A FORUMLA FOR ASSESSING THE ECOLOGICAL VALUE OF TREES

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Abstract. Formulas have been in general use to establish the dollar value of a tree when used in landscaping, or when used for pulp or timber. But none has been developed that recognizes that trees have a real value to the functioning of an ecosystem, unrelated to their value for landscaping or to the lumber or pulp industries. This paper suggests a way to establish a dollar value for any given tree based on the significance of its effects on soil, nutrient, and water conservation, animal usage, and habitat characteristics. Judgements of ecological effects are converted to simple arithmetic steps to produce a numeric dollar value for the ecological contributions of the tree.

Resumé. Des formules furent largement utilisées pour évaluer la valeur monétaire d'un arbre ornemental ou pour des fins de production forestière. Mais aucune des formules développées ne reconnaît que les arbres ont une valeur réelle dans le fonctionnement d'un écosystème, independamment de leur valeur esthétique ou pour l'industrie. Cet article suggère une manière d'estimer une valeur monétaire d'un arbre en fonction de ses contributions à la qualité du sol, en apports en éléments nutritifs, à la conservation de l'eau, pour la faune et pour l'amélioration des caractéristiques du site. Les impacts écologiques évalués peuvent être intégrés à des formules arithmétiques afin de produire une valeur monétaire numérique de la contribution écologique d'un arbre.

The dollar value of trees presently can be appraised from the perspective of real estate value enhancement, from the cost of replacement, from the yield of wood products, or by the amount people spend to use a forest. In this paper, we suggest a formula to set a value on trees based on their ecological contribution to the environment.

Trees benefit humans in many ways while living (microclimate modulation, food, wildlife habitat, soil protection, aesthetics, etc.) and after harvest (lumber, firewood, paper, etc.). Almost everyone will agree that most trees have a positive value (5, 6) but the amount of value varies greatly according to the perceived uses of the trees.

Timber companies can set a value on a forest based on the expected yield, while the value for public recreation is normally determined by how much the users actually spend on forest recreation or would be willing to spend for the opportunity to use the forest (7, 8, 10). The value of forests for soil and water conservation (9) and for the ecological community (2) have been discussed in the literature, without developing a way to set a monetary value on individual trees.

Setting specific dollar values for individual trees has been done by the wood products industry and by the landscaping industry, both using formulas addressing those specific uses of the trees. For example, log cutters in northern Illinois were paying about $11 in 1987 for a standing silver maple (*Acer saccharinum*) 24 inches in diameter at breast height (dbh) containing two 16-foot logs. For standing black walnut *(Juglans nigra)* of the same size, the going price (excluding veneer logs) was from $72 to $198 (1, 4).

By contrast, trees serving landscape purposes in urban areas can be evaluated by arboriculturists to reflect the portion of the market value of the property due to the trees (5, 6). While several formulas exist, the most widely accepted method is the one developed by the International Shade Tree Conference and the National Arborists' Association in 1951 and revised by the International Society of Arboriculture (2, 3, 6) for trees over 9 inches dbh:

Tree value = dbh area × $27 × Species factor × Location factor × Condition factor,

where area is the cross-section area at breast height in square inches, the factors are specified in Neely (6), and the $27 is subject to periodic revision (6).

For example, the silver maple mentioned previously would have a cross-section trunk area of 452 square inches and would thus have a basic value of 452 × $27 = $12,204; then, if this species is determined by a competent appraiser to have a species value of only 40 percent of the best species and a condition of 50% of what it could be, and the location has various problems like being near utility wires resulting in a 50% of perfect rating, the adjusted value of that tree would be: $12,204 × 0.4 × 0.5 × 0.5 = $1220.

Trees smaller than 9 inches dbh have a basic value based upon the guaranteed, planted price of trees from retail nurseries, but their final adjusted value may still include the three modifying factors above.

Neely (6) allows for the same general formula to be applied to forest trees and other non-landscaping trees by using lower values for the location factor (for example, 10-30% for unmanaged woodlands). In this case, at 10%, our silver maple would be reduced to $448.

We feel that neither of the above value-setting methods adequately addresses the value of a tree to the ecology of the area, although the formula of Neely (6) could be adapted.

Property owners and land-use planners often need to know a dollar value for trees that may have to be destroyed. If the trees are not near houses, landscapers' values may be inappropriate, and forest trees of low grade will have a zero value to commercial foresters. Yet ecologists and others who appreciate trees recognize that they may have a substantial ecological value. Ecologists have not published a method of establishing a monetary value of trees, probably because the values to the ecosystem are extremely difficult to measure in terms of dollars. The lack of a way to set an ecological value leaves the public agencies, and the courts, with few choices in setting values to trees.

The purpose of this paper is to suggest a method to establish a dollar value on individual trees based on their identifiable contribution to the ecology of the area.

The Proposed System

Because ecologists have been unable to derive a dollar value based on a multitude of ecological considerations, we propose that the most reasonable alternative is to arrive at a value formula for a tree of maxmium ecological significance, and then apply reduction factors to adjust for less-than-maximum significance.

The initial value can perhaps best be set by consensus of ecologically aware persons, based on what an ecologically-oriented person or agency would be willing to pay to keep the tree functioning if it were threatened with removal. (This is the same value-setting system that is used in land valuation: the price that a buyer is willing to pay to a seller willing to sell.) This initial value would reflect a tree's potential value to wildlife habitat, erosion protection, microclimate modification, and species diversity for the local and distant ecosystems. It would also reflect the fact that the ecological value of a tree will continue year by year into the future, until its death or replacement by another tree. We suggest that the ecological value is not related to the lumber value of a tree, in that crooked, branchy, or partly hollow trees may have as much ecological value as trees in high demand for lumber. Similarly, the species that are most valuable at a sawmill may not be most valuable ecologically, and vice versa.

Although obviously debatable, we believe that the initial value of a tree is generally proportional to its size because large trees have more influence on the ecosystem that small trees.

After the initial value is set, based on tree size, reduction factors are applied to reflect the local effects on the ecosystem, and the more distant effects, such as downstream.

Local Factors

The multiplication factor for ecological influence in the immediate vicinity includes the effects on soil erosion, nutrient recycling, water, local biota, community diversity, and habitat creation.

Regarding soils, a tree could have a high value for stopping streambank erosion or low significance if it were on flat, non-erodable land.

Nutrient recycling may be an important attribute on soils where minerals are more prone to leach or erode away, and less important on level soils with good nutrient-holding capabilities.

Effects on water percolation may be more significant on droughty hillsides than in swamps, and on tight soils than on sandy soils.

Effects on biota, either directly by nest sites, food supply, and shelter, or indirectly by microclimate modification allowing shade-loving or moisture-loving organisms to exist there, may be the most important ecological benefit for many trees. Even the annual crop of fallen leaves may be an essential habitat for some organisms.

If a tree is a rare species in the area, the loss of the tree could significantly change the total species diversity, whereas the effects on diversity would be negligible if the tree species is common in the area. One exception may be the exotic tree which is only temporary in the system.

A tree standing alone, as in a pasture or fenceline, is probably more significant to the nearby wildlife than if the same tree were in a forest. Yet a forest with a closed, mature canopy would be significantly affected by the loss of even one canopy tree, letting sunlight change the plant life on the forest floor.

All of the above considerations, possibly plus others in special situations, combine to produce a multiplicative factor based on local effects.

We do not feel that species per se ought to be a separate value because the species of a tree is too inter-related with other ecological considerations. Species inherently do differ in ecological values but these differences are accounted for in other factors such as nutrient recycling, local biota, and habitat creation.

Projected longevity is also a significant factor. While trees in a state of decline have value, trees of the same size and species in vigorous condition are ecologically more valuable.

Distant Factors

Trees can affect an entire ecosystem, even outside the local area. Considerations for this multiplicative factor include the effects on downstream flooding, siltation, and animals that may occasionally use the tree or forest from outside the area. In most cases, these effects will be difficult to evaluate, particularly for individual trees, but there is no doubt that trees do have these distant ecological attributes.

Suggested Values

We suggest that the basic ecological value of a forest tree of 3 inches or more dbh in the Central Hardwood Forest of North America be set at $3 per square inch of trunk at breast height (4½ feet). The $3 per square inch approximates the value of a prime black walnut of veneer grade.

After calculating the basic ecological value of a tree at $3 per square inch, the adjusted value can then be obtained by evaluating the various factors for local and distant effects (Tables 1 and 3) and converting them to multipliers (Tables 2 and 4).

Finally, an additional reduction must be applied if the tree is expected to die and fall within 30 years. As a tree changes from a healthy condition through gradual phases of dying and finally falling, its importance to the ecosystem shifts. A dying tree's role in the canopy declines, but its value for nest cavity sites or dead-wood animal habitat increases. But when the tree falls, its value for most of the local and distant factors listed in Tables 1 and 3 drops to near zero, although its value to soil invertebrates and fallen-log inhabitants increases temporarily. Thus, for the purposes of this paper, a tree that is likely to fall soon is deemed to have lost much of its ecological value in contrast to a tree that may stand for many more years, contributing ecologically for decades. Suggested reduction factors for soon-to-fall trees are shown in Table 5. While we allow some value up until the tree falls, Helliwell (cited in Miller (5)) drops the landscaping value to zero when the life expectancy falls to 10 years.

The calculation of the ecological value of a tree is the product of four numbers: A) the basic value,

Table 1. Individual local effects of a tree

Factor (and suggested score)	*Score assigned*
Soil erosion	
Tree important for erosion control (5)*	
Tree not significant for erosion control (1)	_____
Nutrient recycling	
Soil subject to leaching without tree (5)	
Soil tight, slow to leach (1)	_____
Water percolation	
Sloping uplands (5)	
Level uplands (2)	
Swamp (1)	_____
Animal usage	
Tree provides unique food, rest, or nest site (5)	
Many similar trees in area (1)	_____
Habitat diversity	
Tree is rare but natural species in the area (5)	
Tree is common or non-indigenous species in area (1)	_____
Canopy and neighbors	
Tree necessary for closing forest canopy (5)	
Tree standing alone (5)	
Neither of above (1)	_____
Total:	_____

*The scorer is free to assign values that are between 1 and 5 in compromise situations suggested at $3 per square inch of trunk, B) the reduction factor based on local effects from Tables 1 and 2, C) the reduction factor based on distant effects from Tables 3 and 4, and D) the reduction factor based on expected additional standing years from Table 5. For example, if a healthy 2-foot diameter silver maple tree in a forest scores 18 in Table 1, its reduction factor for local effects is 0.7; if it scores 10 in Table 3, its reduction factor for distant effects is 0.8; and based on its size and condition, if it is expected to stand more than 30 additional years, its reduction factor for additional standing years is 1.0. The product of the initial value of $3 × 452 square inches = $1356, times 0.7 times 0.8 times 1.0 gives an estimated ecological value to $759. Similarly, a 36-inch diameter standing tree that is dead and alone in a fence line would have a high initial value based on its size, but much of its $3,054 initial value would be gone after multiplying reduction factors of 0.5, 0.5, and 0.2, leaving $153.

Table 2. Reduction factor based on local effects

Total score	*Reduction factor*
27-30	1.0
24-26	.9
21-23	.8
18-20	.7
15-17	.6
12-14	.5
9-11	.4
6-8	.3

Table 3. Individual distant effects of a tree

Factor (and suggested score)	*Score assigned*
Flood prevention	
Drainage system subject to flooding (5)*	
Not subject to floods (e.g., sand dunes) or floods of no consequence (1)	_____
Siltation	
Reservoirs or lakes downstream (5)	
No pools downstream (1)	_____
Animal visitors	
Tree used by migrating or transient animals (5)	
No temporary animal usage likely (1)	_____
Total:	_____

*Compromise situations may be scored at values between 1 and 5

Discussion

In the same way that Neely (6) stresses that the system of setting values adopted by arboriculturists and landscapers should be applied only by qualified professionals, the system proposed in the preceding pages can be applied by qualified ecologists with experience in judging edaphic, hydrologic, and biological community effects of trees. Most of the scoring necessary for finding the proper scores and/or factors depends heavily on judgement, as values for individual factors may fall anywhere between the suggested values given, as determined by an experienced professional. In many cases, several ecologists may be needed for consultation in individual specialities.

The system proposed above may be compared with the tree-value system of Neely (6) and the value being paid by log cutters (1, 4).

For example, the 24-inch healthy silver maple in a forest used previously in this paper would have a value of $448 to $1344 in the system of Neely, using a location factor of 0.1 to 0.3 for unmanaged woodland trees. The same tree is worth $11 to log cutters. And a plausible ecological value as proposed herein could be $759, depending on soils and other local and distant factors. For a tree that size, the highest value it could have under the present proposal if it had the highest possible ecological significance in every way would be $1356 which is 452 square inches times $3,

Table 4. Reduction factor based on distant effects

Total score	*Reduction factor*
13-15	1.0
11-12	.9
9-10	.8
7-8	.7
5-6	.6
3-4	.5

Table 5. Reduction factor based on expected additional standing years

Additional years to stand	*Reduction factor*
30 or more	1.0
20-29	.8
10-19	.6
5-9	.4
Less than 5	.2

while the lowest value under the present proposal, assuming the least possible ecological significance, would be $41, calculated by multiplying $1356 × 0.3 × 0.5 × 0.2.

The present proposal appears to set the ecological value of trees higher than the log buyer's value except in cases of high lumber value species in ecologically insignificant situations. This does not necessarily mean that lumbering should stop, but it does mean that a forest or woodlot tree may be worth moré to society, through its effect on the ecology, than its value to a log buyer, just as trees lining a shady residential street are worth more to the street's residents than they are to the sawmill.

When a forest or woodlot tree comes up for sale, it is often the log buyer, not the ecologist, that will offer the better bid. The reason lies in the capitalistic system. The logging company can make its offer because of the profit benefits to that company. But few companies are willing to pay the price when the benefits accrue to society at large, or the ecosystem, rather than specifically to the company making the expenditure. Fortunately for society and ecosystems, more and more conservation organizations and philanthropic corporations, including some lumber companies, are recognizing the ecological significance of many forest tracts and are willing to provide the funds necessary to protect them from lumber harvest. Some elements of government are similarly involved; this is an appropriate position in the many instances where the benefits are for society in general.

We do not pretend that the valuation system proposed in this paper is the best way to set an ecological dollar value to trees, nor that the numbers and reduction factors suggested are the most realistic. As imperfect as our suggestions may be, we feel that this proposal is a necessary first step to satisfy a definite need. Other organizations and individuals may well suggest refinements and adjustments that allow for a more accurate determination of a true ecological value that can be less arbitrary and better defended. The goal is to develop a system that will enable land-use planners and other agencies to get a realistic estimate of the value of trees from an ecological perspective.

Summary

We propose a method of setting a dollar value on rural or forest trees that is based on their value to the functioning of the ecosystem, rather than on their value for timber or landscaping. The method assigns an initial value of $3 per square inch (+0.465 per square centimeter) of trunk at breast height, which is then reduced by factors reflecting the tree's significance in soil, nutrient, and water conservation, animal usage, and habitat characteristics. The product of the initial value and reduction factors provides a dollar value that can be used by land-use planners.

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