Determinants of Non-Timber Values in Wisconsin Northern Hardwoods

by

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Abstract

A working definition of non-timber value is the difference between the **revenues attainable by implementing an** infinite horizon timber revenue maximizing cutting rule, and the value of the observed harvest. This non-timber value was estimated for the stands of the Forest Inventory Analysis data in the maple-beech-birch type in Wisconsin. Non-timber values averaged 23 $/ha/yr, and were higher than timber revenues, even on industry lands. Hedonic regression was then used to estimate the marginal effects on non-timber value of stand attributes and socio-economic variables. The results gave a vector of non-timber values for trees of different size and species. The marginal contributions of trees to non-timber values were significantly higher in National Forests.

INTRODUCTION

Revealed and stated preference methods of evaluating non-market goods have been researched extensively in the past twenty years (Freeman 1993). In particular, the role of non-timber values has long been recognized in the theory of optimal harvesting decisions (Hartman 1976, Bowes and Krutilla 1985). Compelling empirical evidence exists supporting the relevance of these values to woodland owners. Birch (1994) found that amongst the reasons for woodland ownership, "recreation" and "aesthetic enjoyment", ranked consistently higher than timber production.

Much of the published work has been aimed at deriving non-timber values for benefit-cost analysis. Revealed preference methods, especially based on travel costs, have been used in a number of studies (Michaelson, 1975; Brookshire and Coursey, 1987). Dennis (1989) related harvesting behavior to forest characteristics in a theoretical model that can also accommodate non-timber values. Recently, Lee (1997) derived non-timber values for owners of even-aged forests in the southern United States, with hedonic discrete choice models.

Non-timber values have also been derived by contingent valuation. Walsh et al. 1990, and Loomis *et al.* 1994 estimated the public willingness to pay to protect forests from insects and fires. These studies corroborate the hypothesis that non-timber benefits are substantial, and may exceed timber revenues (Lockwood *et al.* 1992).

The objective of this paper is to report on the magnitude of non-timber value, and its determinants, for maple-birch forests in Wisconsin.

THEORY

Forest owners are assumed to prefer some combinations of forest stand states and timber revenues to others. For uneven-aged stands, the state can be represented concisely by the number of trees of different size and species per unit of land, i.e. the tree distribution.

For the purpose of deriving an infinite horizon optimal timber-harvesting rule in the context of uneven-aged management, Lin and Buongiomo (1998) define N possible stand states. For every state i there is an optimal decision k^*, solution of N recursive equations (Ross, 1983):

$$V_i^{t+1} = \max_k \left[r(i,k) + d \sum_{j=1}^{N} p(j \mid k) V_j^t \right] \qquad (1)$$

$i = 1,..., N; t = 1,..., \infty$

where V^t is the present value of the timber income over t years, $r(i,k)$ is the immediate timber return from cutting a stand from initial state i to stand state k, $p(j|k)$ is the probability of the stand moving from state k to state j, and d is the discount factor. Each state i corresponds to a tree distribution. A decision means cutting the stand from state i to state k. The best decision is unique and depends only on the state.

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Lin and Buongiomo (1998) give the decision matrix and the corresponding optimum rewards $r(i,k^*)$.

However, the forest owner with **utility** for non-timber values would not solve this infinite horizon recursive equation, but a similar one with a reward function that includes timber benefits $r(i,k)$ and non-timber benefits, $r'(i,k)$. Needed is an operational description of the non-timber benefits function $r'(i, k)$.

Here, the non-timber value was defined as the timber revenue foregone by the owner, which must be a lower bound on the non-timber benefits expressed in monetary terms. This NTV is also a lower bound for the compensating variation (CV), the amount that would have to be paid to timber owners to compensate them for having to accept a particular state (due for example to forest legislation) when another, profit **maximizing** state was available.

In terms of the specific decision model (1) the timber-revenue maximizing return obtained by cutting from state i to state k^* is $r(i,k^*)$. *The NTV* of the stand in pre harvest-state i, and post-harvest state k^0 is then:

$$r'(i,k^0)= r(i,k^*) - r(i,k^0), \qquad (2)$$

which is the opportunity cost of choosing state A", rather than stand state k^*. It is natural to assume that the non-timber (amenity) value of the stand depends only on the remaining trees, i.e. on the post-harvest state, k^0, so that $r'(i,k^0) = r'(k^0)$, independently of the pre-harvest state, i.

Given an operational measure of the aggregate non-timber value of a stand state, the next step is to determine the marginal NTV value of each stand characteristic. Thus, for each variable that determines the stand **state,** we seek a price defining the contribution of that variable to the non-timber value. In particular, for each tree species and size, we seek a non-timber vector p' analog to the timber price vector p.

Non-timber benefits of forests are heterogeneous goods tied to a bundle of forest **characteristics** X, defmed in part by the residual stand state, k. The hypothesis that non-timber benefits depend on a heterogeneous set of attributes allows hedonic pricing **of** these attributes (Rosen 1974). The hedonic function is a regression of NTV on X, which decomposes NTV into the contribution of each variable in the vector X. The general hedonic model has the form:

$$\text{NTv}= NTV(\mathbf{X},\mathbf{Z}) \qquad (3)$$

where Z is a vector of socio-economic indicators that in addition to the stand characteristics may influence the NTV. The coefficient of each forest attribute of the vector X, in the regression (3) is its hedonic price, while the coefficients of the socio-economic attributes are **shifters** of the hedonic function.

NON-TIMBER VALUE OF FIA PLOTS

The data were drawn **from** 610 one-acre plots representative of the entire maple-birch forest **type** in Wisconsin, obtained **from** the USDA Forest Service, Forest Inventory and Analysis **(FIA)** data base (Hansen et *al.* 1994). The plots were measured twice **between 1966 and 1984.**

The estimate for each plot of what the owners should have done, had they sought to maximize timber revenues was inferred from the timber-optimal decision rule for maple-birch forests described in Lin and Buongiomo (1998). Applied to each FIA plot, this rule gave the timber revenue in \$/ha/year that would be obtained by an owner acting to maximize timber revenue only, and who placed no value on non-timber benefits as we defined them.

The FIA plot data also contain information on the trees that were actually cut. From these, we computed the actual value of the harvest, in **\$/ha/year,** with the same prices used to fmd the decision that would have maximized the net present value of timber.

Then, the difference between the value of the profit-maximizing harvest and that of the actual harvest gave the non-timber value in **\$/ha/year:** our estimate of the monetary value of the flow of services generated by the stand of trees left after harvest.

Table 1 summarizes the results. The **non-**timber value was highest for national forests: about **\$50/ha/yr**, ten times the timber **revenues.** The average **non-timber** value was **similar** in all non-national forests, at about \$20 to \$24 per hectare per year. For non-national public forests, non-timber revenues were four times larger than timber revenues. They were **almost** twice as large as timber revenues for private non-industrial forests. Even for industrial forests, non-timber values were slightly higher than timber revenues.

Nearly half of the total sampled area belonged to non-industrial private forest owners. They contributed more than half of the total harvest, and 35% of the non-timber value. National forests that had 20% of the forest area contributed 40% of the non-timber value, and less than 10% of the harvest. For industrial forest, the situation was reversed, contributing 30% of the timber harvest, and

15% of the non-timber value on less than 20% of the land area. Non-national public lands contributed equally to timber and non-timber values, less than 10% each, on 15% of the land.

HEDONIC MODEL OF NON-TIMBER VALUE

The hypothesis is that three categories of variables influence the non-timber value of each forest stand represented by an FIA plot: the ecological attributes of the stand, its physical location, and its socio-economic context. To simplify, the stand state was described by the number of trees in three species groups: Tolerant, mid-tolerant, and intolerant, and in three size classes: pole, small saw timber, and large saw timber (defined as in Lin et al. 1996). The ecological diversity of forest stands was measured with Shannon's index **(Pielou, 1975),** for diversity of tree species, size, and color based on four chromatic classes suggested by . Little (1995). The site characteristics tested were site index, the slope, the distance to water and the distance to roads.

Among the **socio-economic** variables, ownership type is probably one of the most important, as suggested by Table 1. The FIA database recognizes several ownership categories, which were grouped into four: National forests, other public forests (i.e. state, county and municipal forests), industrial forests, and other private forests.

To describe the socio-economic environment of a particular stand we used population density of the **county** in which each FIA plot was located, and the average household income of that county.

The conditional mean of NTV was estimated with a linear regression model:

$$NTV|X, Z = \beta'(X,Z) + \varepsilon \qquad (11)$$

Where ε is an uncorrelated, and i.i.d. error term with zero expected value. Model estimation began with a specification that included all of the theoretically relevant. This long regression was then "tested down" to a parsimonious model with only statistically significant variables (Kennedy, 1993). The residuals were heteroskedastic, at conventional levels of significance, thus the standard errors were estimated with White's estimators (1980).

The results showed that among the stand variables, the number of trees of various sizes and species had the highest statistical significance, and most had the expected positive sign. Diversity of species or size did not seem to influence NTV. Of the site variables, all had large standard errors. Among the socio-economic variables, only the dummy variable indicating ownership to a national forest seemed to matter. There was no significant difference among the other ownership.

The higher NTV on national forests revealed by the large and highly significant coefficient of the national dummy variable suggested that the hedonic price of different trees might also be different. This was tested by estimating two models, separately for the plots in national forests, and for others (Table 2). A Chow test confnmed that the coefficients were significantly different, after allowing for a different constant.

The hedonic price models of Table 2 were applied to compute the contribution of different tree categories to harvest and non-timber value in Wisconsin maple-birch forests, during the time between the two inventories. The non-timber value generated by the average hectare of national forests, at the time of the first inventory, circa 1966, net of the harvest taken between the two inventories was **\$50/ha/yr,** of which 70% came **from** the stock of trees, mostly shade tolerant and mid-tolerant, the rest **from** unidentified sources independent of the number of trees and reflected by the constant in Table 4. On non-national forests, 90% of the NTV of **\$22/ha/yr** could be attributed to the stock of trees. On national forests, the value of the average annual harvest was one-tenth that of the non-timber value. For other forests, it was about half. Between the two inventories, the non-timber value, at constant prices, increased by 30% for national forests, and by 55% for other forests. Most species and sizes of trees contributed to this increase.

SUMMARY AND CONCLUSION

This paper proposed as an operational pleasure of non-timber value" the difference **between** what owners, public or private, could have gotten by maximizing timber revenues, and what they actually got. At miniium, this revealed willingness to pay should be a lower bound of the non-timber value. This definition was then applied to estimate the **non-**timber value of all FIA plots in the **Wisconsin maple-**birch forest type, based on the actual harvest and on the result of a Markovian decision model predicting the decision that would have maximized the timber income. Then, a hedonic regression method was applied to determine how the biophysical characteristics of stands, and the socioeconomic setting, influence their non-timber value.

The results showed that for the Wisconsin maple-birch forest type, the non-timber value was highest on national forests, and ten times the timber revenues. This is what the public has been willing to give up to enjoy the amenities provided by national forests. Average non-timber values were similar in all non-national forests, four times larger than timber revenues. Even for industrial forests, non-timber values were slightly higher than timber revenues.

The hedonic pricing model that predicted NTV from stand characteristics and socio-economic variables had modest explanatory power. Still, it gave precise measures of the marginal NTV of trees of different species and size, especially for non-national forests. With these hedonic prices, it was found that from 1966 to 1984, the non-timber value of maple-birch forests in Wisconsin increased by 30% in national forests, and 55% in other forests.

There is growing interest in natural resource accounting to improve environmental and general economic policies (Bureau of Economic Analysis 1994). The assignment of monetary values to single standing trees for their non-timber functions, and as a result the monitoring of a more inclusive economic measure of forests, as fonts of both timber and other goods and services, could be useful in building "satellite environmental accounts" to correct the deficiency of existing national accounts centered on the concept of Gross National Product (Cobb and Halstead, 1994).

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Table 1. Harvest and implicit non-timber value ($/ha/yr).

Value	Ownership	Mean	S.D.	Plots
Harvest				
	National	5.4	17.8	106
	Other public	5.2	13.3	95
	Industry	18.6	35.2	95
	Other private	13.3	28.6	314
Non-timber value				
	National	49.6	51.5	106
	Other public	20.2	23.5	95
	Industry	20.7	29.8	95
	Other private	23.5	34.3	314

Table 4. Marginal non-timber value of trees.

Trees/ha:		$/tree/yr	
		National Forests	Other Forests
Shade tolerant:			
	Small saw	0.53 ***	0.26 ***
	Large saw	1.59 **	1.11 ***
Mid tolerant:			
	Small saw	0.89' **	0.38 ***
	Large saw	0.80	2.37 ***
Intolerant:			
	Pole	0.01	0.03 ***
	Small saw	0.02	0.33 ***
	Large saw	3.62 **	0.86 ***
Constant		15.13 ***	0.05
R^2		0.40	0.50

***, ** significant at 1% and 5% level.