and Hernandez describe marked reductions in federal funding for private forestry programmes – and therefore in tree planting and forest management by NIPF owners (Moulton and Hernandez, 1999). Some policies concerned with reducing atmospheric CO_2 also include expanded tree plantation area as one management option, given joint production opportunities for timber and non-timber services.

In the shorter term (next 5–15 years), the projected rise in growth and harvest in the South is not so much a function of intensifying management as it is an age class phenomenon on both industry and NIPF timberlands. US private harvest 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. Outside the South, all regions are quickly moving to a cut less than or equal to growth condition with rising inventories. Even with notable variation across owners and subregions in the South, this region too is moving toward a cut equal growth condition under our MIC shift assumptions, though at a much higher level of harvest than at present.

Second, policy implications of the smaller amount of past investment in hardwood timber management are notably different than for the softwood case. In the past 30 years hardwoods have become a critical part of the overall wood supply picture of the USA, particularly for pulpwood in the South. A trend toward reduced NIPF harvest would have a major impact on markets. At the same time this is very likely the path of the future, given parcelization of ownerships (Sampson and DeCoster, 2000), changing demographics and owner objectives, and generally reduced interest in timber management. This suggests that future supplies might be augmented by less informal treatment of hardwoods on all private lands. Modest management inputs, or changes in methods, might increase yields to help offset areas shifted out of timber production. Limited hardwood supplies may also justify public and private programmes to raise awareness of options in hardwood silviculture, expand research on more intensive hardwood forest practices, and find silvicultural methods that might achieve both higher amenity outputs with less reduction in timber production. Tracking of hardwood investment behaviour could augment regional forest surveys of standing timber inventories, along with a more focused examination of fragmentation and parcelization issues (Alig *et al.*, 2000b).

In conclusion, model simulations indicate the consequences of changing assumptions regarding future forest investment in the South, a long-standing discussion topic among policy analysts. Historically, the USA has relied primarily upon its

natural endowment of forests to supply its ever-growing demands for wood and wood products. Planting of trees has emerged as a major activity in recent decades, and private forest investment is a critical variable in understanding the long-term prospects for US timber supply. Private timberlands are likely to become increasingly important in the nation's timber supply. Substitution of capital for land on these ownerships will lead to expanding long-term growth and harvest. However, some policy makers are interested in boosting tree planting above likely levels in order to further augment timber supplies and jointly sequester more carbon. This leads to questions about how best to structure incentives to accomplish such targets.

Acknowledgements

Adrienne Van Nalts, Oregon State University, assisted in the preparation of TNAA projections. Peter Ince, USDA Forest Service, provided advice and inputs related to the NAPAP model and Richard Haynes, USDA Forest Service, provided useful suggestions.

Endnotes

[1] Timberland is forestland that is not reserved for other uses and is capable of producing 1.40 m^3 ha^{-1} per year of industrial wood.

[2] The most recent long-term projections developed by the USDA, Forest Service as part of its Timber Assessment programme can be viewed in draft at http://www.fs.fed.us/pnw/sev/rpa/index.htm. An earlier study completed in 1993 is available in Haynes *et al.* (1995).

[3] Roundwood is logs, bolts or other round sections cut from growing stock and non-growing stock sources (e.g. dead trees); roundwood supplies is the volume of roundwood harvested or available for harvest in the future. Timber supplies is synonymous with roundwood supplies in this chapter.

[4] See note 2 for sources of these projections.

[5] At the same time, forest fragmentation and parcelization are likely to occur, especially for smaller parcels (Alig *et al.*, 2000b; Sampson and DeCoster, 2000). Impacts on aggregate timber supply can include increased costs of production and some management tools (e.g. prescribed burning) may become more difficult to use on small parcels.

[6] A detailed discussion of the TNAA (TAMM/NAPAP/ATLAS/AREACHANGE) system can be found at the website noted in note 2.

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