Chapter 24.

Timber Market Research,

Private Forests, and Policy Rhetoric

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Abstract—The development of the profession and practice of forestry in the United States can be linked to urgent concerns regarding timber shortages in the late 19th century (Williams 1989). These were based largely on perceived failures of forest landowners to protect or invest enough in the productive capacity of their forests (Manthy 1977). The South, as the only major timber-producing region of the United States in which private interests have almost exclusively controlled forests and where unfettered interaction between private buyers and sellers has determined timber prices and harvests, provides the clearest example of the way the private sector manages forests. It provides a setting for evaluating core assumptions regarding markets, market failure, and conservation rhetoric, and for examining the potential role of various policy approaches for attaining conservation goals. We examine the history of research into private timber management and the function of private timber markets in the South. In particular, we examine research that provides insights into the behavior of private forest owners and the structure of private timber supply. We also examine how this body of research has been influenced by and in turn may have influenced policy perspectives regarding forests in the United States. Research on the function and structure of timber markets, especially in the South, has clearly illustrated that the private sector can generate an orderly market for a commodity (timber) with a long production period. Investment responses to scarcity signals in the South demonstrate that timber capital is viewed as a reasonably liquid asset and that market failure with respect to intertemporal allocation does not hold. In an interesting reversal of rhetoric, it appears clear now that timber production from public forests—more strongly influenced by policy shifts and administrative process—is much less reliable or stable than private timber supply. Policy concerns regarding southern timber markets have evolved partially in response to an improved understanding derived from timber market research. Current concerns focus on the ability of forests to provide a broad range of resource values, and improved understanding of how timber markets operate is required for a full understanding of the ultimate sustainability of forests, their functions, and their derivative benefits.

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INTRODUCTION

The workings or failings of timber markets are core issues at the foundation of the conservation movement in the United States. The rhetoric of timber famine, which dates back at least to the 1500s in North America (Hyde 1980), obtained strong public currency in the late 1800s and eventually led to the establishment of Federal forestry programs and creation of the national forests. Regulation of forestry activities by some States also resulted. The profession and practice of forestry in the United States likewise can be linked to these urgent concerns regarding timber shortages in the late 19th century (Williams 1989).

Timber shortages can be viewed as resulting from market failures with several potential causes. Overharvesting—that is, harvesting without adequate provision for future needs—implies either (1) an insecure timber resource or (2) a lack of information regarding overall timber inventories. Without secure property rights, timber owners cannot be certain about future access to their timber, and have a strong incentive to harvest soon. The same outcome would result from timber being harvested from a common property resource. Without information on overall inventories, timber owners cannot anticipate oncoming shortages, and so fail to recognize the potential for additional returns from delaying their harvests. Both cases would lead to departures from the economically optimal allocation of harvesting over time, pushing harvest rates beyond socially optimal levels.

Another related concern regarding timber markets has been a perceived failure of forest landowners to protect or invest enough in the productive capacity of their forests (Manthy 1977). Investment below socially optimal levels could result from several potential causes. One is simply that returns from forest investments are not competitive with those from alternative investments; that is, expected returns from timber fail to justify the investment on financial grounds. In cases where investment is competitive but is not undertaken, the reasons could be (1) a lack of access to investment capital, (2) a lack of information regarding production potential, (3) a lack of market information regarding current or anticipated future prices, (4) a long production period that effectively locks up capital for unreasonable periods of time—sometimes called capital illiquidity, or (5) excessive investment risk. All five of these concerns have been raised as explanations for a perceived underinvestment in forests.

The South is the only major timber-producing region of the United States in which private interests have almost exclusively controlled forests and where unfettered interaction between private buyers and sellers has determined timber prices and harvests throughout the 20th century. Private landowners currently control 89 percent of timberland (productive or potentially productive forest land) in the region (Conner and Hartsell 2002). Twenty percent is held by the forest industry. The South provides the clearest example of the way the private sector manages forests. It provides a setting for evaluating core assumptions regarding markets, market failure, and conservation rhetoric, and for examining the potential role of various policy approaches for attaining conservation goals. In this chapter, we examine the history of research into private timber management and the function of private timber markets in the South. In particular, we examine research that provides insights into the behavior of private forest owners and the structure of private timber supply. We also examine how this body of research has been influenced by and in turn may have influenced policy perspectives regarding forests in the United States.

HISTORICAL PERSPECTIVES ON PRIVATE FORESTS

Patterns of resource utilization across time and space are defined by the intersection of social organization with initial resource reserves, underlying biological productivity, and technological change and adoption. The history of forest use in the United States is an outcome of, among other factors, divestiture of a public domain, establishment of forest reserves, long-sustained economic expansion, and the structure of private property rights. The role of private enterprise, both in supplying and consuming timber, has long been contentious and is often seen as the root of natural resource problems in the United States.

At the turn of the century, perceived abuse and waste of private forests was the primary motivation for the American Conservation Movement in the United States.[2] The rhetoric of timber famine then, and for many decades to follow, was strongly rooted in the belief that private timber owners would fail to sustain the productivity of their forests. The national illusion of timber inexhaustibility began to wane by the late 1800s, and the resulting conservation and wilderness movements of the late 19th and early 20th centuries were based almost exclusively on the argument that private-sector management of forests would lead to destruction of forest lands and emergence of a "timber famine" in the young United States (Pinchot 1947, Williams 1989). A treatise on emerging timber scarcity in 1874 (Hough, as cited by Steen 1976) initially formalized the issue for the Federal Government, attracted the attention of President Grant, and led in 1876 to the establishment of the Division of Forestry within the U.S. Department of Agriculture (Steen 1976). Public ownership of forests in the form of the forest reserves (eventually the national forests) and the formation of the U.S. Department of Agriculture Forest Service (Forest Service) implicitly recognized concerns regarding timber scarcity and the assumption that private ownership was the root cause of resource destruction and eventual shortage.

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[2] The related wilderness movement of the day was clearly motivated by other concerns, but both can be viewed as motivated by concerns regarding the loss and destruction of forest lands. Even at this early date, however, the wilderness movement, led by John Muir, was separate from and often at odds with the conservation movement led by forestry advocates (see Nash 1967).

Until the 1960s, forest policy in the United States was driven almost exclusively by this timber scarcity rhetoric,[3] and resulted in efforts to expand the Federal forest estate and Federal programs to support State and private forest management. The latter initiative dates from the Clarke-McNary Act of 1924, which authorized funding for, among other things, forest nurseries and technical advice to woodlot owners to support reforestation, and extended authority to acquire private land for national forests for the purpose of providing timber.

The antipathy toward private ownership had other results. Into the 1940s and especially in the 1930s, conservation leaders, including some Chiefs of the Forest Service, argued for national regulation of timber harvesting and management on private lands (e.g., U.S. Department of Agriculture Forest Service 1941). National private harvest regulation was never approved—the responsibility for forest regulations remaining with the States—and disappeared from the Agency's rhetoric by the late 1940s. Still, private land continued to be viewed as a primary source of resource problems and increasing resource scarcity in the United States.

ECONOMIC PERSPECTIVES ON RESOURCE SCARCITY

The belief that private ownership resulted in timber scarcity was essentially taken as self-evident and remained untested until the 1970s, when research into the limits of growth began to focus broadly on material scarcity. Motivated in large part by concerns regarding oil supplies, a major thrust of resource economics in the 1970s and the 1980s was the study of resource scarcity. This body of work focused especially on how to measure changes and trends in resource scarcity in a way that provided information about the potential for and limits of economic growth.

Economic scarcity is not strictly a physical quantity concept but is influenced by information, technology, and quality. To illustrate, consider that a mineral ore is scarce only if it is needed (demanded) in some form for the production of goods and services. It seems logical that as the ore is extracted and used it would become "more scarce." However, the availability of this ore for human uses is determined not by its total quantity (which is generally not known), but by the known quantity (the information part) that can be extracted by affordable means (the technology-driven cost part).

The available quantity of this ore can actually be increased in two ways. One is through discovery of additional deposits, i.e., by improved information. The other is through technological advances that either allow more efficient use of the ore extracted from existing deposits, i.e., through utilization of lower quality grades, or enable substitution of other materials for the ore in the production of the relevant goods. With a renewable resource such as timber, stocks may also be directly enhanced through investment. Information and technology, therefore, play important roles in defining resource scarcity.

Resource economists use trends in resource prices (rents) or in the marginal costs of extraction to gauge changes in economic scarcity. With good market information, producers will internalize their expectations regarding future returns (based on inventories and technology) and current and anticipated demands into decisions regarding what to produce now vs. what to produce in the future. Therefore, sustained increases in price provide a strong signal that the resource is becoming scarcer as producers withhold material from the market in anticipation of higher future returns. Conversely, a sustained decline in prices signals decreasing scarcity. Erratic price movements or discrete jumps in price paths might indicate that producers were surprised by a change in market conditions impossible to foresee or an information failure.

Analyses of price trends were the first studies to directly challenge the premises of historical scarcity rhetoric. Studies by Libecap and Johnson (1978) and Berck (1979) failed to reject the hypothesis that wood product prices in the late 19th and early 20th centuries increased at rates consistent with the prevailing, risk-free interest rates. This pattern of price growth is predicted by economic theory for the optimal use of an exhaustible resource. That is, these findings offered evidence that refuted the notion that historical timber harvesting had been completely indifferent to future implications.

Evaluation of 20th-century price paths also did not suggest market failure. In the 1960s and 1970s, researchers beginning with Barnett and Morse (1963) evaluated trends in resource rents (*in situ* prices) for various natural resources to look for

[3]A clear exception to this claim is concern and debate regarding the impacts of forest removals on the condition of navigable streams and on potential for flooding that dominated the debate regarding the Weeks Act of 1911. As specified by the Weeks Law and until revised by the Clarke-McNary Act of 1924, property for eastern national forests could only be acquired to protect navigable streams (Steen 1976).

evidence of increasing scarcity. Contrary to popular sentiment, evidence suggested no emerging scarcity for nearly all resources evaluated, even mineral resources. Technological changes coupled with new discoveries were credited with effectively augmenting resource stocks in the 20th century. Throughout these studies, however, the major exception to the trend away from scarcity was timber, which showed an unambiguous increase in scarcity. Rates of increase for timber rents (stumpage prices) were, however, not inconsistent with an optimal depletion pattern.

These results suggest that there has not been an information failure in timber markets; i.e., they do not support the notion that producers failed to account for the future when making harvest decisions even as harvesting shifted from one region of the country to another. However, they do not completely allay concerns regarding conservation of forest resources, even from a strictly timber harvest perspective. Most important, they suggest that timber was not managed as a renewable resource through the early portions of the 20th century. On the contrary, timber price trends appeared consistent with those expected for mining of a nonrenewable resource.

One explanation of why a potentially renewable resource would be utilized as a nonrenewable resource is that old-growth timber and second growth or managed timber are two very different resources. It can be argued that old growth is essentially nonrenewable, since economic conditions do not promote the production of old-growth timber. Second growth is also expensive to produce and is not financially attractive as long as relatively inexpensive old growth is available. The interactions between old-growth harvesting and second-growth management have been explored in a study by Lyon (1981). Using optimal control theory, he found that an orderly timber market would start with a mining phase that would eventually trigger an investment phase in a transition to a sustained, agricultural style of timber production. The trigger mechanism is timber price. Investment in forests commences when the price is high enough to warrant competitive rates of return to second-growth timber production. After transition, landowners anticipate and adjust timber stocks to ameliorate resource scarcity. Timber production and forest management in the United States since the 1970s seem to be consistent with these general prognoses.

Taken together, these studies might suggest that concerns regarding timber famine perhaps were overstated. However, these findings are viewed through a lens of economic theory and data analysis that was unavailable during the early 20th century. In addition, the activities spawned by the American Conservation Movement in the late 19th century may have provided information—scarcity signals—that modified the behavior of timber producers. That is, the rhetoric of the American Conservation Movement may have led to change before policy actions did. Whatever the causal path, it became clear by the 1980s, at least to economists, that timber famine was not a relevant contemporary policy concern. By the 1990s timber scarcity had disappeared from forest policy rhetoric completely. Scarcities of contemporary concern relate to the habitat or ecosystem conditions provided by forests.

The net effect of this research into resource scarcity had important influence on the thinking of resource economists and policy analysts. It (1) rejected the notion that private timber production necessarily proceeded without anticipating future scarcity, (2) left open the question of whether anticipated shifts to renewable agriculture-style production would occur, and (3) illustrated that scarcity can emerge—timber prices can rise—even where no market failure occurs. Overall, this body of work clarified a set of hypotheses for studying the structure and function of timber markets.

SOUTHERN TIMBER MARKET RESEARCH

Research into material scarcity shifted the foundation of forest economics research. Until this time, much research was targeted at understanding the magnitude of assumed market failures. From the 1980s forward, however, the focus shifted to understanding how market behavior could influence forest conditions. For some research, the focus shifted from addressing problems with the intertemporal allocation of timber to understanding how timber management might shape allocative problems with other nonpriced benefits from forests. In other cases, the research focused fully on modeling and forecasting the future evolution of forest production, prices, and forest incentives with increasingly greater precision.

The resource economics research into material scarcity changed the frame of reference for forest economics research but provided only an incomplete understanding of timber markets and private production. These initial analyses were based on highly aggregate data for a very heterogeneous resource, and the findings left several questions regarding market mechanisms unaddressed. For example, Can local "scarcities" appear and drive spatial redistribution of demand? Do prices for some species increase at the risk-free rate of interest until it becomes profitable to shift to a substitute species? How are timber markets related spatially? Why should (or do) timber prices increase in the long run if the timber resource is in its "sustained production" phase? If they do increase over time, is this the result of information failure or market failure? Forest economics research in the South and elsewhere applied multiple approaches to develop a better understanding of the specific working of timber markets in the region, but these questions to some extent remain unanswered.

Economic research generally targets either the behavior of individual agents, e.g., producers or consumers, or the operation of highly aggregate markets, e.g., the interaction between price and quantity on a large scale. Forest economics research has focused both on the behavior of individual forest landowners and on aggregate timber markets, mainly for softwood products. Both approaches have been exploited in the South to develop insights into the ultimate outcomes of forest management on private lands.

ANALYSIS OF HARVEST CHOICES

The central conceptual construct of forest economics is the optimal harvest model. The first correct formulation is credited to Faustmann in 1849 and still serves as a point of departure for research into landowner behavior (Faustmann 1849). Indeed, Newman (1988) identifies more than 85 derivative publications in the modern literature. Extensions of the optimal rotation literature address the influence of nonmarket values (Hartman 1976), spatial configuration (Swallow and Wear 1993), and price dynamics (Brazee and Mendelsohn 1988, Clarke and Reed 1989, Forboseh and others 1996, Gong 1999, Haight and Holmes 1991, Lohmander 1988, Thomson 1992). These studies explore management choices (mainly harvest) that would result from a given set of production functions, objectives, and constraints.

The intertemporal structure of forest production is what defines forest economics as a unique endeavor, and the many variants of optimal harvest models provide the theoretical foundation for nearly all of the work that is forest economics, especially work on individual harvest and management choices. These models have been used to construct normative, simulation approaches for investigating individual behavior and have been the theoretical basis for constructing models for positive statistical analysis of harvest choices. We explore these two approaches in turn below.

NORMATIVE TIMBER MANAGEMENT MODELS

Much early research into forest economics involved comparing actual timber management with the behavioral norms defined by optimal rotation models. "Normative" research approaches prevailed from the 1950s through the 1970s. In the South, this research focused on investment behavior across landowner types to investigate the potential for increasing timber supply from private land.

Research on individual investment behavior has directly addressed whether landowners were pursuing optimal management regimes—as defined by the economist—within their forests. Differences between optimal and actual investment levels were viewed as an untapped potential to produce timber from private lands. These foregone investments were labeled timber investment opportunities (TIO). Suboptimal management was attributed to various market failures, including information failures with respect to technical knowledge of forest management, but more importantly with respect to timber prices and timber price trends, and due to prohibitive upfront costs, failure of markets to reflect the future value of standing timber, and limited access to capital (Adams and others 1982).

The results of TIO analysis were used to argue for various forest policies to address these failures. In particular, TIO results were central arguments for programs that subsidize forest planting, including cost-share programs such as the Forestry Incentives Program and the Agricultural Conservation Program. In effect, these programs were designed to overcome the "front-end loading" of costs that discourages investment in long-run timber production. Assessments of timber markets through the 1980s identified TIOs on private lands as clear evidence that information and capital failures impeded timber supply and as a strong indication that public assistance could leverage additional timber supply from the private lands.

In addition, the gap between actual investment and modeled optimal investment was used as an indication that the lack of a widely available price reporting system was retarding the efficient expansion of timber investment in the South—

an information failure. The demand for price information led eventually to the formation of a price reporting service covering the entire South.

Another element of the nonindustrial private forest (NIPF) market failure discourse addresses risk. Some perceive forest management as a risky investment heavily influenced by physical risk of catastrophic loss caused by insects, disease, fire, ice, or wind. It has been argued that risk reduction through fire prevention and suppression efforts set the stage for forest investment activities in the region. Government-sponsored insurance for timber production was also proposed to address the TIO untapped potential. Insurance policies of this sort have not developed, although some private timber insurance is available today. Subsequent research suggests that risk levels are perhaps not as high as once thought and are effectively mitigated by mixed (geographically and biologically diversified) holdings of forest land. Still, for the risk-averse small landholder with a single holding, the probability of a catastrophic loss, although small, could strongly influence his or her decisions.

The premise of much early forest economics research on individual behavior was that these market failures did occur; analysis was used to measure the implications of market failure. Beginning in the 1970s, however, research began to challenge these premises. The development of individual choice econometric models, coupled with the development of computational speed and capacity, allowed researchers to compare observed landowner choices with economically rational choices. As a result, various hypotheses regarding choices could be tested directly.

POSITIVE HARVEST CHOICE MODELS

Econometric models of individual choices examine the probability of a choice as a function of relevant explanatory variables. The selection of variables, as well as the functional form of the model, can be developed by the theory of producer behavior, modeling landowners as producers seeking to maximize the provision of timber and perhaps other products, or consumer behavior, modeling landowners as individuals maximizing the utility that they derive from forests in the context of a household budget constraint. In both cases, the model structures are based on market behavior. Tests of significance of the relevant variables are construed as tests for consistency with market behavior.

Harvest choice models provide direct insights into the responsiveness of timber owners to signals from timber markets. If landowners were indifferent to scarcity signals in the form of timber prices, then the market would fail to allocate timber efficiently across time. This is one expression of the timber famine hypothesis. This hypothesis has been universally rejected by a collection of harvest choice studies (Binkley 1981, Dennis 1990). All of these studies find a positive correlation between timber prices and the propensity to harvest timber and, therefore, reject the null hypothesis that harvests are not price sensitive. However, these studies did not address the relative efficiency of harvest behavior and, thus, leave unanswered questions regarding the optimality of harvest responses to relative prices.

The econometric harvest choice literature also began to crystallize the idea that rational behavior need not only embrace the provision of timber products. A study by Hyberg and Holthausen (1989) challenged the application of the production theory model to forest landowners. Newman and Wear (1993) found management by nonindustrial private landowners not to be inconsistent with profit-maximizing behavior but rather to reflect the relatively high value such landowners place on holding standing inventory. Also, findings from harvest choice studies consistently showed that certain demographic variables, including age, education, and ownership type, were significant in explaining harvest choices (Binkley 1981, Dennis 1990). This implies that harvest preferences are heterogeneous and may be linked to nontimber goods and services derived from forest holdings. In other words, departures from the expected behavior under a single ownership objective of timber production may not be proof of market failure. Instead, such departures may be the result of rational behavior in a well-functioning market, if other private values are also produced from the forest.

ANALYSIS OF TIMBER MARKETS

Economists also study the behavior of production at aggregate levels. In the case of timber markets, much research has addressed the structure of timber supply at various levels of aggregation, but has focused mainly on the supply response of relatively homogeneous regions. Aggregate analysis provides a framework for evaluating the feedbacks between timber demand and supply in defining the response of the private sector to scarcity signals. Various techniques have been applied to this area of investigation. As with harvest choice modeling, the discussion may be split into two parts dealing with normative and positive approaches.

NORMATIVE TIMBER SUPPLY MODELS

The original applications of normative models to timber supply were simply aggregations of normative harvest choice models. They defined the optimal rotation for each quality class of forests for a given price and then summed the average annual harvest implied for each forest class to define total harvest. By solving the problem for a large number of prices, the aggregate supply relationship could be defined. Such analyses were constructed for the State of Georgia by Montgomery and others (1975), for east Texas by Hickman and Jackson (1981), and for Louisiana by Hotvedt and Thomas (1986). This approach implicitly models the supply that would flow when each forest class has achieved a uniform age distribution between zero and its optimal harvest age (the forester's "normal" forest), an outcome that could result in a long-run static equilibrium for the given price. Accordingly, this approach defines only a long-run supply, because it does not explicitly address the existing age structure of forests. This approach can provide insights into the maximum potential timber output by modeling the output consequences of strict adherence by landowners to maximum profit objectives.

Normative models can, however, provide an extremely rich supply specification and, as shown by Hyde (1980) and Jackson (1980), can provide a tractable approach to examining the market consequences of various forest sector policies; for example, public land management strategies and timber taxes. The detailed supply specification also allows for analysis of market effects of technological or environmental changes. Normative models can also be implemented to address conversion of land from forest use to nonforest uses and vice versa. These strengths derive from the explicit linkage between individual behavior and aggregate outcomes, which can account for heterogeneous forests and forest owners.

Normative supply models provided an important and explicit bridge from stand-level analysis to market-level assessment. They provided the first economically grounded estimates of timber supply and credible measures of maximum supply potential for a region; Vaux (1954) is credited with the first application. In spite of the limitations implicit in any attempt to fully simulate market interactions and short-run behavior, they provided an early mechanism for exploration of the potential welfare implications of various management and policy strategies. These studies, therefore, framed a set of questions that would eventually be addressed by the use of increasingly sophisticated analysis.

Extensions of this mechanistic or engineering approach, especially using linear programming, expanded their usefulness. Dynamic adjustment processes can be modeled to address short-run responses. Quadratic programming can be used to simulate the interaction of supply and demand (Greber and Wisdom 1985, Samuelson 1952). Entropy constraints can be used to simulate the variability of observed market responses (Sallnas and Eriksson 1989). The strength of this modeling approach is its rich supply specification, which allows for analysis of the economic and welfare implications of new technologies and new or hypothetical policy instruments (Wear 2003).

POSITIVE TIMBER MARKET ANALYSIS

Positive analysis of timber markets departs from normative models' focus on supply potential to address expected supply responses. Positive models of timber supply implicitly link the biological model of timber production to a behavioral model of harvest choice and are developed by applying statistical methods to observed behavior. Their strength is the calibration to observed behavior, while the challenges of this modeling approach have been statistical methodologies and access to adequate data. Methodological concerns have largely been resolved; i.e., through the development of simultaneous equation and other estimation techniques and improvements in computational power that allows their application. Data availability and quality can still stand between theoretical development and application.

There are two core motivations for estimating positive timber market models. One is to test hypotheses regarding the structure and function of timber markets and the effects of forest policies. For example, such models provided the first empirical tests for simple price responsiveness of timber supply, i.e., that forest owners harvest more timber when prices rise. More sophisticated approaches have permitted more refined testing which addresses increasingly refined hypotheses regarding investment response, policy effects, market structure, and market extent.

The second, and perhaps the more compelling, motivation for this area of research has been to develop forecasts of market activity. Public and private planners need forecasts of both harvest quantities and timber prices. Initial developments of positive market models in the 1970s took place at a time when there was much concern about underinvestment by NIPF landowners, especially in the South. Price information, including forecasts of future prices, was seen as a necessary condition for the encouragement of optimal investment in forest management. In addition, national forest planning regulations developed in the late 1970s required timber price forecasts, and the Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974 explicitly required the Forest Service to assess future timber supply and demand.

Several studies focused on southern timber markets or contained a southern market component. McKillop (1967) provided the initial positive analysis of aggregate timber markets. Robinson (1974) examined regional stumpage and lumber markets for the South and the Pacific Northwest for the period 1947 to 1967. His study raised a set of questions regarding the magnitude of the supply response (quantified by the price elasticity of timber supply) that were addressed by subsequent research. As part of their national timber market analysis for RPA, Adams and Haynes (1980) specified southern sawtimber supply functions for two subregions of the South. Daniels and Hyde (1986) applied a regional supply and demand model to the total (hardwood and softwood) wood products sector in North Carolina.

Newman (1987) was the first to model markets for different products in the South concurrently. He used a profit-maximization approach to derive timber demand and supply equations to model the southern pulpwood and solid wood markets in the South. This allowed for the delineation of substitution possibilities by stumpage producers in the region. Newman found solid wood timber to be a weak complement to pulpwood supply as owners jointly produce both goods and, more significantly, this study clarified the important part that the joint production of different timber products may play in determining the structure of timber supply. Prestemon and Wear (2000) further characterized the implications of joint production on timber supply.

These positive timber market models provide the central behavioral construct for developing timber market forecasting models. Timber forecasting models are generally hybrids of both empirical and simulation approaches, constructed by linking empirical estimates of supply response and timber demand to mechanistic models of timber growth, as well as models of land use change and timber investment behavior.

Timber market forecasting models have played critical roles in anticipating change and discussing policy approaches to or implications of forest production. The model developed by Adams and Haynes (1980) is still the centerpiece of national timber market assessments conducted for the RPA (e.g., Adams and Haynes 1996) and has been used to simulate the impacts of various forest sector policies including cost-share programs and international trade scenarios. Regional analysis, which demands a higher degree of spatial specificity than is generally provided by international or national models, is likewise anchored by timber market forecasts. In the South, models developed by Abt and others (2000) have been used for this work (e.g., Prestemon and Abt 2002).

An important area of research that developed through the 1990s involved testing the extent of markets and the linkages between spatially separated markets; in effect, this tests the law of one price. Understanding how shocks and the effects of policies are transmitted across space is essential for characterizing how timber markets respond at the relatively fine spatial scales of regional models. Research on spatial price linkages can also be used to evaluate market efficiency. For example, efficient price transmission between markets allows production in one region to respond immediately to shocks in another region, implying that the effects of policies and market shocks, e.g., hurricane damage, large mill closures, etc., are rapidly shared across regions. Incomplete price transmission, on the other hand, would imply that the consequences of local policy shifts and shocks would be borne locally. Tests of "market integration" have been conducted for various levels of production and at various spatial grains. Analysis of markets for materials at higher stages of production (e.g., finished materials such as lumber) generally supports market integration, even between broad regions (Jung and Doroodian 1994, Murray and Wear 1998, Uri and Boyd 1990). Studies of stumpage markets have not generally supported market integration hypotheses (Bingham and others 2003, Nagubadi and others 2001, Prestemon and Holmes 2000) defining a set of questions regarding not only the structure of stumpage markets, but also the linkages between markets at various stages in the production chain.

ONGOING INITIATIVES

Timber market research continues to address questions regarding the current and future use and conditions of southern forests. However, these questions have shifted away from core behavioral questions and aggregate outcomes and toward understanding the spatial structure and ecological implications of timber market activities. The integration and cointegration line of research continues to investigate the communication of prices between subregions of the South, exploring the spatial extent of markets for various products. In addition, research is beginning to model the supply response of private landowners in spatially explicit fashion.

Increased spatial definition is required to address questions regarding the effects of forest uses on ecological and environmental conditions. Increasingly, concerns are being raised regarding the effects of timber market activity on the structure of forested ecosystems and on the ability of these systems to sustain ecological integrity and a variety of benefits beyond timber products (Wear and Greis 2002). A key concern with respect to the ecological structure of southern forests is the extent, location, and management intensity of pine plantations. These are determined as the outcomes of investment decisions by private landowners. Clearly, the answers to these types of questions require insights into where, within the South, production and investment will respond to expanding demands for southern timber.

Spatially refined forecasting requires aggregate models with the spatial and production detail used to construct normative supply models and individual choice models in the past. Research into supply responses at finer scales has begun to explicitly bridge from the findings of individual choice models to the implications at regional levels. The key to this research is linking harvest behavior to supply responses through a forest inventory. Prestemon and Wear (2000) accomplish this by modeling harvest choices for individual inventory plots, based on a general optimal harvest choice framework, and then estimating supply impacts by applying a harvest probability to the area expansion factor of each plot; this link between a behavioral model and the area frame structure of an inventory was first developed by Hardie and Parks (1991). Pattanayak and others (2002) also use the forest inventory and analysis inventory to model supply responses from partitions of the inventory defined by ownership, location, and quality. Both approaches provide promise for building spatial, ownership, and productivity detail into market forecasting models.

Another aspect of understanding the spatial structure of timber markets is a more comprehensive understanding of individual choices regarding uses of forest land. This requires addressing the linkages among all interrelated decisions regarding land and resources, including land use, investment, and harvest choices. A better understanding of the influence of landowner characteristics on management choices is also needed. This would be required, for example, to forecast how changing demographics could influence the area of forest as well as the supply of timber from forests. For example, the Southern Forest Resource Assessment describes a future in which the area of pine plantations will rapidly expand southwide (Prestemon and Abt 2002). But as the South becomes more populated, the so-called accessibility question regarding timber inventories, i.e., defining how much inventory would be accessible to timber harvesting in the future, becomes more important. Newman and Wear (1993) modeled timber supply and investment in a common analytical framework. However, while several investigators have studied land use, investment, and harvesting separately, none have yet linked all three into a common analysis to address the accessibility question.

CONCLUSIONS

Forest economics research often addresses issues at the core of forest policy debates, and it has had a strong influence on policy rhetoric, perspectives, and, at least indirectly, policy outcomes. Research on the function and structure of timber markets, especially in the South, has clearly illustrated that the private sector can generate an orderly market for a commodity (timber) with a long production period. Investment responses to scarcity signals in the South demonstrate that timber capital is viewed as a reasonably liquid asset and that market failure with respect to intertemporal allocation does not hold. In an interesting reversal of rhetoric, it appears clear now that timber production from public forests—more strongly influenced by policy shifts and administrative process—is much less reliable or stable than private timber supply.

The public and policy concerns regarding whether or not private timber markets will work to provide a sustainable level of timber harvests have been answered. The emphasis has now shifted to understanding how these markets work in attempts to predict how market activity will reshape the extent and structure of forests within the South. This is the crux of understanding how human occupation and utilization of land and resources will influence ecosystem structure and function in the future. Understanding how the private sector will organize timber production is one of the keys to understanding overall forest sustainability that addresses the provision of all desired goods and services derived from forests.

Researchers should not, however, mistake the presence of an orderly private timber market as an indication of a fully efficient market. Indeed, research into industrial organization shows that markets that are not completely competitive can exhibit aggregate behavior that is qualitatively similar to the perfectly competitive case. However, inefficiencies can impose substantive welfare costs on consumers. In the case of timber markets, findings of inefficiency derived from integration studies raise some concerns in this regard. Research into individual landowner choices has not yet fully addressed whether observed investment is suboptimal due to capital constraints, tax structure, risk perspectives, or combinations of these factors. Research into the presence and effects of market power is generally underdeveloped—Murray's (1995) analysis of southern timber market structure is an exception.

Policy concerns regarding southern timber markets have evolved partially in response to an improved understanding derived from timber market research. Current concerns are urgent, and improved understanding of how timber markets operate is required for a full understanding of the ultimate sustainability of forests, their functions, and their derivative benefits in the future.

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