FUNDAMENTAL RELATIONSHIPS AFFECTING NONINDUSTRIAL

PRIVATE FOREST TIMBER OUTPUT

by

Thomas J. Straka and Harold W. Wisdom

ABSTRACT

Positive projection models of nonindustrial private forest (NIPF) long-run timber output have been slow to develop, mainly due to the diverse motivations and objectives of NIPF landowners. Such a positive model would project what NIPF timber output will be, as opposed to more common approaches that project what it should be or what it may be if past trends continue. Homogeneous timber output response cells are a means to adapt forest resource data into a form amenable to regression analysis and positive projections of NIPF timber output.

Size of forest holding is inversely related to a NIPF landowner's alternative rate of return (ARR). A NIPF landowner's ARR is inversely related to his investment in forest management intensity. Thus, size of forest holding is positively correlated with forest management intensity and long-run timber output. An ARR framework can be used to project changes in NIPF timber output due to shifts in the distribution of size of forest holdings among NIPF landowners and due to the effect of forest policy alternatives that influence NIPF landowners' silvicultural cost and revenue relationships.
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INTRODUCTION

The nonindustrial private forest (NIPF) and national timber supply
are inextricably related. Throughout this century the NIPF's contribution
to timber supply has been regarded as a national forestry problem. The
NIPF sector controls 58 percent of the nation's commercial forest area and
in 1976 supplied about 46 percent of the nation's roundwood harvest and 39
percent of the sawtimber harvest (USDA Forest Service 1980). These kinds
of statistics appear to support the traditional view of the NIPF problem,
that inadequate future timber supply will result in undesirably high wood
product prices and that poor forest management on NIPF lands is the major
cause of this projected timber supply shortfall. Recent research has not
supported this traditional view of the NIPF problem and researchers have
found that NIPF management practices compare favorably with those of the
public and industrial forest sectors (McComb 1975, Clawson 1979). This
discussion serves merely as background; the important point, an indisput-
able point, is that the NIPF supplies a very important portion of the
nation's timber supply.

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TIMBER SUPPLY PROJECTION MODELS

Timber supply and output models for the NIPF sector are relatively common. Three general approaches are used to project long-run timber supply: mensurational, normative, and positive.

The mensurational approach is used to describe a trend in the forest situation by observing changes in its physical condition over time. This approach is most evident in Forest Service "timber trend" type analyses.

The normative approach, like the mensurational approach, examines the physical condition of the forest resource, but goes one step further and examines its financial potential. Forest landowners are usually assumed to follow some sort of economically rational behavior and timber supply is projected on the basis of this behavior.

The positive approach recognizes all the foregoing estimates, but also examines the actual past management behavior of forest landowners. A positive study responds to the question of what timber supply will be in the long-run, in contrast to the normative study which addresses the question of what timber supply should be if all landowners behave rationally. Consequently, a positive approach timber supply study would require identifying key variables that affect NIPF timber output response and projecting these variable relationships into the future. We are most likely talking about regression techniques when attempting to use a positive approach.

A POSITIVE APPROACH TO NIPF TIMBER SUPPLY PROJECTION

Modeling techniques have been proposed for use with a positive approach. Marty (1969) described an approach of cross classifying
timberlands on the basis of physical productivity and economic characteristics to produce "homogeneous resource cells or timber production sources." Mills (1976) described a similar approach based on "homogeneous supply response area cells" for positive projection of timber supply. Vaux's 1973 California timber supply study and GASPLY, the Georgia timber supply model (Montgomery 1975, Robinson 1978), are both based on physical and economic stratification.

How might such an approach be applied to the formulation of positive NIPF timber output projections? First, a positive approach would be based upon past observed relationships. Projections of what will occur must be based on data representing what has actually occurred in the past. Second, a homogeneous timber output response cell approach would require the total NIPF resource to be stratified by its physical and economic characteristics. That is, all of the NIPF acreage in a study region would be divided into classes of uniform biological potential and uniform economic characteristics.

Figure 1 is an example of a homogeneous timber output response matrix. This particular matrix is three-dimensional. The concept allows for unlimited dimensions, but very large matrices would be quantitatively unmanageable. Thus, the modeler would use biological and economic relationships that allowed for a matrix of manageable size. The stratification dimensions in this case are site quality, forest type, and size of forest holding. Even in this simple example, each cell of the matrix would probably possess acreage of somewhat uniform timber output response. For example, a small pine holding of medium site quality would be expected to exhibit a different timber output response than a medium sized pine-oak holding of low site quality.
Figure 1. Example of a three dimensional Homogeneous Timber Output Response Matrix.
What kinds of stratification dimensions might be used? Basically, stratification dimensions relate to the forest site or to the forest resource itself (Mills 1976). The forest site might be stratified by site index, physiographic class, size of forest holding, or soil type. The forest resource could be stratified by forest type, timber quality and volume, stand age, operability, or stocking. Also, type of ownership would probably be important. Even within the NIPF sector, farm owners may possess a different timber output response than miscellaneous private landowners. If the study region is large, geographic regions might also be used for stratification.

Once we've developed a homogeneous timber output response matrix, how do we go about making positive timber projections? If the timber output response for each cell is known, this value will represent a dependent variable observation that can be used in regression analysis. The values of the stratification dimensions for each cell of the response matrix represent independent variable observations. This allows for development of a NIPF timber output projection model based upon a regression analysis of past NIPF landowner behavior.

**Basic Economics Relationships Affecting NIPF Timber Output**

Several economic relationships affect NIPF sector timber output projections. The physical attributes of the NIPF forest resource that affect timber output response are well known. Characteristics like forest type and site index are obvious physical timber output determinants. However, the economic relationships are not so well defined.
Literally, hundreds of NIPF landowner studies have been completed since the early 1940's. One NIPF owner characteristic, size of forest holding, has been discussed in almost all of these studies. Size of forest holding has been consistently shown to be a major determinant of forest management intensity practiced on a particular forest tract. Large forest holdings tend to be in the hands of forest landowners interested in timber value. Timber value and volume, when on a per acre basis, are known to be positively correlated with both forest management intensity and size of forest holding (McMahon 1964).

Why should forest management intensity be related to size of forest holdings? Several explanations are possible. One explanation holds that diseconomies of tract size limit forest management intensity on small tracts. Row (1978) showed that the size of forest holding influenced both silvicultural costs and financial returns available from forest management. A second explanation lies in the concept of diminishing marginal utility. Nontimber benefits from a very small NIPF holding might be large. However, as tract size increases, nontimber benefits may be derived from just a small portion of the holding, leaving a large portion under intense management for timber benefits. A third explanation deals with the NIPF landowner's alternative rate of return (ARR).

The Alternative Rate of Return

The alternative rate of return (ARR) is that rate of return available to the forest landowner from his best alternative investment (allowing for risk). A landowner will invest in forestry only when his expected rate of return from the forestry investment exceeds or equals the ARR of any nonforestry investment.
A landowner's ARR is inversely related to timber output. As the ARR decreases, the landowner is more apt to invest in forest management and more apt to increase rotation length, resulting in increased timber output.

The effect of the ARR upon optimal rotation age (and, thus, long-run timber supply) can be seen in Figure 2. A landowner's ARR is fixed at any point in time; in this figure the ARR is shown at a fixed rate of 3 percent. The forest value growth percent represents the value of each year's incremental growth. Since the growth rate eventually slows down as rotation length increases, the forest value growth percent is shown as a decreasing function of rotation age. The forest value growth percent is primarily based upon wood product prices and biological growth potential, so for a specific stratum (like a homogeneous timber output response cell) it can be considered fixed. As the ARR decreases, one can see that optimum rotation age will increase, and with it long-run timber output.

Size of Forest Holding and the Alternative Rate of Return

How does the ARR relate to size of forest holding? Larger forest holdings tend to be controlled by landowners with better income levels and asset positions than owners of smaller holdings. Landowners who hold large forest holdings just simply tend to have more investment capital than holders of small forest tracts and, as standard capital budgeting theory suggests, will tend to have lower ARR's than holders of small tracts. The lower a landowner's ARR, the more likely he is to invest in intensive site preparation and regeneration. Also, the more likely he is to lengthen his rotation. Both effects have a positive impact on long-run timber output.
Figure 2. Determination of optimal rotation age, based upon forest value growth percent and the landowner's alternative rate of return.
To summarize, a landowner's ARR is inversely correlated with his income level and asset position. Landowners with high income levels and good asset positions have more investment capital and, hence, lower ARR's. At the same time, landowners who control large forest holdings tend to have good income and asset positions and, thus, lower ARR's. Therefore, the landowner's ARR is expected to be inversely related to size of forest holding. Since forest management intensity and timber output are inversely related to the forest landowner's ARR, they then are positively related to size of forest holding.

Figure 3 consolidates these relationships. The functional flow is from the size of forest holding to the alternative rate of return, to the forest value growth percent, to long-run timber output. In the upper graph, NIPF landowners with a 200 acre size of forest holding behave as if their ARR is 2.25 percent. The result, in the lower graph, is an expected timber output of 60 cubic feet per acre per year. The relationship between graphs assumes a NIPF landowner will invest in timber production to the point where the forest value growth percent equals his ARR. The relationship between the ARR and size of forest holding provides a mechanism to project long-run NIPF timber output.

**Policy Analysis**

Each homogeneous timber output response cell represents forest acreage that is physically and economically uniform, resulting in an identical forest value growth percent for each acre within a cell. This means that the relationship between the forest value growth percent and rotation length (and the corresponding long-run timber output level) is
Figure 3. Relationship between the alternative rate of return, size of forest holding, and timber output.
fixed within each cell. Since the acreage within each cell is also economically uniform, the ARR is also fixed within each cell. The inverse relationship between ARR and timber output is shown in Figure 4. The inside graph shows that at an ARR of 3 percent 30 cubic feet per acre per year is the expected timber output.

How might a policy maker attempt to increase this output to 60 cubic feet per acre per year? We see from the figure that reducing the average ARR to 1.25 percent will accomplish this result. However, the policy maker has negligible (if any) control over a landowner's ARR, so the approach is not viable.

The policy maker does have some control over the factors that influence the forest value growth percent (e.g., silvicultural costs and revenues can be affected by public subsidy, tax treatment, or improved technology for harvesting timber from small holdings). Such changes will shift the relationship between ARR and timber output. In this example, a reduction in costs or an increase in revenue caused the function to shift outward and resulted in the desired 60 cubic feet per acre per year.

The policy analyst will possess a known timber output response for the acreage assigned to each cell, allowing for a two-part analysis. First, changes in the alternative rate of return over time can be related to expected changes in timber output. The policy analyst would monitor projected changes in the ARR (via the observable size of forest holding statistic) to project "naturally" occurring shifts along the ARR/timber output function.

Second, the analyst would project shifts in the ARR/timber output function (changes in the forest value growth percent). This type of
Figure 4. Hypothetical relationship between alternative rate of return and timber output.
shift could be managed by any change in the cost/revenue relationships. The analyst then could project both shifts along and shifts of the ARR/timber output function to obtain long-run timber output projections.

**SUMMARY**

A functional NIPF long-run timber output projection system for use with a homogeneous timber output response cell approach has been outlined. It centers upon the inverse relationship between size of forest holding and the landowner's ARR and the resulting positive relationship between size of forest holding and long-run timber output. As part of this research, regression analysis was performed to determine whether or not these relationships do exist. The time allocated to this presentation did not allow for both a detailed discussion of basic NIPF timber production relationships and presentation of the regression results. I will merely state that the relationships discussed today were shown to be statistically significant, and that the results of the regression analysis have been submitted to the *Journal of Forestry*. Our main objective was to present fundamental NIPF timber output relationships, with the hope that these concepts will provide some useful insights into basic NIPF landowner behavior.
LITERATURE CITED


