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Some Considerations in Modelling Private Woodlot Timber Supply

by

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Abstract

Private woodlot owners have diverse backgrounds, ownerships, and forest management objectives. Among these management objectives timber production may be of secondary importance. The diversity of forest landowners and ownerships results in considerable uncertainty in availability of timber from these lands. In this paper we use a literature review to identify the variables and techniques that are important to determining timber supply from private woodlots. We also discuss how models designed for timber supply analyses under a single owner objective are invalid for modelling private woodlot timber supply, and suggest ways to modify existing timber supply models to incorporate ownership variability.

Résumé

Les propriétaires de boisés privés sont issus de divers milieux, et n'ont pas les mêmes types de propriétés et les mêmes objectifs d'aménagement forestier. Parmi ces objectifs d'aménagement, la production de matière ligneuse semble être d'importance secondaire. La diversité entre les propriétaires de boisé et entre les types de propriétés, a pour conséquence d'exercer une incertitude considérable sur la disponibilité de la matière ligneuse issue de ces forêts. Nous avons utilisé dans cet exposé une revue de littérature pour identifier les variables et les techniques qui sont importantes pour déterminer l'approvisionnement en matière ligneuse tiré des boisés privés. Nous discutons aussi comment les modèles conçus pour effectuer des analyses d'approvisionnement en matière ligneuse selon l'objectif d'un seul propriétaire sont incapables de simuler l'approvisionnement en matière ligneuse issu des boisés privés, et nous suggérons des façons de modifier les modèles existants d'approvisionnement en matière ligneuse afin d'y incorporer la variabilité des types de propriétés.

Introduction

Private woodlots are owned by individuals or organizations who do not own wood processing facilities and must sell their timber to wood processors (Clawson 1979). These ownerships vary in size from less than one to tens of thousands of hectares. In addition, private woodlot owners have diverse backgrounds and forest management objectives. Among these management objectives timber production may be of secondary importance. The diversity of forest landowners and ownerships results in considerable uncertainty in timber availability from these lands.

Private woodlots exist in all provinces, but play a particularly important role in supplying industrial roundwood in the Maritimes. There are approximately 80 000 private woodlot owners in the region. Collectively, this group owns over 40% of the productive forest land and supplies about the same proportion of the total volume of commercial timber. Provincial and federal governments and forest industries are looking at private woodlots as a critical source of timber for

both now and the future. Therefore, accurate predictions of timber supply from private woodlots are needed because of its importance to industrial operations and economic stability.

In this paper we use a literature review to identify the variables and techniques that are important to determining timber supply from private woodlots. We also discuss how models designed for timber supply analyses under a single owner objective are invalid for modelling private woodlot timber supply, and suggest ways to modify existing timber supply models to incorporate ownership variability.

1. Modelling the Behavior of Private Woodlot Owners

Timber supply from private woodlots results from two decisions: the decision to harvest which affects the immediate timber availability, and the timber management or investment decision which affects biological allowable cut and future physical and economic availability. In this review we identify a number of factors important to general timber supply analysis, describe private woodlot owners and their characteristics related to timber management and harvest decisions, and cover studies that attempt to model timber production from private woodlots.

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Bruce (1980) cited a number of specific and major determinants of timber supply. He stated that timber supply is a function of:

- current and expected stumpage prices;
- current and expected non-wood benefits;
- current and expected silvicultural, harvesting, and transportation costs;
- the opportunity cost of capital;
- inter-regional trade of wood products;
- forest characteristics, such as type, productivity, age-class distribution, and current growing stock volume;
- silvicultural technology and intensity;
- risk due to fire, disease, insects, and world, national, and local market changes;
- forest ownership patterns; and,
- institutional, legal, and other governmental constraints.

Timber supply modelling techniques have been relatively successful at capturing the importance of most of these factors (see Alig *et al.* 1984 for an in-depth review of timber supply models). However, criticisms of recent timber supply analyses have been made with respect to modelling the dynamics of private woodlot owners. The next sections examine studies that specifically consider the timber harvest and management decisions on private woodlots.

Owner and Ownership Characteristics

McMahon (1964) reviewed a number of studies that described private woodlot owner and ownership characteristics and related these characteristics to management behavior (see: Mignery 1956, Anderson 1960, Zivnaska 1959). Basically, these studies posed the question: What role does forest landownership play in improving management practices? These studies also hypothesized that certain characteristics of owners and properties influence management practices. General conclusions from these pre-1964 studies indicated that participation in forestry practices was related to:

- landowner age, occupation, income, asset position, and place of residence relative to the land holding;
- landowner interest in, and knowledge of, forestry practices and markets; and
- size, stocking and tenure of forest holdings.

A review of more recent studies of private woodlot owners supported these earlier conclusions¹. Recent studies, however, rely on statistical analyses of owner and ownership characteristics, rather than the simple descriptive techniques used in earlier studies. The statistical techniques used in these studies include analysis of variance, and contingency, discriminant, multivariate, probit, and logit analyses. These studies posed essentially the same hypothesis as the pre-1964 studies (i.e., forest management and harvest decisions of private woodlot owners depend on certain owner and ownership characteristics), and used statistical analyses to validate the influence of particular characteristics. Some of these studies could also be used to predict the likelihood that a landowner would engage in forest management or harvest timber.

¹See Binkley (1981), Boyd (1984), Greene and Blatner (1986), Jamnick and Beckett (1988), Larsen and Ganser (1973), Max and Lehman (1988), Romm, *et al.* (1987), Royer (1987), Schuster (1983), Schuster and Niccolucci (1983), and Thompson and Jones (1981).

McMahon (1964) also noted that in many of the early private woodlot studies "...problem formulations [had] been generally incomplete". Subsequently, he developed a comprehensive theory of private woodlot management behavior, and concluded that the returns from investing in timber management were generally smaller than the alternative investments available to private woodlot owners. Because of this discrepancy, he concluded that private woodlot owners behaved in an economically rational manner by not investing in timber production.

Other studies have also attempted to explain the behavior of private woodlot owners on the basis of economic theory, but have been only partly successful (Adams *et al.* 1982, Straka 1985, Straka *et al.* 1984). These studies proved inadequate because private woodlot owners mostly do not make timber management decisions with strict economic rationale. As numerous surveys and statistical analyses indicate, the characteristics of private woodlot owners that are strongly correlated with timber management are sociological and non-economic. That is, private woodlot owners are more likely to maximize utility (both economic and non-economic satisfaction), rather than profit when making forest management decisions.

Three recent studies have adopted the notion of utility maximization as a basis for modelling private woodlot owner production and supply behavior (Binkley 1981, Boyd 1984, Hyberg 1985). Hyberg's paper compares the normative behavior expected of private woodlot owners if they act as profit or utility maximizers. He concluded that utility maximizers will "...invest larger amounts of capital and grow their timber using longer rotations than..." profit maximizers.

Binkley (1981) also hypothesized that a landowner makes timber harvest decisions by maximizing his or her utility. His model maximized utility subject to constraints on the total outlays and the technical ability of the land holding to produce combinations of timber and nontimber outputs. Using logit regression, Binkley estimated the probability of harvesting as a function of timber prices, the area of forest land owned, and the age, income, and educational level of the landowner. For a New Hampshire data base, he concluded: (1) timber supply from private woodlot owners results from economic rationality, (2) stumpage price is a major determinant of the likelihood of harvesting, (3) owners with small holdings are less likely to harvest, (4) farmers make different timber harvest decisions than non-farmers, (5) more wealthy landowners are less likely to harvest.

Boyd (1984) tested his utility maximization model using probit regression analysis. Explanatory variables included sawtimber prices, area of forest land owned, landowner income, education, and residence, and dummy variables indicating whether or not a landowner had received assistance and cost sharing, or was a farmer. Results for a North Carolina data base indicated that engaging in timber stand improvements was positively related to educational level, receiving technical and financial assistance, and area of forest land owned. Harvesting behavior was found to be positively related to receiving technical assistance, the amount of forest land area owned, whether the landowner was a farmer, and sawtimber price.

Summary

A review of the literature reveals some interesting features of modelling private woodlot owner behavior. First, private woodlot owners have been found to act economically rational, and to respond to prices, costs, and alternative rates of return when making their harvesting or management decisions. Second, utility maximizing models may be more appropriate than profit maximizing models because private woodlot owners have diverse objectives and constraints and generally hold forest land for a variety of reasons. Finally, some owner and ownership characteristics that influence harvest and management decisions are independent of geographic location.

II. Discussion

While a number of simulation and optimization modeling approaches have been used to perform timber supply analyses, none have been particularly successful in capturing the forest management behavior of private woodlot owners (Alig *et al.* 1984). These general timber supply models have similar problems in the way they handle wood supply analyses for private woodlots. Problems stem from a lack of consideration in three areas: (1) the diversity of private woodlot owner management objectives and forest holdings, (2) the supply response of private woodlot owners to changes in stumpage prices, and (3) changes in land use patterns.

These problem areas can be further divided into short-term and long-term supply concepts. It is generally believed that factors affecting short-term supply are stumpage price, owner and ownership characteristics, and condition of the resource. The factors that affect the long-term supply are investment behavior, land use trends, and changes in owner and ownership characteristics. As expected, some of these factors are interrelated. For example, investment behavior is generally assumed to be a function of stumpage price and owner and ownership characteristics. Furthermore, since the timber resource is both the product and the factory, the two supply concepts are linked; today's investment in timber management affects the timber resources available for harvesting tomorrow.

Short-term Supply: Timber Availability

Most existing models implicitly assume that private ownerships can be treated as a homogeneous group under a single management objective. Although management objectives may be roughly common for groups of landowners with similar characteristics, the variability of these objectives invalidates the use of a single estimate of harvest and management projections on private woodlots. Models should be used or developed to provide a range of expected annual or periodic harvest levels under a variety of management scenarios. Since it is not possible to "direct" the harvest on private woodlots, the expected supply response under a given management scenario is the best "projection" that can be obtained.

Classifying landowners by their owner and ownership characteristics and determining how each class responds to stumpage price is an important step in building a comprehensive supply model for private woodlot owners. As the literature review indicated, a number of characteristics are important in determining the propensity of owners to harvest or manage their forest land. The techniques for determining the importance of these characteristics are well developed and their potential for use in timber supply models has been

demonstrated in a number of recent papers (e.g., Binkley 1981, Boyd 1984, Jamnick and Beckett 1988, Romm *et al.*, 1987). It is important to capture these responses because of the inter-temporal relationship between timber harvest today and timber supply in the future.

These types of analyses could be used to develop a multi-dimensional matrix of owners. Each cell in the matrix would represent a group of owners with similar owner and ownership characteristics who would be expected to respond similarly to stumpage prices. An availability factor could be directly calculated for each cell in the matrix and this information could then be incorporated in current supply models².

It would be useful to link individual landowners to their ownerships so that the resource characteristics could be directly associated with each cell. If possible, stand classifications should also incorporate descriptions of operability, accessibility, and average distance to processing facilities. These factors would allow a model to account for the existing resource conditions and their effect on the economic and merchantable timber supply.

Stand and site characteristics could be integrated into equations for estimating harvesting and transportation costs. In turn, these costs would be used to determine what stand types are economically feasible to harvest at given mill-delivered prices. For future development, other factors such as species mix and quality, marketing restrictions, and product demands must also be considered in economic supply forecasts. With this type of information and GIS technology, harvesting, transportation, and processing costs could be estimated for each owner/ownership cell, thereby providing a comprehensive "supply-demand" wood supply model.

Long-term Supply: Forest Investment and Land Use

Investment in forest management is probably the most crucial factor affecting the long-term wood supply. Unfortunately, theory and conceptual models of forest investment are not well developed, and most empirical analyses have been conducted at the stand level (Alig *et al.* 1984). In addition, most techniques for timber investment analysis assume that the landowner's objective is to maximize economic gain from the timber resource alone. These assumptions and deficiencies make it particularly difficult when modelling the investment behavior of private woodlot owners because this behavior depends on a variety of socio-economic factors.

The classification scheme outlined above could also be applied to modelling investment behavior. With the approach outlined in the literature review (e.g., Boyd 1984), estimates of the likelihood of engaging in different levels of forest management intensity could be made for each cell in an owner/ownership matrix. An economically or biologically appropriate management regime could be selected, and subsequent timber yields determined, depending on the level of management intensity, the ownership conditions, and the existence of landowner assistance programs. The timber supply analyst should also have the capability to account for the possibility that not all timber investments will be carried out to maturity, thus foregoing some of the anticipated timber yields.

²See Jamnick and Clements (1988) for a complete discussion of how information from logit models can be used to estimate private woodlot timber supply.

Development of an investment model would, of course, depend on acquiring the owner and ownership data for the region being analyzed. Additionally, changes in these data over time should be monitored to understand the dynamics of private woodlot owner and land use changes. It might be possible to use the projections of owner and ownership characteristics in combination with the information collected from a land study to develop specific projections for each homogeneous group of owners.

Deletions from, or additions to, the existing forest land base are bound to occur over time. Since Crown forest lands are allocated to timber production, the majority of these changes in the forest land base will probably occur on the private forest lands in a region. Losses to urbanization, roads, and agriculture might be expected. Alternatively, abandoned agricultural land may revert back to forest. This type of information will be important in determining the long-term wood supply.

It is unnecessary to incorporate a model of land use change into existing wood supply models. Information from a separate land use study could be used as model inputs. To consider changing land use patterns, analysts should ask: Why and how much forest land is taken out of timber production? Is the removal permanent? What could be done to lessen the removal or make forest production more attractive? Supply analyses could be conducted with these questions in mind by using sensitivity analysis to evaluate the impact of alternative land use scenarios. Again, we observe that timber supply forecasts for private woodlots are better handled with a range of possibilities, rather than a single estimate or production target.

In the immediate future, land use changes could be simulated by assuming that areas in all stand types change by some percentage over time or else randomly selecting stand types for changes in land area. Supply forecasts could be made to simulate increases and decreases in the private woodlot land base. This type of analysis should also be tied into the landowner classification scheme outlined above.

III. Conclusions

Timber supply projection techniques used in Canada are based primarily on physical resource inventories, but largely ignore the influence of owner and ownership characteristics. Many of these models give superficial consideration to timber availability by using subjective estimates of the percentage of timber that will be available over a given time period. While these models work well for ownerships that have a single management objective (e.g., Crown and large freehold), they are not directly applicable to the multiple objective situation of private woodlots.

Improvements to the existing methods for estimating private woodlot timber supply could be made by classifying owners into distinct groups. The literature review identified a number of attributes that could be used to classify owners including landowner age, income, education, and responsiveness to changes in stumpage prices. The next step would be to quantify the supply response of each group of private woodlot owners. Past and future surveys could provide the needed information. Once this type of analysis is completed,

it should be a relatively simple matter to incorporate the information into existing wood supply models and to update the information on a regular basis. Though these modifications would not solve the problem of projecting private woodlot timber supply, we believe they would reduce the uncertainty associated with these supply estimates.

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