United States
Department of
Agriculture

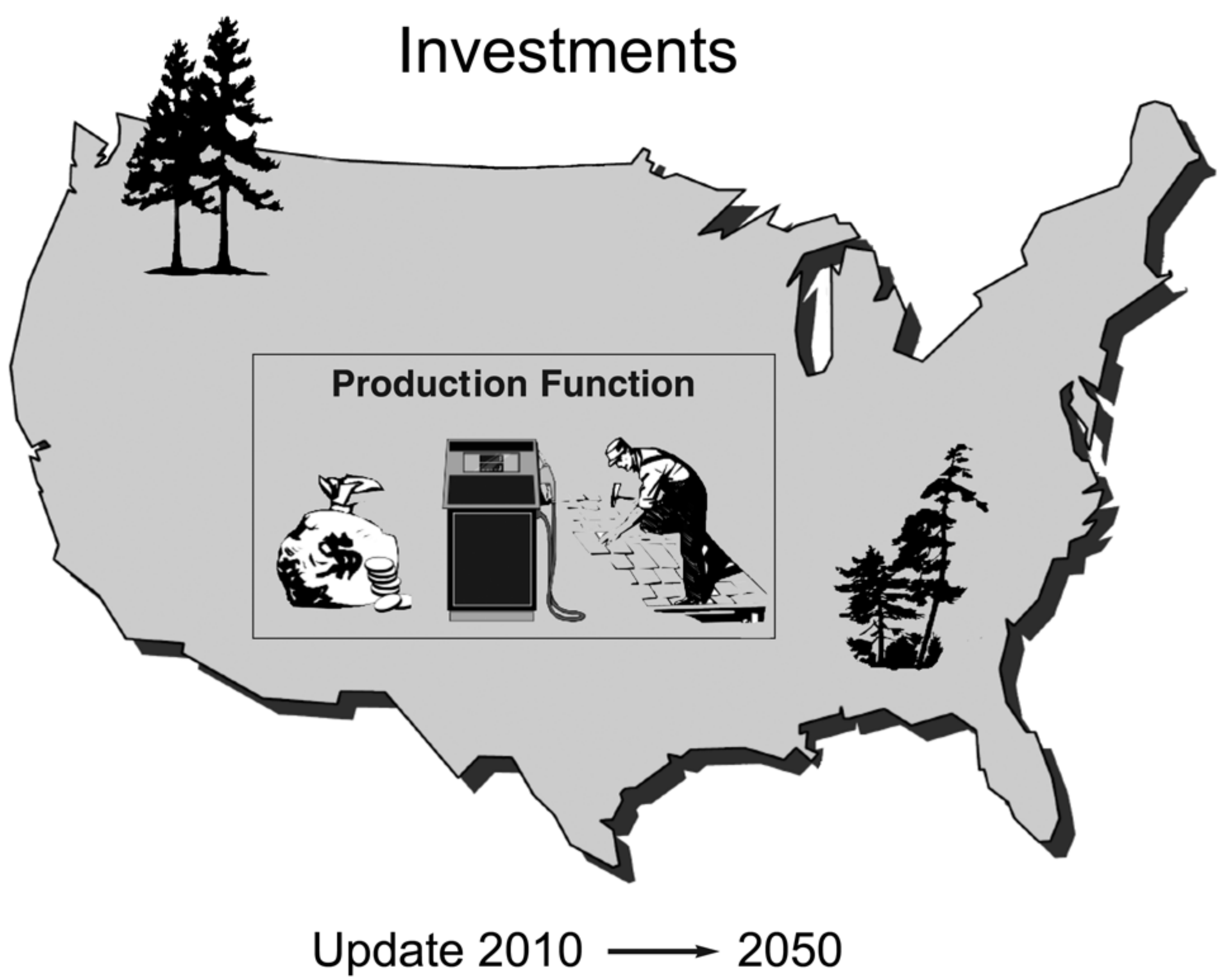
Forest Service

Pacific Northwest
Research Station

General Technical
Report
PNW-GTR-684
September 2006

Regional Cost Information for Private Timberland Conversion and Management

Lucas S. Bair and Ralph J. Alig



Authors

Lucas S. Bair was an economist and **Ralph J. Alig** is a research forester, Forestry Sciences Laboratory, 3200 SW Jefferson Way, Corvallis, OR 97331. Bair is currently located at CH2M HILL, 2485 Natomas Park Drive, Suite 600, Sacramento, CA 95833.

Abstract

Bair, Lucas S.; Alig, Ralph J. 2006. Regional cost information for private timberland conversion and management. Gen. Tech. Rep. PNW-GTR-684. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 26 p.

Costs of private timber management practices in the contiguous United States are identified, and their relationship to timber production in general is highlighted. Costs across timber-producing regions and forest types are identified by forest type and timber management practices historically applied in each region. This includes cost estimates for activities such as forest establishment practices such as reforestation and afforestation on crop and pastureland. Establishment costs for reforestation in the Southern United States are less than in other regions, although regional differences in establishment costs are less evident in hardwood than in softwood stands. Also, included in the list of timber management costs are the intermediate management treatments of precommercial thinning, herbicide, and fertilizer application. Intermediate management treatments are less costly in the Southern United States than in other regions. Trends in timber management costs are reported as part of the timber management cost reporting.

Keywords: Timberland, costs, production, timber management, intermediate treatment.

Contents

Introduction

Private timberland management costs are an important factor in timber production decisions and land use research. For example, not only do timber management costs play a significant role in informing the decisions of private landowners but also are essential elements in regional and national forest resource supply analyses. This analysis may include the use of timber management cost data for models of timber production and identification of carbon sequestration opportunities (Adams et al. 1996, Alig et al. 1994). The economic and environmental variation across the United States, leading to differences in timberland production characteristics, can cause significant regional disparities in timber establishment and management costs incurred by private land managers. Unfortunately, even in relatively active timber producing regions, comprehensive estimates for public and private timberland management costs are relatively uncommon (Arno et al. 2002, Gebert et al. 1999).

In this study, we identify the costs of private timber management practices in the contiguous United States and highlight their relationship to timber production in general. Most management practices are observed to differ across regions and forest types and have significant influence on timber yields. The costs of these management practices influence how forests are managed and thereby affect future timber supply. We highlight costs across timber-producing regions and forest types by identifying the forest type and set of timber management practices applied historically in each region. This includes cost estimates for activities such as forest establishment practices like reforestation and afforestation on crop and pastureland. Also, included in the list of timber management costs are intermediate management treatments. These intermediate treatments are precommercial thinning along with herbicide and fertilizer application.

Identifying trends in timber management costs is also part of timber management cost reporting. Changes in input costs as a result of fluctuating labor or fuel costs and increased demand for forest wood products influence management decisions made by private landowners, and consequently timber supply in the United States. Observing past trends, specifically in the Southern regions of the United States, provides insight into what future costs may be in view of assumptions about related production variables.

Review of Cost Estimation

Three primary approaches to estimating timber management costs are survey, engineering, and statistical (Alig et al. 1984). The survey method uses direct inquiry of timber operators to obtain management cost estimates. This method, although relatively easy to undertake, has several limitations (Alig et al. 1984).

Three primary approaches to estimating timber management costs are survey, engineering, and statistical.

It is difficult to separate survey costs into fixed and variable costs, let alone individual management treatments. When using the survey method, it is also difficult to identify individual factors influencing cost, such as economies of scale and changing technologies or management practices.

The engineering approach is based on an understanding of inputs and outputs and their relationships. In this approach, analysis begins with an "engineering production function," where optimal input combinations for producing a given level of production are identified (Alig et al. 1984). Cost can be obtained by multiplying each level of input usage by the current price of the input and summing over the inputs. One limitation is that cost estimates are often made based on pilot operations, not actual production. The engineering approach is commonly used in natural resource management studies and other areas where there are gaps in information. This is a significant advantage to the engineering approach.

The statistical approach uses quantitative methods to estimate timber management costs. This requires either cross sectional or time series data, or a combination of both. Although this method is able to account for variation in specific treatment costs across time, holding constant other conditions (e.g., technology, environmental conditions, etc.) the sample does need to be of sufficient size to carry out the analysis. This constraint based on data quantity, and also quality, is the most significant limitation to the statistical approach.

The timber management cost information contained in this report relies heavily on studies that used the survey approach. For example, Dubois et al. (2003) used surveys of private landowners and forest professionals to estimate timber management costs in the South. In Dubois et al. (2003) and other publications, such as Moulton and Richards (1990), expert opinion of professional foresters either supplemented or took the place of survey data estimates.

The transformation of inputs, such as timber management practices, into timber yields or outputs can be characterized in a production function.

Timberland Production Costs

For practical decisionmaking purposes in forest management, it is helpful to obtain estimates of production and cost functions. The transformation of inputs, such as timber management practices, into timber yields or outputs can be characterized in a production function. This is expressed mathematically as:

$$Y = f(X_1, X_2, X_3 \ldots\ldots\ldots\ldots X_n),$$

where

Y = yield

X_n = inputs.

In most cases, inputs consist of land, labor, and capital. In the timberland example, time is often an input representing opportunity cost of the timber investment (Rideout and Hesseln 1997). The classic timber growth function is depicted as the input of time, measured against output or yield (fig. 1). Other examples of inputs in timber management may include such activities as precommercial thinning, fertilization, and herbicide application. When evaluating one of these inputs, all other inputs are held fixed. This makes it possible to identify the individual influence that each input has on the yield function.

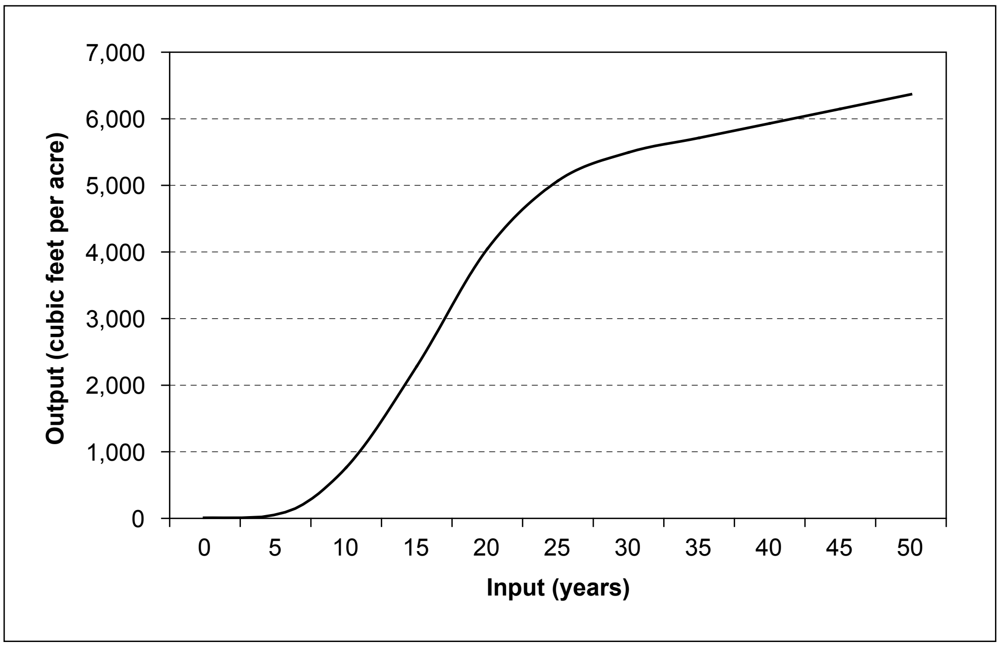


Figure 1—Production function for planted pine, South-Central Region, forest industry, high site class, high management intensity (Source: Mills 2003).

There is an extensive literature concerning timber yield simulators (Ritchie 1999). With these tools, future timber stand conditions can be estimated, and various aspects of a production function can be determined. These include such items as rates of transformation, inflection points, marginal costs, etc.

When reviewing the illustration of a production function, one important aspect in the relationship between inputs (i.e., costs) and output (i.e., yield) is the concept of returns to scale. In the traditional yield function, initial growth increases at an increasing rate for each additional unit of input. This is considered the first stage of the production function. Once an inflection point is reached on the function, and the curve changes from convex to concave, each additional unit of input increases output at a decreasing rate. This is the second stage of the production function. Output in timber yield production functions will also begin to decrease once time or management treatments become excessive enough to act as a detriment to growth. This result indicates that yields from various timber management practices (i.e., costs) are not linear. For example, initial applications of fertilizer to timberland will increase the level of growth. An additional treatment of fertilizer, within the same period, may not be as beneficial. It may increase growth, but not to the extent the initial application did. A third application of fertilization may be excessive and actually cause damage to the timber, indicating the third stage of the production function, decreasing growth projections. This is due to biological limitations of the forest, considering that only a given level of nutrients can be utilized over a period and excess amounts of fertilizer can cause physical damage.

Another important production function characteristic is the idea of various levels of multiple inputs producing a fixed level of output. This relationship between inputs and output is called the technical rate of substitution. This relationship between two inputs is illustrated by using a production possibility frontier (fig. 2). One example is between the inputs, land and capital (Wear 1993). In any region in the United States, a reduction in the forest land base, and subsequently the aggregate forest volume, could be compensated for by increasing the management intensity across the remaining area of forest land. A higher level of management intensity (input) would increase volumes (output) across the region, potentially equal to what was lost in aggregate volumes to land conversion. However, the theme of diminishing returns still applies in this case. Increasing management activities on forest land can only compensate for a reduction in the land base to a certain extent. After a point, increased timber management would not supplant a loss in forest area.

The relationship between inputs and outputs in a production function is the initial step in developing information for timber management decisions. Assigning costs to inputs and values to output is the next step.

The relationship between inputs and outputs in a production function is the initial step in developing information for timber management decisions. Assigning costs to inputs and values to output is the next step. This process links the economic and physical dimensions of timber management. Estimating cost functions relies on the production function information and valuation of inputs. In economics, it is usually hard to perform controlled laboratory experiments with which to estimate costs, so actual operating data are used with some statistical procedures to derive these estimates.

Cost data for variable inputs are used to develop information sought by analysts. Variable costs, such as planting or precommercial thinning, influence the output and allow landowners to make efficient choices based on the output price they are observing. This efficient choice is where the landowner's profit is maximized. This occurs when the marginal cost, the cost for an additional unit

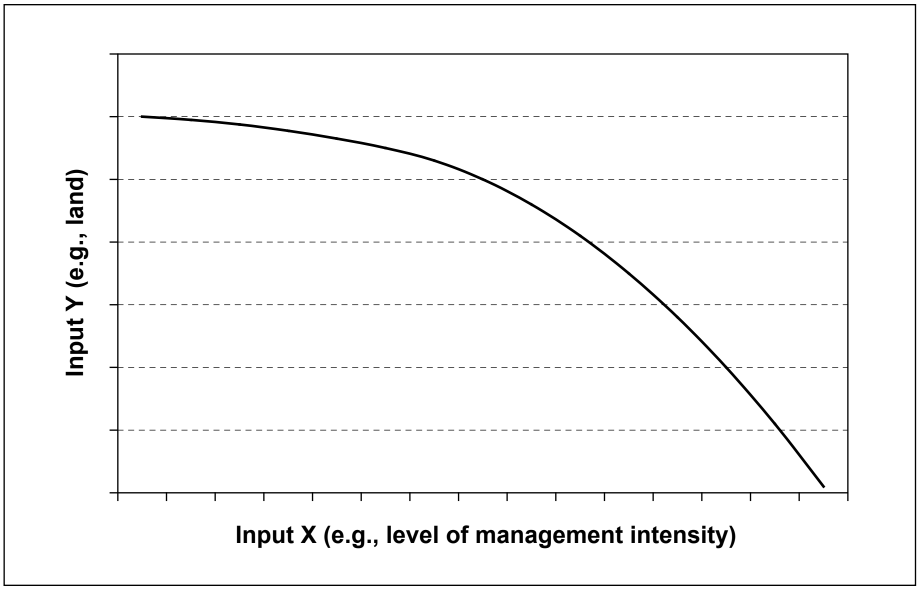


Figure 2—Example of timber yield production possibility frontier with various levels of two inputs producing a fixed level of output.

of production, is equal to the marginal benefit, the revenue received for an additional unit of output. Even with positive returns, landowners may not benefit from lengthening rotation ages when marginal costs are greater than marginal returns. However, this point in time where the marginal benefit is equated to marginal costs is not always explicit. Variations in forest type, growing conditions, the market, etc., create a level of uncertainty for a landowner. Detailing the variable costs improves a landowner's level of information and the ability to make efficient management decisions.

In a perfectly competitive market, in the short run, the revenue received for each unit of output is fixed. Large numbers of producers in the timber industry create a situation where no individual producer has the ability to influence timber price.[1] This is why marginal cost is important to analysts. Landowners have control over the incremental level of resources allocated to inputs, or marginal cost, unlike the revenue they will receive for their output. Variable input costs give the producer the ability to determine the quantity and type of product for the market.

Other costs, such as fixed costs, are independent of the production function. These may be costs such as property taxes or nontimber capital costs, which do not directly influence the output level. It may be relatively easy to estimate the use of labor in production, but to estimate capital usage can be very difficult.

[1] Perfect competition in the softwood products market is not always the case. This is made explicit by the recent controversy between the United States and Canada over softwood lumber markets.

Fixed and quasi-fixed (i.e., fixed costs that increase or decrease once a specified threshold is reached) capital costs may be hard to separate from variable capital costs. In this report, we focused our attention on variable timber management costs. Also included in the data reporting are aggregated fixed decadal management costs including items such as boundary maintenance and management plan development.

Timber Management Intensity and Yields

Management intensity is an important factor in the total timber yield by the end of a rotation and in the growth characteristics of that yield throughout the rotation.

Forest practices used by private landowners differ across forest type and region. The regional variability in management intensity is evident in the Aggregated Timberland Assessment System (ATLAS) area allocated by management intensity in the Southern and Pacific Northwest West regions (table 1) (Mills 2003). Planted stands in the Pacific Northwest West, South-Central, and Southeast regions comprise tens of millions of acres. Most of these planted stands receive some form of intermediate treatment (e.g., fertilization or precommercial thinning) to improve growth. Regions outside the three most productive timber-producing regions are only assigned to low management intensity, with no explicit intermediate treatments in the ATLAS model.

Table 1—Timberland area of ATLAS-designated management intensity in the contiguous United States

	Pacific Northwest West		South Central		Southeast	
Management intensity	Forest industry	Nonindustrial private forest	Forest industry	Nonindustrial private forest	Forest industry	Nonindustrial private forest
			Thousands of acres			
Natural regeneration:						
Even-age	3,454	3,357	8,398	16,894	4,577	35,611
Uneven-age	814	10	6,367	55,801	1,705	10,582
Planted:						
Without intermediate treatments	1,353	639	761	411	1,142	1,080
With intermediate treatments—	1,696	139	6,241	4,962	6,239	7,074
Precommercial thinning	1,696	139	5,914	4,962	5,325	7,074
Fertilization	1,696	139	4,519	1,449	4,272	2,241
Herbicide	0	0	985	0	835	0

Planted stands in the South Central and Southeast regions are planted pine.
Source: Mills 2003.

Management intensity is an important factor in the total timber yield by the end of a rotation and in the growth characteristics of that yield throughout the rotation. Growth in planted stands occurs at a more rapid rate than it does for naturally regenerated stands, although the longer the timeframe evaluated, the closer the total volumes become (fig. 3). However, landowners may choose to harvest at financially optimal rotation lengths reached before the two sets of yields come close to merging.

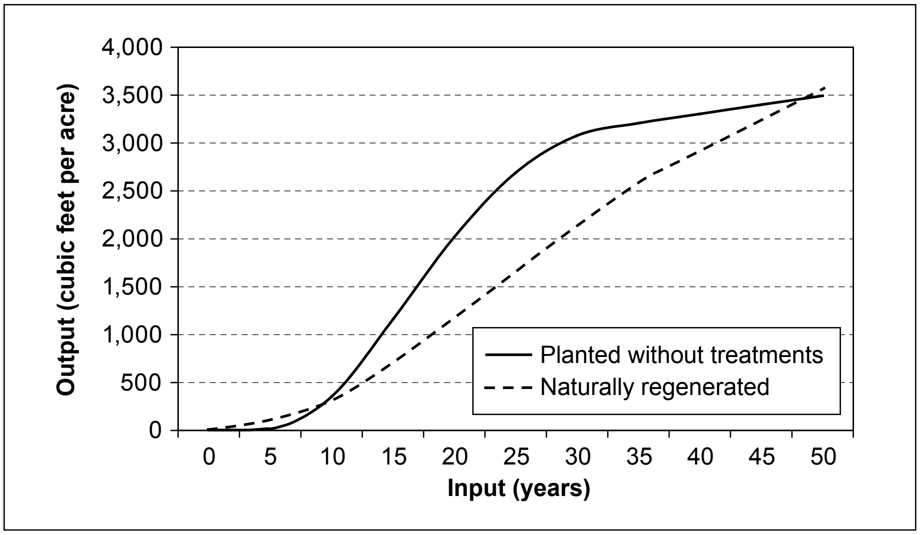


Figure 3—Planted and naturally regenerated timber yield estimates for pine, South-Central Region, nonindustrial private forest, high site class (Source: Mills 2003).

Intermediate treatments also can influence output to a significant extent. Up to 2,000 cubic feet of difference in production is possible in the South between planted pine with no and high levels of intermediate treatment (Mills 2003) (fig. 4). Similar findings are reported by Wear and Greis (2002), who estimated that intensive planted pine technology in the South nearly doubles timber yields. Understanding the output levels associated with intermediate treatments and their associated costs is essential to determine the level of timber management to undertake.

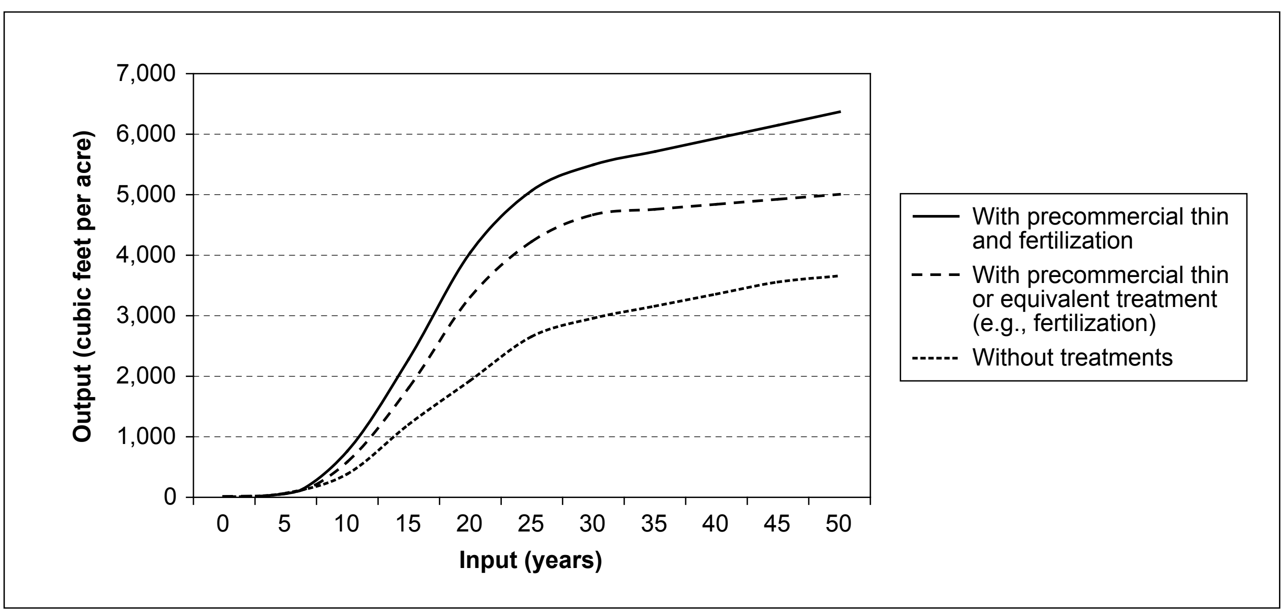


Figure 4—Timber yield estimates for planted pine, Southeast Region, forest industry, high site class under three different management regimes (Source: Mills 2003).

Identifying Timberland Management Costs

Cost estimates at a regional level for land use conversion and timber management practices are available through various sources. Most literature pertaining to private timberland management cost is based on direct correspondence with state forest officials and private owners. However, this type of information gathered by using survey techniques tends to be limited temporally and spatially.

The bulk of documented timberland management cost information is available from publications representing the Southern United States. For example, the only comprehensive study for forest practices in the South and the contiguous United States is "Costs and Cost Trends for Forestry Practices in the South," which has been published on a periodic basis, 16 versions in total, for several decades and provides the most complete regional information (Dubois et al. 2003, Floyd and Kutshcha 2000). This series of biannual publications encompasses a variety of timberland treatment costs. Cost estimates from the survey used to collect the information were obtained from private firms and public agencies in 12 Southern States. This would include the area south and east of the fall line, the boundary between the coastal plain and the Piedmont, and the upland area east from Alabama into Arkansas. Additional sources were used to support "Costs and Cost Trends for Forestry Practices in the South" and estimate costs for various activities throughout the South (Huang et al. 2004, McKee 1987, Vasievich 1983, Wear and Greis 2002). These publications provided additional cost estimates for the 12-state area reported in Dubois et al. (2003) and for eastern Texas and Oklahoma. This additional timber management cost information is also obtained from surveys of state foresters, private forest owners, and forestry consultants.

Cost information pertaining to timberlands outside the South was available through documented survey information, although on a much more limited basis than for the South. According to Floyd and Kutshcha (2000), "Growing costs are surveyed in the South, but no comparable survey is conducted in the West." Limited region-specific information was obtained for the Pacific Northwest West from a survey of professional foresters in Oregon (Cathcart 2003), and other earlier comprehensive references using similar methods were used to estimate costs for the remaining regions (Moulton and Richards 1990, Vasievich 1983).

To format input cost information in a useful way, estimates of land use conversion and timber management costs corresponded with the framework for the Forest and Agricultural Sector Optimization Model (FASOM) (e.g., Adams et al. 1996). For forestry, the FASOM regions are similar to those used in modeling with the ATLAS (Mills and Kincaid 1992) model used in the Resource Planning Act

(RPA) Assessments. The ATLAS model is an area-based model (Mills and Kincaid 1992), with the contiguous 48 U.S. states divided into broad timber-producing regions of different importance. For our use, we grouped the ATLAS regions into nine regions with significant timber production (Adams et al. 1996). These include two Eastern regions, three in the Midwest, and four in the Western United States (fig. 5). This allows greater compatibility with future studies that use ATLAS data or other research with similar regional and resource classification divisions.

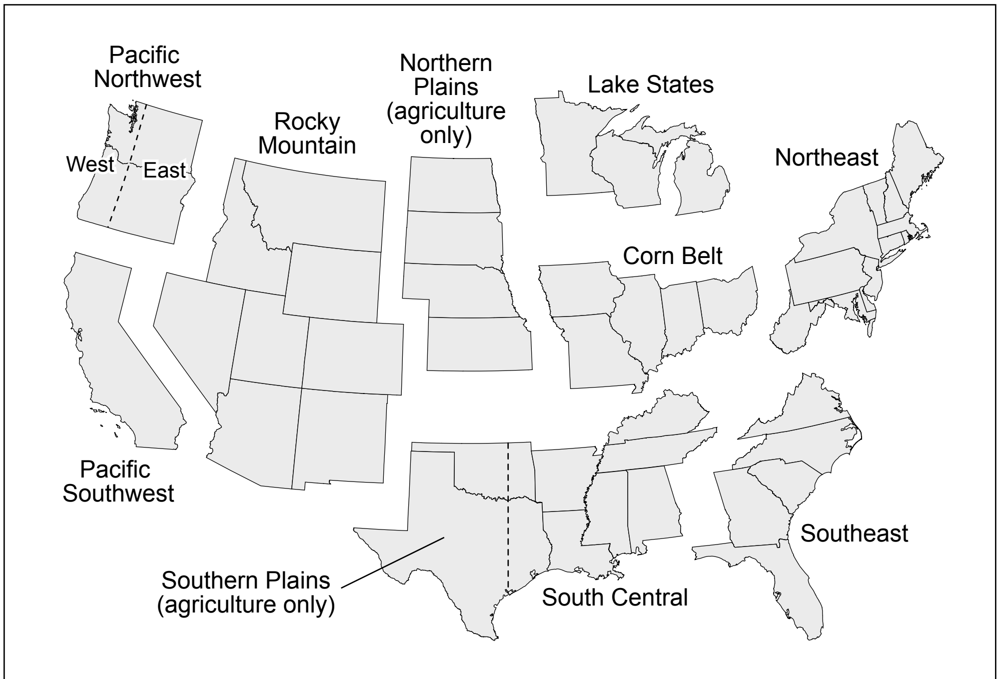


Figure 5—Timber-producing regions in the conterminous United States (Source: Adams et al. 1996).

In the South, it was deemed important to include management cost information for bottomland hardwood afforestation because of the potential capture of future carbon credits and other environmental benefits.

To further detail timberland management costs in a region, estimates were delineated by RPA forest type where applicable (e.g., Alig and Butler 2004). For example, in the South, it was deemed important to include management cost information for bottomland hardwood afforestation owing to an increased interest in bottomland restoration because of the potential capture of future carbon credits and other environmental benefits (Amacher at al. 1997, Huang et al. 2004, Shabman et al. 2000, Stranturf et al. 2000). The distribution of forest type across regions is detailed in table 2.

Timberland management costs are also arranged by activity. The two broad timber management categories are forest establishment and intermediate management costs. The establishment costs account for naturally regenerated and planted

Table 2—Timberland area of ATLAS-designated forest type in nine selected regions within the contiguous United States

	Forest industry		Nonindustrial private	
Region	**Hardwood**	**Softwood**	**Hardwood**	**Softwood**
		Thousands of acres		
Corn Belt	377	50	25,502	1,614
Lake States	2,396	972	22,953	4,013
Northeast	7,041	3,955	45,009	13,315
Pacific Northwest East	0	2,879	119	2,953
Pacific Northwest West	923	6,236	1,277	2,826
Pacific Southwest	826	2,156	1,748	2,707
Rocky Mountain	8	2,918	2,680	12,457
South Central	7,434	15,095	52,435	29,814
Southeast	4,193	10,315	30,945	29,977

Source: Mills 2003.

timberland on reforested or afforested land. The intermediate treatment costs are also delineated by management intensity and whether naturally regenerated or planted, and additional costs are identified, such as herbicide, fertilizer, and precommercial thinning, which landowners may use under high management intensity. This suite of additional high-management-intensity treatment costs was chosen because of their importance in the ATLAS model in defining various management intensities (Mills 2003). The following tabulation illustrates the identified management intensities:

Natural regeneration management practices:

- Even-age management
- Uneven-age management

Planted management practices:

- Without intermediate treatments
- With intermediate treatments
  - Precommercial thinning
  - Fertilization
  - Herbicides

Costs that possibly would occur as fixed over limited periods are not included in the estimated forest establishment and intermediate treatment costs. For example, we assumed that before reforestation or afforestation activities take place, landowners have a clear definition of their boundaries (e.g., historical fencing, fire breaks, etc.) and reasonable access to their land (e.g., established roads, drainage, etc.). Based on this assumption, these infrequent but significant infrastructure costs typically incurred by landowners were not included in the cost estimates.

Timberland Management Costs

Establishment Costs

Deciding which establishment activities are necessary for desired stand growth is one of the first input choices a landowner can make. We assumed that naturally regenerated stands, with reasonable levels of stocking during establishment, require minimal intervention. This includes such activities as site preparation, but they are significantly less intense than for planted stands. Site preparation for planted stands includes manipulation of existing logging residue and seedbed preparation (Dubois et al. 2003). Beyond this level of management, during establishment a landowner has the option to plant softwood or hardwood types on reforested or afforested stands.

Naturally regenerated stands occupy much more area on private land than do areas of higher management intensity.

Naturally regenerated stands occupy much more area on private land than do areas of higher management intensity (Smith et al. 2004). Even on Southern forest industry land, naturally regenerated forest area is over half of the total timberland area. The cost of establishing these naturally regenerated stands differs by forest type and region (fig. 6). Establishing naturally regenerated softwood stands is more problematic than establishing hardwood owing to seed source issues (Fowells 1965). This difference is reflected in the establishment costs. In several regions,

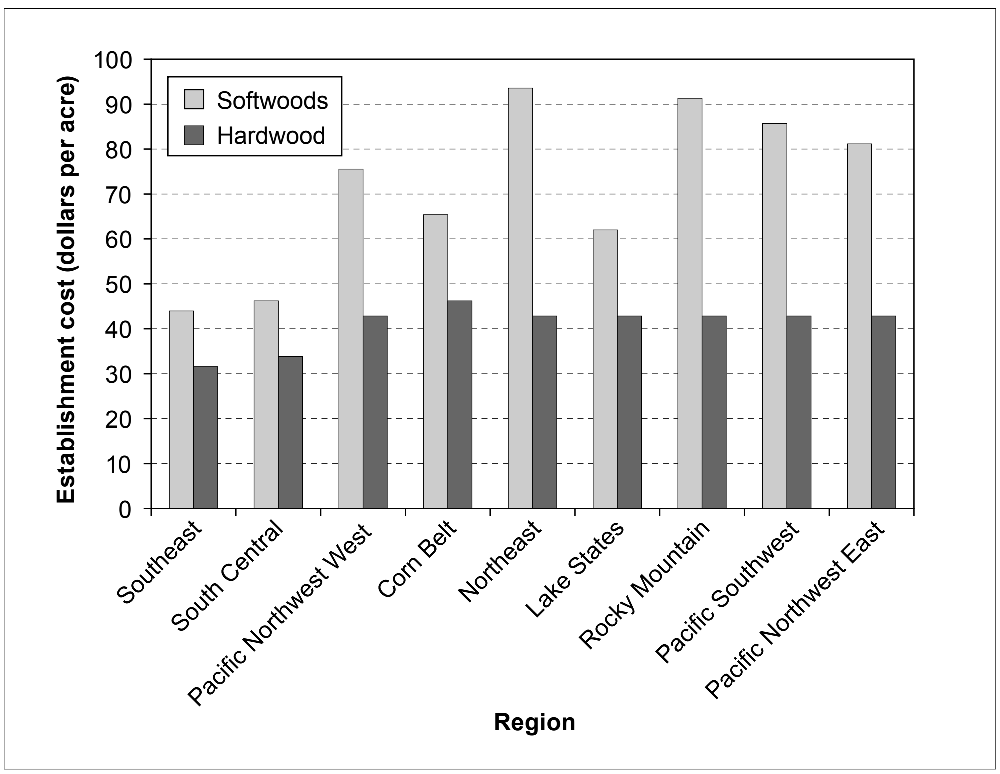


Figure 6—Stand establishment costs for naturally regenerated stands, 2002 dollars (Source: Adams et al. 1996).

low-management-intensity establishment costs of natural regeneration are at least $10 per acre more for softwood stands than for hardwood stands, and in some cases, such as the Northeast and Rocky Mountain, are $50 more per acre.

Regional differences in establishment costs are less evident in hardwood than in softwood stands. This difference may be due to different establishment requirements for hardwood and softwood during natural regeneration. It is quite possible that hardwood stands are influenced less by regional environmental factors given their hardy regeneration. For example, the Southern regions have the lowest overall establishment cost for naturally regenerated softwood stands. The favorable geography and climate in the region may decrease the ratio in establishment cost between hardwoods and softwoods, compared to other regions with much more varied landscapes and harsher climates, such as the Rocky Mountain and Northeast Regions. Establishment costs for softwood stands in the Rocky Mountain and Northeast Regions are twice the costs in the South.

Although regional environmental conditions influence establishment costs, current levels of timber supply and general activity levels in the forest sector (e.g., availability of factors of production such as seedlings or forestry machinery) can also influence management costs. Economies of scale can decrease timber management costs across a region. Gerbert et al. (1999) found lower unit costs for timber management activities in areas with a larger timberland base. Regions such as the South, with relatively extensive planted timberland, have a management cost advantage when compared to other regions with less intensively managed timberland area. It is possible this is reflected to a certain extent in the lower establishment costs of the Southern regions.

Landowners who are interested in more intensive timber management activities may reforest or afforest an area to accelerate the establishment of timberland. Site preparation for reforestation costs on average approximately $80 per acre more than natural regeneration (table 3). Stands with advanced regeneration would be less costly to establish after harvest.

Seedlings can be planted mechanically or by hand. Private landowners are likely to evaluate costs such as labor, and to a lesser extent fuel, when making a decision between the two. Landowners in locales with less expensive labor or varied topography may choose to hand plant, whereas landowners with access to relatively inexpensive fuel or geography favorable for mechanical planting may forego the hand planting for mechanical stand establishment.

For reforested stands in high-production regions, hardwood (e.g., bottomland hardwoods in the South) and softwood (e.g., Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) in the Pacific Northwest West and planted pine (*Pinus* spp.) in the

South) site preparation and planting costs exhibit the opposite relationship from what was observed in establishment of naturally regenerated stands. Hardwoods are much more costly in both the site preparation and planting phases (table 3). The site preparation is approximately $30 to $40 higher across regions, and the seedling and planting costs are almost double that of softwoods, specifically in the South. This cost disparity indicates several potential differences between softwood and hardwood seedlings. These differences could be biological (e.g., seedling survival rates) or economic (e.g., economies of scale).

Table 3—Per-acre site preparation and planting costs for high-management-intensity stands (i.e., planted) in the three most productive regions in the United States, 2002 dollars

	Site preparation costs		Planting costs	
Region	**Softwood**	**Hardwood**	**Softwood**	**Hardwood**
	Dollars per acre			
Southeast	124.86	156.08	67.45	135.42
South Central	146.58	183.22	79.17	158.97
Pacific Northwest West	160.79	200.99	119.70	179.70

Softwood includes planted pines in the South and Douglas-fir in the Pacific Northwest West.
Hardwood establishment costs in the South are for bottomland hardwood.
Planting costs include seedling costs.
Source: Dubois et al. 2003, Moulton and Richards 1990.

Reforestation cost differences across regions follow patterns similar to the establishment costs for naturally regenerated stands. Establishment costs for reforestation in the Southern regions are less than in other regions, potentially owing to the same factors influencing naturally regenerated stands. Geography and climate may play important roles when comparing such regions as the Pacific Northwest West and the South. The Pacific Northwest West has greater variation in geography than the South and less favorable climate, possibly increasing the cost for high-management-intensity reforestation activities in the region. Costs in the Southern regions are very similar to each other.

Active afforestation is another investment option for landowners interested in timberland establishment. In our estimation, afforestation takes place on crop or pastureland that is suitable for use as timberland. Some regions have no available crop and pastureland for afforestation, and because of this we detail afforestation in the Southern regions and Corn Belt only.[2]

[2] From a regional perspective, the Pacific Northwest West's crop, pasture, and forest lands are considered to be in equilibrium, and little to no conversion is projected to occur (Lettman 2002).

Site establishment for afforested land is less costly than site preparation on reforested land.

Site establishment for afforested land is less costly than site preparation on reforested land (table 4) (Moulton and Richards 1990). This results from favorable conditions for tree planting on crop and pastureland. The absence of logging residue on cropland makes the transition from agriculture to forest less expensive than reforestation on timberland. Additionally, cropland is more suitable to afforestation than pastureland owing to site characteristics (Moulton and Richards 1990). Beyond the reduced site preparation costs, afforested stands follow cost patterns similar to those for reforested establishment practices (table 4). Hardwoods are more expensive than softwoods to establish through afforestation across regions. This is the case on both crop and pastureland. Afforestation in the Corn Belt is more expensive than in the Southern regions. Planting costs are estimated to be the same in the two Southern regions.

Table 4—Per-acre site preparation and afforestation costs for the three regions with afforestation activity, 2002 dollars

Management activity	Southeast		South Central		Corn Belt	
	Crop	Pasture	Crop	Pasture	Crop	Pasture
			Dollars per acre			
Planted pine site preparation	64.92	82.41	73.29	80.62	114.36	157.07
Bottomland hardwood site preparation	81.16	103.01	91.61	100.77	142.95	196.34

Source: Adams et al. 1996, Amacher et al. 1997, Dubois et al. 2003, Huang et al. 2004, Moulton and Richards 1990, Shabman and Zepp 2000, Stranturf et al. 2000.

Intermediate Management Costs

After stand establishment, landowners can choose between various intermediate treatments for the upkeep and productivity of timberland. Periodic maintenance may include activities such as management plans, boundary maintenance, survey and cruising, and fire protection. Costs for these management practices are combined and estimated for a 10-year period (fig. 7). The cost estimates across regions are arrived at by using a combination of past prices found in the literature and current prices for factors of production, such as labor and fuel (Adams et al. 1996, Mouton and Richards 1990, US DOE 2005, Wilson 2002). As was the case for establishment costs, intermediate management cost estimates are influenced by forest type characteristics and regional differences. Costs are $10 per acre less for periodic management in regions with favorable timber management conditions, such as the South, than in high-cost regions like the Pacific Northwest West. Across forest types, periodic timber management costs for hardwood stands peak in the Corn Belt, Lake States, and Rocky Mountain Regions, costing approximately an

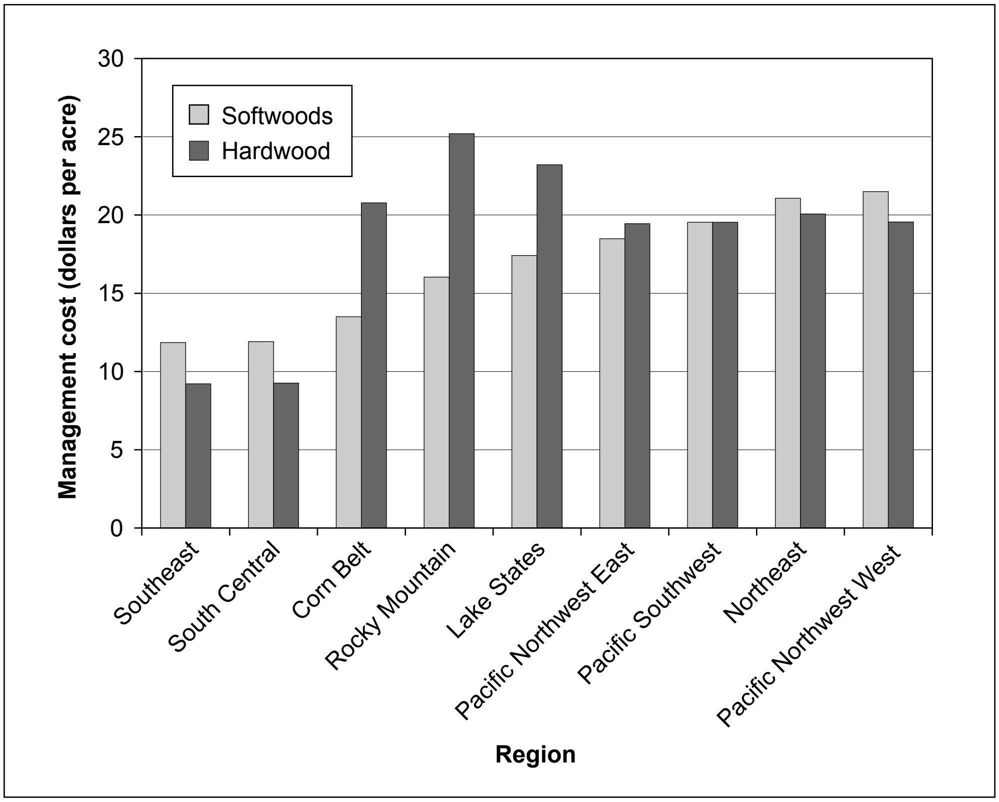


Figure 7—Decadal management costs for naturally regenerated stands, 2002 dollars (Source: Adams et al. 1996).

additional $5 to $9 per acre over a 10-year period. The remaining regions' hardwood and softwood costs are similar to one another.

Stands that are established through planting are assumed to have higher periodic management treatment costs than naturally regenerated stands (Arno et al. 2002). The treatments are not assumed to change, only the intensity with which they are implemented; for example, logging residue manipulation and site preparation. In the regions evaluated, decadal management costs are an estimated $10 to $20 per acre more for planted than for naturally regenerated stands. Although the costs are greater for periodic maintenance on high-management-intensity stands than on naturally regenerated stands, the relative cost differences across region and forest types are the same.

Intermediate treatments release a stand from competition and provide additional resources for growth. These treatments include precommercial thinning, fertilization, and herbicide treatment.

Landowners who are managing timberland under higher management intensity employ the use of additional intermediate treatments. Intermediate treatments release a stand from competition and provide additional resources for growth. These treatments include precommercial thinning, fertilization, and herbicide treatment (table 5). The costs of implementing these management practices differ across treatment, region, and forest type. For example, costs can range from

Table 5—Per-acre decadal and intermediate management costs for high-management-intensity stands (i.e., planted) in the four regions with planting in the contiguous United States, 2002 dollars

Region	Softwoods	Hardwood
	Dollars per acre	
Pacific Northwest West:		
Decadal management	39.00	35.46
Precommercial thin	95.55	N/A
Fertilizer	44.67	N/A
Southeast:		
Decadal management	21.50	16.71
Precommercial thin	65.11	N/A
Fertilizer	50.76	14.82
Herbicide	58.48	58.48
South Central:		
Decadal management	21.61	16.80
Precommercial thin	65.11	N/A
Fertilizer	50.76	14.82
Herbicide	58.48	58.48
Corn Belt:		
Decadal management	24.49	37.70

Softwood includes planted pines in the South and Douglas-fir in the Pacific Northwest West.
Hardwood establishment costs in the South are for bottomland hardwood.
Source: Adams et al. 1996, Amacher et al. 1997, Dubois et al. 2003, Huang et al. 2004, Shabman and Zepp 2000, Stranturf et al. 2000.

approximately $15 per acre for bottomland hardwood fertilization in the Southern regions to almost $100 per acre for precommercial thinning softwood stands in the Pacific Northwest Westside. This difference is mostly likely due to different characteristics in forest type and region. As was illustrated in the timber yield curve of high-management-intensity planted pine, these additional treatments can increase total output by 2,000 cubic feet per acre at the end of a rotation (fig. 4).

Timber Cost Trends

Trends in total timber management costs are influenced by factors such as input costs and demand for wood products. In the Southern regions, trends for real timber management costs have slightly increased over the last several decades (fig. 8) (Dubois et al. 2003). Fertilization and herbicide treatment costs have remained relatively constant, but there has been an increase in site preparation and precommercial thinning costs. These upward trends in timber management costs reflect the increasing demand for wood products and increasing labor and capital costs (Dubois et al. 2003, Wilson 2002).

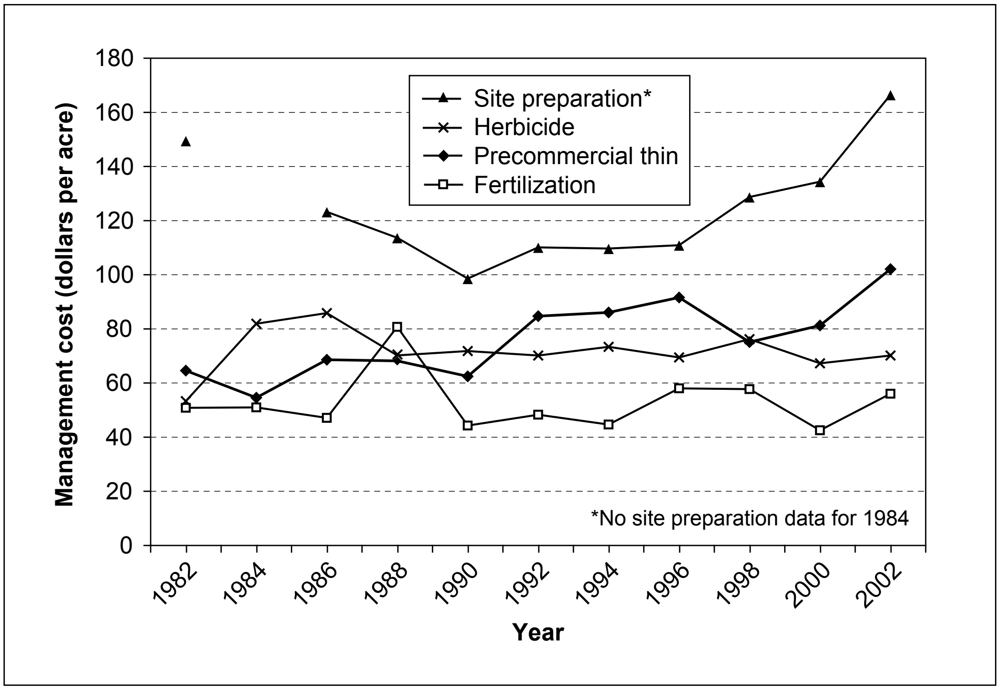


Figure 8—Trends in Southern intermediate treatment costs in timber management, 1982–2002, 2002 dollars (Source: Dubois et al. 2003).

Costs for labor-intensive timber management treatments are influenced by any change in regional labor costs. Unit labor costs in real terms have increased in both of the Southern regions, although less so in the Southeast region (fig. 9) (Wilson 2002). The increase in private timber management costs across the two Southern regions may be partially due to the increase in unit labor costs. The Rocky Mountain and Pacific Southwest regions are the only timber-producing areas where unit labor costs have declined over the past decade. This trend would decrease private timber management costs in the area. An actual decline in timber management expenditures in these areas would also depend on regional demand and capital costs.

The costs of energy-intensive timber management practices, such as site preparation, also are influenced by energy costs. In real terms, fuel price trends have fallen from 1980 to 2000 (fig. 10) (US DEO 2005). Although there was a spike in fuel prices in 1999 and 2000, the overall trend in fuel price has been downward sloping.[3] This has occurred across regions, where fuel price declines are similar in magnitude and variability. Although fuel prices have trended downward over the last decade, other factors have increased energy-intensive timber management costs. Dubois et al. (2003) cited the increasing use of relatively expensive machinery in

The costs of energy-intensive timber management practices, such as site preparation, also are influenced by energy costs.

[3] Even though data up to 2000 indicates a downward trend in real gasoline prices, recent spikes in real price may alter long-term trends.

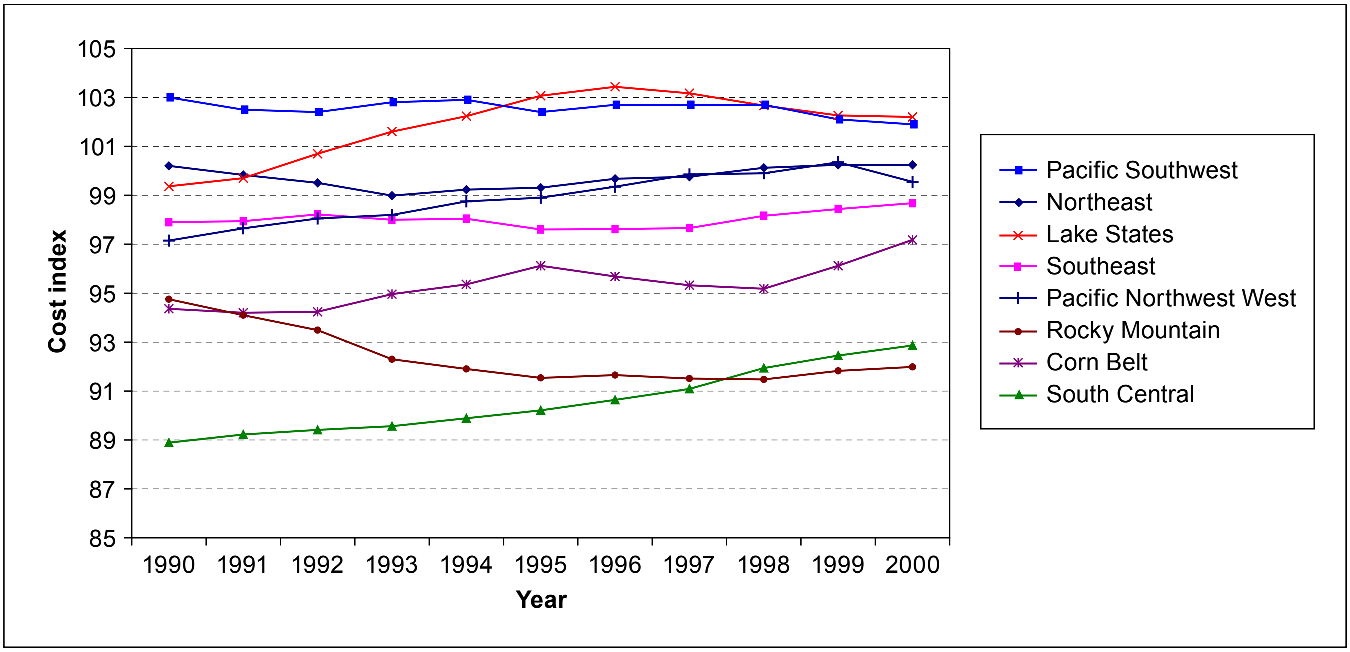


Figure 9—Regional labor cost index by region, 1990–2000, where 100 = 1992 (Source: Wilson 2002).

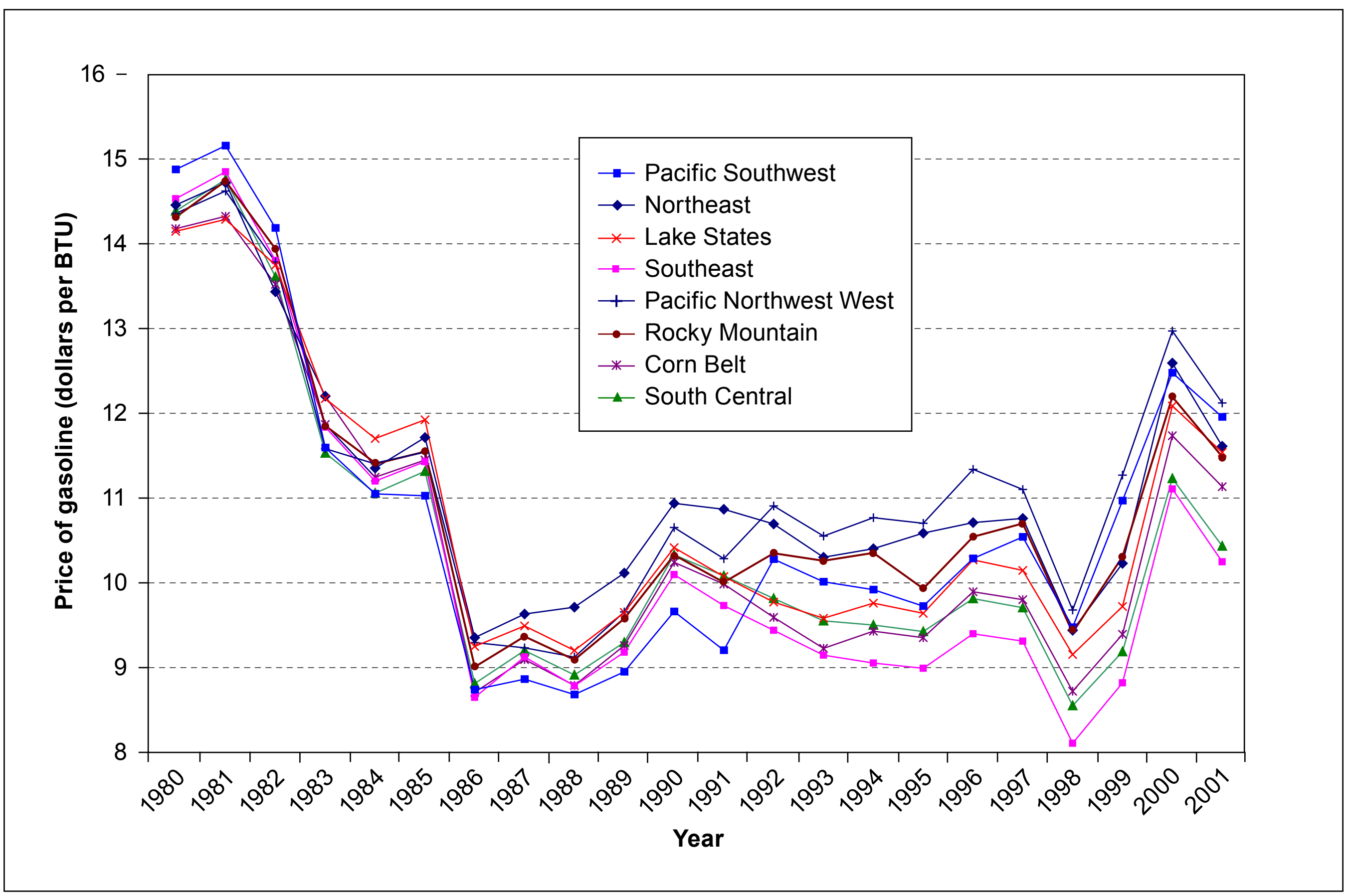


Figure 10—Gasoline fuel price by region, 1980–2001, 2002 dollars (Source: US DOE 2005).

site preparation activities as an offset to moderating fuel prices. Other factors such as increasing demand for intensive treatment practices have led to an increase in energy-intensive timber management costs.

The extent to which landowners invest in their timberland, as outlined in the production function discussion, can be thought of as forest capital, which can also influence trends in costs. Capital can be an improvement in timberland through direct investment, timber management activities, and appreciation or growth of timberland over time. An increase in timberland capital can add to the economies of scale of a region (Phillips 1993). This in turn can reduce the per acre timber management costs for site preparation, precommercial thinning, etc. Wear (1993) developed a capital index to track the changes in forest capital from 1952 to 1992 in the Southern regions. Over the period, forest industry's capital index increased, although nonindustrial private forest's capital index decreased. The result is a slightly declining or flat total private forest capital index. This indicates that for Southern forests, capital investment was not substantial for the period, and any gains from economies of scale were not realized. Other regions with increasing investment in forest capital could benefit from the increased emphasis on timberland investment and the resulting economies of scale. This is especially true in regions with relatively small areas of timberland, where initial gains would be relatively large. Timberland productivity began to plateau in the 1990s, including private timberland (Smith et al. 2004).

Another factor that influences trends in timberland management activities is the demand for wood products (Dubois et al. 2003). The United States has increased its consumption of softwood lumber in recent years and is expected to continue to do so over a 50-year projection period (Haynes 2003). The domestic supply used to meet the increase in demand will be met mostly by the Southern regions (fig. 11). The Pacific Northwest West region is the only one that has seen large declines in harvest since 1952, although declines in softwood timber harvest after 1997 are predicted to be no more dramatic than in the other regions, with relatively static harvest activity. The increase in harvested timber will push private timber management costs up.

Technology is another factor that can influence timber management costs. Timber management practices (e.g., site preparation, planting, thinning, etc.) that use new technology can be more cost-effective but can also be more costly (Wear and Greis 2002). The benefit of increased cost-effectiveness must outweigh the increase in cost for a new technology to be used.

Technology is another factor that can influence timber management costs. Timber management practices (e.g., site preparation, planting, thinning, etc.) that use new technology can be more cost-effective but can also be more costly.

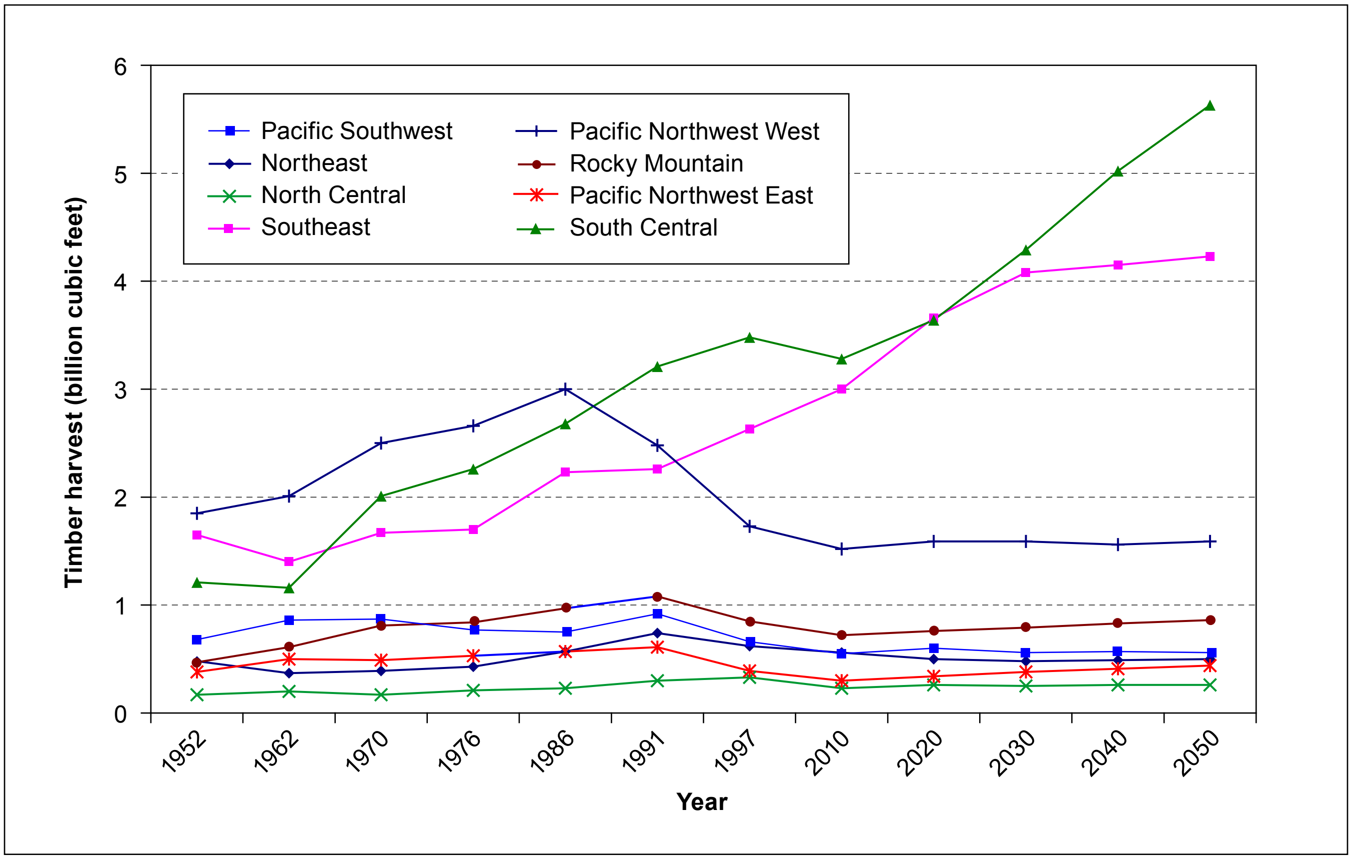


Figure 11—Softwood timber harvest by region, 1952–2050 (Source: Haynes 2003).

One example of new technology is the use of site preparation technology. Labor costs in the major production regions have increased over the past decade (Wilson 2002). This increase has led to a substitution of mechanical site preparation methods for labor. The net effect has been increased per-acre site preparation costs in these regions (Dubois et al. 2003). However, because mechanical site preparation is more productive, and machinery is taking on multiple roles in the reforestation process, the total cost in relation to output may be more favorable (Dubois et al. 2003). Therefore, even though costs for individual management practices are rising owing to technology usage, the multiuse aspect of many of the technologies and advantages from economies of scale are encouraging the adoption of new technologies.

Agricultural production costs are another way to identify trends in inputs that are used across the forest and agricultural sector. Fertilizer, fuel, and labor are three of the agricultural production costs reported by the USDA Economic Research Service (ERS) that are applicable to forest production activities (US ERS 2005) (fig. 12). Although results from the ERS are not directly comparable to the previous examination of fuel and labor costs (Wilson 2002 and US DOE 2005),

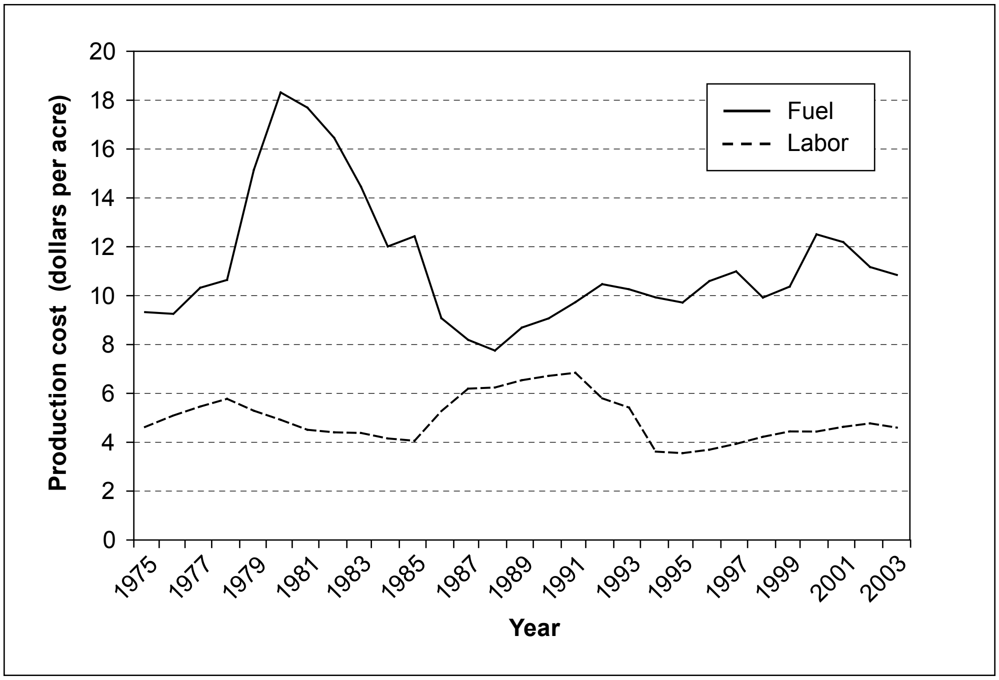


Figure 12—Average production costs (i.e., fuel and labor) of barley and oats in the United States, 1975–2003, 2002 dollars (Source: US ERS 2005).

the relative change in costs are very similar. Agricultural input cost trends may be a better comparison to forestry operations than other industries, because of the similar industrial organization. Although, in this case, fuel and labor costs are not much different from industry-wide variations.

In the Southern States, per-acre production costs for soybeans and cotton indicate that between 1997 and 2003, labor was more costly per acre than fuel in 2 out of 7 years (ERS 2005). The converse is true for fuel and labor costs for the overall United States for wheat production. Although direct comparison to forestry operations is not appropriate, this does give an indication of the relationship between labor and fuel in the South and the possible impact they have on choices in production technology. Current prices would also indicate future trends in production technology and costs, such as site preparation.

Discussion

Increasing demand for wood products and changes in timber supply on public lands in the West has focused more attention on timber supply from private timberland in the Southern States. Softwood production is projected to increase over the next 50 years in the South, supplying the Nation with a large portion of its softwood (Haynes 2003). The lower than average establishment and intermediate treatment costs in the Southern States provide a comparative advantage for timber production in this region. This advantage is evident in timber establishment and afforestation costs. Such an advantage is likely to persist, given the relatively large timberland base and the increased production in the area providing for potential economies of scale.

Trends in timber management costs in the South, and presumably in the other regions, have increased on average just over 20 percent, in real terms, in the last decade. This increase is due to rising input costs influenced by increasing labor and capital costs. This change in input costs will discourage investment in timberland, although rising output prices may compensate for a portion of this (Haynes 2003). Without significant government assistance programs, investment such as planting is expected to decrease on nonindustrial private forests in the Southern States, although the opposite is expected on forest industry land (Alig and Butler 2004, Kline et al. 2002). Although timberland management intensity and demand are changing throughout the contiguous United States, the many factors that sometimes work in opposition continue to promote the relatively productive regions like the Southern States and the Pacific Northwest West as the major timber producing regions.

Cost information for timber management is not only important for efficient timber-production decisions, but also in the production of various other goods and services derived from timberlands.

Cost information for timber management is not only important for efficient timber-production decisions, but also in the production of various other goods and services derived from timberlands. These might include such activities as wildlife habitat restoration, aesthetic enhancement, carbon sequestration, reduction of wildfire danger, and other goods and services. Each one of these management objectives is obtainable through application of various timber management practices—often the same type of management actions taken to improve financial return in a stand of timber. For example, precommercial thinning may be used to decrease stand density to improve wildlife habitat, reduce fuel loading, or increase growth to sequester carbon or produce high-quality timber.

Production decisions are not always made with the single goal of producing one type of output. Several complementary goods or services are derived from a forest stand. For example, increasing the timberland productivity of an area, while also improving habitat for wildlife, can be complementary management objectives. Rohweder et al. (2000) determined that competitive and complementary relationships are common between multiple objectives. The joint objectives can often be commodity and noncommodity goods derived from the forest. Rohweder and others (2000) also concluded that the feasibility of the various management options in the production of joint products is influenced significantly by the costs of management activities. This increases the value of timber management cost information in natural resource analyses.

Research Needs

Although timber management costs in the Southern regions are detailed in Dubois et al. (2003), few survey results are widely distributed for the remaining timber-producing regions in the contiguous United States. Detailed cost estimates for establishment and intermediate treatments for regions outside the South would improve the accuracy of such estimates. Ideally, estimates for states or smaller areas would supplant the current regional cost figures. Obtaining timberland management costs by physiographic zone would reduce some of the homogenization that is currently taking place when estimating costs by regions.

Obtaining timberland management costs by physiographic zone would reduce some of the homogenization that is currently taking place when estimating costs by regions.

Increasing the detail of private timberland management costs would make a significant difference in the quality of cost estimates. For example, separate cost estimates for nonindustrial private forest and forest industry lands by site class would improve modeling capabilities. However, to obtain such detail would be time intensive and most likely would require extensive survey work, given that most cost estimates are obtained from surveys of landowners and forestry professionals. One possibility is to develop a database that would coordinate various survey results across regions and agencies, to which individual actors could contribute. This would provide a forum for periodic and well-known data sources, such as Dubois et al. (2003), to be combined with infrequent state or county surveys. Such information updated periodically would improve the ability to make comparisons across regions, ownerships, forest types, and possibly other attributes of interest. This would also provide detailed information from which to identify trends in timber management costs outside the Southern States.

Acknowledgments

The authors acknowledge John Mills for the ATLAS yield output and Andrew Yost for Forest Vegetation Simulator (FVS) yield output. Research was funded by the U.S. Environmental Protection Agency, Office of Atmospheric Programs.

Metric Equivalents

When you know:	Multiply by:	To find:
Acres (ac)	0.405	Hectares
Cubic feet (ft^3)	.0283	Cubic meters

References

Adams, D.M.; Alig, R.J.; Callaway, J.M. [et al.]. 1996. The Forest and Agricultural Sector Optimization Model (FASOM): model structure and policy applications. Res. Pap. PNW-RP-495. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 60 p.

Alig, R.J.; Butler, B.J. 2004. Area change for forest cover types in the United States, 1952 to 1997, with projections to 2050. Gen. Tech. Rep. PNW-GTR-613. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 106 p.

Alig, R.J.; Parks, P.J.; Farrar, R.M., Jr. [et al.]. 1984. Regional timber yield and cost information for the South: modeling techniques. Gen. Tech. Rep. GTR-RM-112. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 28 p.

Amacher, G.; Sullivan, J.; Shabman, L.; Zepp, L. 1997. Restoration of the lower Mississippi Delta bottomland hardwood forests: economic and policy considerations. Res. Bull. 185. Blacksburg VA: Virginia Water Resource Research Center, Virginia Polytechnic Institute and State University. 85 p.

Arno, K.G.; Cushing, T.L.; Munn, I.A. 2002. Forest management expenses of Mississippi's nonindustrial private forest landowners. Southern Journal of Applied Forestry. 26(2): 93–98.

Cathcart, J. 2003. Oregon Department of Forestry cost share rates for the Forest Land Enhancement Program (FLEP). Unpublished report. On file with: Land Use and Land Cover Dynamics Team, Forestry Sciences Laboratory, 3200 SW Jefferson Way, Corvallis, OR 97331.

Dubois, M.R.; Straka, T.J.; Crim, S.D.; Robinson, L.J. 2003. Costs and cost trends for forestry practices in the South. The Forest Landowner Manual 34th Edition, March/April. 20 p.

Floyd, S.L.; Kutshcha, N.P. 2000. Development of softwood plantation timberland in the United States. Forest Products Journal. 50(11/12): 20–24.

Fowells, H.A. 1965. Silvics of forest trees of the United States. Agric. Handb. 271. Washington, DC: U.S. Department of Agriculture.

Gerbert, K.M.; Niccolucci, M.J.; Schuster, E.G. 1999. Timber management costs in the northern region: a historical analysis. Western Journal of Applied Forestry. 14(4): 200–207.

Haynes, R.W., tech. coord. 2003. An analysis of the timberland situation in the United States: 1952 to 2050. Gen. Tech. Rep. PNW-GTR-650. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 219 p.

Huang, C.-H.; Bates, R.; Kronrad, G.D.; Cheng, S. 2004. Economic analyses of sequestering carbon in loblolly pine, cherrybark oak, and northern red oak in the United States. Environmental Management. 33(1): S187–S199.

Kline, J.D.; Butler, B.J.; Alig, R.J. 2002. Tree planting in the South: What does the future hold? Southern Journal of Applied Forestry. 26(2): 99–107.

McKee, B. 1987. Natural and artificial regeneration of loblolly pine. ANR-408. Auburn, AL: Auburn University, Department of Forestry Cooperative Extension System. 15 p.

Mills, J. 2003. Personal communication. Research forester, Forest Sciences Laboratory, P.O. Box 3890, Portland, OR 97208.

Mills, J.R.; Kincaid, J.C. 1992. The aggregated timber assessment-ATLAS: a comprehensive timber projection model. Gen. Tech. Rep. PNW-GTR-281. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 160 p.

Lettman, G.J. coord. 2002. Land use change on non-federal land in western Oregon, 1973–2000. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; Oregon Departments of Forestry, Land Conservation and Development, and Agriculture. 48 p.

Moulton, R.J.; Richards, K.R. 1990. Costs of sequestering carbon through tree planting and forest management in the United States. Gen. Tech. Rep. GTR-WO-58. Washington DC: U.S. Department of Agriculture, Forest Service. 17 p.

Phillips, S. 1993. Forest products manufacturing: factors and trends affecting the working forest. Washington, DC: The Wilderness Society.

Rideout, D.B. ; Hensen, H. 1995. Principles of forest and environmental economics. Resource and Environmental Management, LLC.

Ritchie, M.W. 1999. A compendium of forest growth and yield simulators for the Pacific Coast States. Gen. Tech. Rep. PSW-GTR-174. Albany CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 59 p.

Rohweder, M.R.; McKetta, C.W.; Riggs, R.A. 2000. Economic and biological compatibility of timber and wildlife production: an illustrative use of timber production possibilities frontier. Wildlife Society Bulletin. 28(2): 435–447.

Shabman, L.; Zepp, L. 2000. An approach for evaluating nonstructural actions with application to the Yazoo River (Mississippi) backwater area. Blacksburg, VA: Virginia Water Resource Research Center, Virginia Polytechnic Institute and State University. 134 p.

Smith, W.B.; Miles, P.D.; Vissage, J.S.; [et al.]. 2004. Forest resources of the United States, 2002. Gen. Tech. Rep. GTR-NC-241. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 137 p.

Stranturf, J.A.; Gardiner, E.S.; Hamel, P.B. [et al.]. 2000. Restoring bottomland hardwood ecosystems in the lower Mississippi alluvial valley. Journal of Forestry. 98(8): 10–16.

U.S. Department of Agriculture, Economic Research Service [US ERS]. 2005. U.S. and regional cost and return data. http://www.ers.usda.gov/Data/CostsAndReturns/testpick.htm. (March 15, 2006)

U.S. Department of Energy, Energy Information Administration [US DOE]. 2005. Annual energy review. http://www.energy.gov. (March 15, 2006)

Vasievich, M. 1983. Average cost/acre for forest management treatments in selected cost regions in the South. Unpublished report. On file with: Forestry Sciences Laboratory, 3041 E Cornwallis Road, Research Triangle Park, NC 27709.

Wear, D.N. 1993. Private forest investment and softwood production in the U.S. South. Gen. Tech. Rep. RM-237. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 12 p.

Wear, D.N.; Greis, J.G., eds. 2002. Southern forest resource assessment. Gen. Tech. Rep. SRS-53. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 635 p.

Wilson, W.T. 2002. The effect of right to work laws on economic development. Midland, MI: Mackinac Center for Public Policy. 39 p.

Pacific Northwest Research Station

Web site	http://www.fs.fed.us/pnw/
Telephone	(503) 808-2592
Publication requests	(503) 808-2138
FAX	(503) 808-2130
E-mail	pnw_pnwpubs@fs.fed.us
Mailing address	Publications Distribution Pacific Northwest Research Station P.O. Box 3890 Portland, OR 97208-3890

U.S. Department of Agriculture
Pacific Northwest Research Station
333 SW First Avenue
P.O. Box 3890
Portland, OR 97208-3890