ECOLOGICAL CLASSIFICATION SYSTEM: INFORMATION AND ECONOMICS[1/]

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Abstract.--Forest managers deal with ecologic and economic risks and uncertainties. An Ecological Classification System (ECS) provides an opportunity to reduce biological risks and related financial risks. By using a multi-factor ecological land inventory, an ECS holistically combines biotic and abiotic factors in defining and locating land units. Economic value can be attributed to this unique information. Two approaches are used to estimate the value of ECS information to Huron-Manistee National Forests managers. The long-term approach, based on present net value differences, provides a range of value estimates influenced by future uncertainties. A short-term budgetary approach is also examined.

Keywords: land classification, risk analysis, economics, information

INTRODUCTION

Land managers base their decisions on long-term and short-term objectives. The former involve desired vegetative composition, land-use patterns, forest outputs, economic efficiency and other factors. The latter are often related to forest output targets, budgets, and prescriptions for individual compartments.

As managers, they deal with risks and uncertainties in society as a whole as well as those associated with the ecosystems they manage. Their knowledge can be increased to reduce risks in some cases. In this context, risk exists when an event or outcome has some known, non-unitary probability of occurring. Uncertainty exists when a probability can not be assigned objectively or subjectively to the occurrence of the event or outcome (Marty 1964).

Collecting more information is a common used means of reducing risks and uncertainties. Appropriate information on the composition, growth, and spatial relationships of forest stands enables land managers to develop biologically and economically sound management prescriptions. Direct mensuration and indirect site evaluation methods are often employed for this purpose. However, in most cases neither approach adequately satisfies these information needs.

Direct measurements of stand characteristics such as basal area and height normally are used to estimate stand potentials and boundaries. An invalid assumption implicit to this approach is that current conditions reflect potentials, particularly in disturbed landscapes. Indirect methods, such as soil survey or habitat typing, are also used, but do not simultaneously examine all important physical and biological factors. Interrelationships among stable abiotic factors of landform and soil and dynamic biotic factors related to vegetative structure and composition are generally not determined.

An Ecological Classification System (ECS) is an alternative to traditional forest evaluation methods. Combinations of biotic and abiotic factors are used concurrently to define

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and locate land units. These units differ significantly in terms of stand successional and productivity potentials. An ECS provides an opportunity to reduce biological risks (eg., lower yields, regeneration problems, etc.) and related financial risks.

An ECS, of course, should be evaluated in the context of the economics of information. This paper presents: 1) ECS objectives and concepts, 2) concepts related to risk analysis, and 3) examples of risk analysis applied to ECS-generated information on the Huron-Manistee National Forests in northern Michigan. The analysis provides estimates of the expected value of the ECS information.

ECS OBJECTIVES AND CONCEPTS

The ECS being developed for mapping lands on the Huron-Manistee National Forests is based on ecological principles and uses quantitative methods to maximize its usefulness in resource planning and management. Since 1982 the Huron-Manistee National Forests has contracted and cooperated with the Michigan State University Department of Forestry in ECS development. The following sections describe the objectives and conceptual basis for the ECS development. Details on sampling and analysis procedures are beyond the scope of this paper; interested persons should refer to other publications for more details (Barnes et al. 1982; Cleland et al. 1985; Jordan 1983; Pregitzer and Barnes 1982; Ramm et al. 1984).

ECS Objectives

Objectives of the ECS being developed for the 950,000-acre Huron-Manistee National Forests are to: 1) define ecosystems with differing properties and behavior important to management, 2) provide management guidelines based on ecosystem biological and physical potentials, and 3) inventory ecosystem units occurring across the Forests' landbase (Cleland et al. 1985).

This paper is based on comparisons of ecosystems that are not discernable using soil series information, but that have different productivity and regeneration capabilities as identified by the ECS. Thus, this paper is related primarily to objectives 1 and 2 above.

ECS Concepts

The Ecosystem Concept

Early in the history of forestry, it was recognized that uniform areas of land called "sites" were the basic units for management (Cajander 1926). This has become synonymous with the term forest ecosystem which can be defined as an areal extent of forest with a uniform structure of vegetation, soils, geology and surface shape which functions in a consistent way because of interactions between structural components and outside environmental factors. This idea of uniform areas of specific structure with predictable function influenced by environmental factors is the most basic concept for developing an ecosystem classification system (ECS) to inventory forest land.

The Regionalization and Area Hierarchy Concepts

Regionalization is another concept which provides a foundation for an ECS. When an external environmental factor influencing an ecosystem's internal function is relatively uniform over a large areal extent, it defines a region in which similarly composed ecosystems will react similarly. Examples are uniform climatic zones and relatively large areas of patterned geologic materials and physiographic features. Actually, uniform relates to uniformity of influences on ecosystems, not necessarily absolute uniformity of characteristics. The existence of regions within which climate, geography, and physiography exert uniform influences on ecosystem components can be important in the way an ECS is developed and used (Denton 1985).

Regionalization areas for climatic and geologic-physiographic factors have very different scales of extent. Normally the climatic area is larger and can be subdivided into smaller geophysiographic areas. An area hierarchy exists when a larger regionalized area can be subdivided into several smaller regionalized areas of more uniform environmental influences. These smaller areas or ecosystems with nearly identical geology, physiography, soil and vegetation should function similarly due to the influence of both internal and external factor interactions.

ECS Units Definitions

A forest ecosystem is defined as having a specific structure which functions in predictable ways due to interactions of internal components and effects of the external environment. Waring and Schesinger (1985) point out that use of the forest ecosystem concept must be based on a definition of its boundaries in space and time. The Forests' ECS units have areal boundaries where important changes in vegetative composition, soils, geology, hydrology or physiography occur. Each is based on uniformity within units, and differences between units are associated with boundaries which may be very distinct or more gradual transition zones. Within the uniform area the ECS unit provides a sound foundation for planning and management.

The time or temporal boundary definition is also critical. The ECS unit definition must allow for distinctions between successional series and predictions of successional change and for regeneration and productivity potentials for both native and introduced species. For example, a mixed aspen-oak stand converted to aspen or planted to red pine undergoes large changes in structure and function, and technically is a different ecosystem. However, both the aspen and pine systems within the same land area should succeed through time to a similar mixed oak ecosystem.

In the absence of major disturbances, forest ecosystems change dynamically and slowly through successional and ecosystem development processes. These changes include growth, normal mortality, nutrient cycling and associated minor changes in tree and understory vegetation. ECS units are based on conditions existing late in the ecosystem development process rather than on conditions following drastic disruptive change. Thus, late successional stands are used to describe the ECS unit. These ECS units provide a framework for traditional stand mapping of all successional stages and stand conditions leading to improved projections of stand potentials.

In summary, the ecological classification process for forest lands on the Huron-Manistee National Forests will use ECS units that are:

1) Contiguous areas with uniform composition of ecological components resulting from uniform interactions of climate, geology and physiography;

2) Predictable in function including composition, productivity, regeneration and responses to treatment;

3) Undergoing ecosystem development processes of a dynamic nature; and

4) Subject to conversion to other predictable cover types following natural disturbances or management treatments.

Ecological landtype phases (ELTP) are the basic units used in this hierarchical classification system (Nelson et al. 1984).

Twelve upland ELTPs have been identified to date on the Manistee National Forest (Cleland et al. 1985). In this paper, two examples of using ELTP-based information are presented.

RISK ANALYSIS CONCEPTS

Many concepts can be related to risk analysis in the context of ECS-generated information. Among them are: with/without analysis, partial analysis, risk preferences and value of information. Analysis can be performed before new information is created (ex ante analysis) or after it is developed (ex post analysis) as we have done. Ex ante analysis is more speculative; either approach requires a number of assumptions and satisfactory growth and yield models for projecting management consequences (Rose 1983).

Managers have limited information on the ecosystems they manipulate. New information reduces management risks by providing better information on site-specific productivity, vegetative composition, and regeneration potentials. Given managerial objectives, less risky biologic decisions are made with ECS information than without it. Stated another way, the probability of achieving the desired objectives are increased with new knowledge.

To estimate the value of the ECS information, expected results with the information should be compared to expected results without the information. It is assumed in this analysis that managers are never made worse off by having ECS information instead of existing soil survey data. The analysis provides a framework for estimating the value of ECS information relative to available soil survey data.

Partial analysis allows analysts to examine a few relevant management questions without concerning themselves with complex organizational interactions. In this case, we are examining economic implications of having ECS information in a limited number of cases. A broader analysis would cover an entire forest recognizing multiple management options for each ELTP. Situations where ECS information is most valuable could be identified, and information development could be prioritized for those high-value situations first. This broader analysis is beyond the scope of this paper, but can become a part of the national forest planning effort.

In partial analyses, it is useful to distinguish between those things that are constant among options and those things that change among options. For example, if the same growth response from two types of release treatments is expected, you may simply be interested in release costs which vary. Presumably a manager would opt for the least expensive release, all other things being equal.

Costs and revenues that change from one management option to another are called variable costs and revenues; those that are invariant are referred to as fixed costs and revenues. In analyses such as this where the emphasis is on change, fixed costs can be omitted. Thus, general administration (overhead), fire protection, and most other costs have been omitted from this analysis.

One fixed cost worth noting in this analysis is the cost of developing ECS data. Presently, it costs approximately $1.00 per acre to develop, map and interpret site-specific ELTP data. Since this is equivalent to the per acre cost of soil survey information, these costs are ignored in the analysis. If developing ECS information were a new program rather than a program substitution, the costs would be treated as variable costs. In some of these situations, new program costs may offset economic gains. Variable costs and revenues used in this analysis are presented in the applications section of this paper.

Another concept related to risk analysis is the concept of risk preferences. Two types of managers may be envisioned: aggressive managers (risk takers) and conservative managers (risk averters). Without ECS information, aggressive managers are willing to gamble assuming they will be right more often than wrong in their judgements. Conservative managers prefer having more information before making decisions. They tend not to gamble for personal or institutional reasons until the risk of being wrong has been sufficiently reduced. These managers place different values on information. For this paper, risk neutrality is assumed; that is, neither aggressive nor conservative behavior is analyzed.

An important concern for anyone generating new information is the value of that information. General statements such as "data collection provides valuable management information" carry a data gathering process for only a limited time. Long-term support comes from examining the management implications of the data and its associated economic consequences.

Isolating the value of new information alone is difficult in management situations where obvious differences exist between sites. The two applications presented in the next section are comparisons between similarly appearing stands so that value estimation is simplified.

The first application compares the use of prescribed fire in managing for northern red oak sawtimber on two ELTPs, 40 and 43. The ECS information increases the probability of achieving desired objectives by providing statistically based management information. The expected value of the ECS information is the difference between expected discounted net revenues from managing with the information and managing without it. Other approaches to risk analysis, such as Monte-Carlo simulation, dynamic programming, and portfolio analysis can be used (Hertz and Thomas 1983; Hoganson and Rose 1984; Mills and Hoover 1982). However, the approach used here (Marty 1964) was selected because it is straightforward and adaptable by field personnel. A 4% discount rate is the standard rate used by the USDA-Forest Service and is the rate used for all analyses presented in this paper.

Though economists prefer to look at the long-term economic consequences of management decisions, many people are concerned with short-term consequences. The second application deals with short-term budget concerns related to adequate stocking following harvest. ELTP 10 and ELTP 20 sites have Rubicon and associated soils and average 1436 cubic feet and 1897 cubic feet of pulpwood at age 81, respectively. Fill-in planting often will be required on ELTP 10 sites to get adequate regeneration. The discounted cost of fill-in planting 5 years after harvest is a measure of the value of ECS information to federal managers required to ensure adequate regeneration.

Finally, analysis has no meaning if managers can not act on the new information provided to them. For example, new information has no value if all 100,000 acres of ELTP 43 and ELTP 40 are going to be receive prescribed burns for northern red oak management when only 40,000 acres are in ELTP 43. Similarly, it would be difficult to inpute value in the case of ELTP 10 and ELTP 20 if no management of those sites is proposed.

VALUE OF ECS INFORMATION

Two applications are analyzed in this section and additional analytical opportunities are identified. Section subheadings are used to state management objectives for the applications.

In one example, northern red oak sawtimber management regimes on ELTP 40 and ELTP 43 are compared. Both are on well-drained Kalkaska sands (sandy, mixed frigid, typic Haplorthod) and have similar overstories composed of sugar maple, beech, northern red oak, and red maple. These ecosystems are similar, but ELTP 43 is more productive due to the presence of fine textured substratums (banding).

The second example compares forest regeneration potentials on ELTP 10 and ELTP 20. On newly harvested sites, similar numbers of black oak, white oak, and red maple seedlings occur. However, ELTP 20 supports merchantable red maple as a mature tree while it remains a very shrubby, small tree on ELTP 10. As a result, planting is often required on ELTP 10 to achieve satisfactory stocking.

Long-Term Management for Northern Red Oak Sawtimber

In northern Michigan, many opportunities exist for managing lands with a mixture of northern red oak and sugar maple. Fire can be used on these lands in site preparation to reduce competition and promote composition of northern red oak.

Based on ELTP survey data interpretations, the site will have approximately 25% basal area of northern red oak and 75% basal area of sugar maple at age 60 if fire management is not used. In this analysis, the effects of prescribed fire are uncertain. Therefore, the analysis includes three possible basal area outcomes at age 60 following prescribed fire: 50-, 75-, and 100-percent red oak basal area.

The Lake States version 2.0 TWIGS (The Woodsman's Ideal Growth Projection System) model was used to project timber yields for four hypothetical stand conditions each for both ELTP 40 and ELTP 43. Basal areas were derived from actual stand average conditions at age 68 for ELTP 43 and age 62 for ELTP 40.

Yields and present net value calculations were developed using three harvest regimes given outcomes of 25-, 50-, 75-, and 100-percent red oak basal area. The regimes were: 1) thin from below at basal area 120 to basal area 90 with final harvest at age 80, 2) thin from above and below (half and half) at basal area 120 to basal area 90 with final harvest at age 80, and 3) no thinning with final harvest at age 70. Thinning from above and below generally yielded the greatest present net value and only results related to that management regime are presented in this paper (table 1). No attempt was made to determine optimal financial maturity.

Table 2 presents variable management costs and timber prices, including real price increases, used in the Forests' planning efforts and in this analysis (Huron-Manistee National Forests 1985). Present net values based on data presented in tables 1 and 2 are in table 3. Due to site preparation costs, a manager would lose money attempting red oak sawtimber management on ELTP 40 in all cases. Site preparation costs are outweighed by additional returns on ELTP 43 when red oak basal area is 75- or 100-percent. These present net values provide the basis for estimating the value of ELTP information.

Without the ELTP information, the probability of properly selecting ELTP 43 for oak management is approximately 0.4 or 40 percent probable (40,000 acres of ELTP 43 out of 100,000 combined acres). With the information, it is assumed that a manager can correctly identify the ELTP at least 90 percent of the time.

The expected value of the ECS information combines probabilities noted in the preceding paragraph and present net values listed in table 3. For example, the expected value of ECS information for a manager who achieves 100% red oak basal area is calculated as follows: [.9 ($31.39) + .1($14.11)]-[.4($31.39) + .6($14.11)]=$11.38. In other words, the

Table 1.-- Sawtimber and pulpwood timber yields from 1) thinning from above and below and 2) clearcutting by ELTP. 1/

ELTP	Red Oak Basal Area at Age 60	Management Practice	Harvest Age	Volume	
				Sawtimber	Pulpwood
			(Years)	(Board feet)	(Cords)
40	25%	Thin	68	1666	6.8
		Clearcut	80	3130	31.1
43	25%	Thin	68	2112	7.5
		Clearcut	80	3463	32.2
40	50%	Thin	69	1798	7.2
		Clearcut	80	6134	30.0
43	50%	Thin	67	1950	7.4
		Clearcut	80	9014	33.0
40	75%	Thin	71	1856	7.5
		Clearcut	80	9909	28.5
43	75%	Thin	68	1872	7.3
		Clearcut	80	12690	32.0
40	100%	Thin	72	1616	7.3
		Clearcut	80	11623	27.9
43	100%	Thin	68	3631	8.4
		Clearcut	80	14234	32.0

1/Based on TWIGS projections.

Table 2.--Management costs and timber prices (in 1978 dollars).

Category	Management Practice	Cost or Revenue	Unit of Measure
Management costs:			
Site Preparation	Burn	25	$/acre
Sale preparation	Thin	48	$/MCF
Sale preparation	Clearcut	34	$/MCF
Harvest administration	Thin	13	$/MCF
Harvest administration	Clearcut		
Timber prices			
Sawtimber	Harvest	202 1/	$/MCF
Pulpwood	Harvest	49	$/MCF

1/ Based on the real price increase estimated for the Huron-Manistee National Forests, sawtimber price is multiplied by 2.19 before discounting (Huron-Manistee National Forests 1985).

Table 3.--Present net values using a 4% discount rate (in 1978 dollars).

ELTP	Site Preparation	Red Oak Basal Area	Present Net Value 1/
40	None	25%	16.07
43	None	25%	18.95
40	Fire	50%	- 0.08
43	Fire	50%	9.44
40	Fire	75%	10.37
43	Fire	75%	19.28
40	Fire	100%	14.11
43	Fire	100%	31.39

1/Based on management practices identified in table 1 and 2.

manager has increased the probability of getting $31.39 per acre from 40%(.4) to 90%(.9). At the same time, the probability of getting a discounted net return of $14.11 has decreased. Expected present net value estimates are presented in table 4 for 25-, 50-, 75-, and 100-percent red oak basal area for managers with and without ELTP information.

This range of basal area possibilities is presented because experiences with oak regeneration following fire do not yet allow managers to estimate objective or subjective probabilities for basal area composition. That is, managers are uncertain about the outcome. Further research may allow probabilities to be assigned to these outcomes.

Table 4 results indicate that managing for 25-percent red oak basal area (no prescribed fire) is more economically efficient than achieving only a 50-percent level. In all cases, the expected present net value is greater with ELTP information than without it. The value of the information is greatest when red oak basal area is 100-percent and least when oak sawtimber management is not pursued. Thus, an exact measure of informational value is difficult to estimate due to the uncertainty of management outcomes and potential changes in other important variables.

Sensitivity analyses allow managers to exam the effects of changes. For example, the values for sawtimber in table 2 do not reflect any price adjustments for species, grade, or diameter-height groups. If markets develop for quality material as it becomes available in northern lower Michigan, higher prices may be expected for northern red oak sawtimber produced on ELTP 43 (table 5). Large sawtimber prices (d.b.h. greater than 17 inches) may be from 2 to 25 percent greater than small sawtimber prices.

Table 4.--Per acre expected present net value and value of information for four northern red oak basal area outcomes (1978 dollars).

Red Oak Basal Area	Expected Present Net Value		
	Without ELTP Information	With ELTP Information	Value of Information 1/
25%	$17.22	$18.66	$1.44
50%	3.73	8.49	4.76
75%	13.93	18.39	4.46
100%	21.02	29.66	8.64

1/Assumes management is pursued primarily on ELTP 43.

Table 5.--Average northern red oak and sugar maple diameters (d.b.h.) at age 80 following an earlier commerical thinning.1/

ELTP	Red Oak Basal Area	Diameter Breast Height	
		Northern Red Oak	Sugar Maple
	(percent)	(inches)	(inches)
40	25%	12.5	9.4
43	25%	17.1	9.5
40	50%	12.9	9.4
43	50%	17.6	9.6
40	75%	12.9	9.6
43	75%	17.5	9.6
40	100%	13.1	--
43	100%	17.7	--

1/ Based on TWIGS projections.

In addition, prices for grade 2 oak logs may be 50 percent greater than similar grade and size sugar maple (USDA-Forest Service 1982). The value of ECS information would increase significantly if these factors were calculated. Additional sensitivity analysis related to costs, interest rates, and yields can also be performed to portray the riskiness of a manager's decision.

Short-Term Regeneration Concerns

Federal land managers are required generally to achieve acceptable stocking within 5 years of final harvest. Managers, whether conservative or aggressive, may harvest mixed hardwood stands on Rubicon and associated soils achieving stocking results similar to those presented in table 6. With this visual evidence and stump sprouting estimates based on table 7 data and procedures in Sander and Johnson (1976), managers may expect acceptable stocking on both ELTP 10 and 20.

This conclusion is incorrect because red maple seedlings in ELTP 10 will not develop into large, mature crop trees based on analysis of ECS information. The shrubby growth is due to complex, growth-stress relationships within the ecosystem. From a managerial standpoint, fill-in planting on ELTP 10 probably will be required for acceptable stocking of crop trees. Expected planting costs can be reduced if ECS information is available.

By assuming (1) a 50 percent likelihood of harvesting on ELTP 10 without ECS information, (2) a 10 percent likelihood of harvesting on ELTP 10 with ECS information, (3) $175 per acre planting costs in 1985 dollars, and (4) planting is required 5 years after harvest, an estimate of the partial value of ECS information can be calculated. It is a partial estimate because net revenues from harvesting existing timber are ignored as well as net revenues from future harvests. This estimate is based on adjusting planting costs to 1978 dollars for comparability with the red oak example, discounting the costs

Table 6.--Average number of seedlings per acre on ELTP 10 and ELTP 20. 1/

ELTP	Number of Seedlings		
	White oak	Black oak	Red maple
10	40	14	110
20	0	7	128

1/ Based on ECS survey plots.

Table 7.--Average number of stumps per acre on ELTP 10 and ELTP 20. 1/

ELTP	Number of Stumps			
	White oak	Black oak	Red oak	Red maple
10	114	61	--	--
20	59	106	106	13

1/Based on ECS survey plots.

for 5 years, and differences in the likelihood of fill-in planting. The 50 percent likelihood is based on acres in ELTP 10 and ELTP 20; the 10 percent likelihood is based on the subjective judgement of ECS developers.

In this case, the value of the ELTP information is the average expected per acre planting cost. Approximately $24 (1978 dollars) per acre is saved by having ELTP data. Thus, a manager would save $24 per acre in planting costs by concentrating management on ELTP 20 where fill-in planting is not necessary. The long-term value would be greater than this amount since average standing timber volume is greater on ELTP 20 and productivity is slightly higher.

As in the long-term example, ELTP information improves managers' understanding of species-site relationships. The short-term savings in this example compare favorably to the long-term net returns in the earlier example. The benefits of ELTP information easily cover the $1.00 per acre development costs, and the opportunity for more scientific management is an added intangible benefit.

These benefits may seem modest on a per acre basis; however, we must keep in mind that we are dealing with marginal improvements in present net value. The Forests' proposed long-term timber management program, which also provides wildlife and other resource benefits, will lose approximately $9.00 per acre managed (Huron-Manistee National Forests 1985). ELTP-based management can undoubtedly reduce these losses and has the potential for creating positive overall returns.

Additional Evaluations

Preliminary analyses presented in this paper are based on three years of ECS development and several economic and biologic assumptions. Additional evaluations that could be pursued at this time are:

(1) Prediction of economic and biologic benefits and risks associated with maintaining red pine plantations versus allowing natural reversion to hardwood types on ELTPs with intrinsically different hardwood regeneration potentials.

(2) Determination of site-specific suitability for hardwood and conifer species based on relative growth rates and economic returns.

(3) Examination of the occurence and vigor of insects and disease relative to plant hosts as they occur within plant communities associated with ELTPs. For example, sweetfern occurs exclusively on ELTP 10. Since sweetfern is an alternate host for Sarasota spittlebug on

red and jack pine, better decisions on planting site selection can be made using ELTP information.

(4) Estimation of the biologic and economic effects of aggregating ECS information in planning. The first series of national forest plans is being completed. Many of these plans are based on very broad aggregates of ECS information called landtype associations. Effects of aggregating ECS information can be examined by developing comparative analyses for a small geographic area using landtype associations, ecological landtypes, and ELTPs.

DISCUSSION

An Ecological Classification System reduces, but does not eliminate managerial risks. The value of ECS information depends on a number of factors. It is a function of the timeliness and form in which the information is presented to managers as well as risk preferences, future uncertainties, and so on.

Analysis of this value is possible at least partially. More complete analyses can be developed after information is available for wider areas of the Forests and is integrated with planning and management direction. The risk analysis concepts including with/without analysis could then be applied on a broader basis. The application will not be exact because there are many situations where the marginal value of the new information will be difficult to estimate. Assumptions regarding risk preferences would also be needed. For example, we could assume that federal land managers tend to be conservative rather than aggressive; this is consistent with their stewardship role. This assumption would tend to increase the value of ECS information. The analyses presented in this paper are fairly straight forward. They would be slightly more complicated if informational costs were variable rather than fixed. From an economist's standpoint, the long-term perspective is preferrable to the short-term perspective. The long-term perspective is consistent with ECS objectives and USDA-Forest Service management.

These analyses and situations document two situations where ELTP information has economic value. These situations are applicable to many acres of forest land and support the decision to conduct a holistic, multifactor ECS land inventory.

Additional analyses can be conducted as ECS information becomes available for the entire Huron-Manistee National Forests. Management guidelines, updated costs and revenue information, existing forest conditions, and ECS information can all be integrated at that time as part of the national forest planning process. Then the total economic contribution of ECS information can be more clearly estimated.

REFERENCES CITED

Barnes, B.V., K.S. Pregitzer, T.A. Spies, and V.H. Spooner. 1982. Ecological forest site classification. Journal of Forestry 80: 493-498.

Cajander, A.K. 1926. The theory of forest types. Acta. For. Fenn. 29: 1-108.

Cleland, D.T., J.B. Hart, K.S. Pregitzer, and C.W. Ramm. 1985. Classifying oak ecosystems for management. In Proceedings of Challenges in Oak Management and Utilization, Madison, Wisconsin, March 28-29, 1985. pp. 120-134.

Denton, S.R. 1985. Ecological climatic regions and tree distributions in Michigan. Unpublished Ph.D. dissertation, University of Michigan, 390p.

Hertz, D.B. and H. Thomas. 1983. Risk analysis and its applications. New York: John Wiley & Sons. 323 p.

Hoganson, H.M. and D.W. Rose. 1984. A simulation approach for optimal timber management scheduling. Forest Science 30(1):220-228.

Huron-Manistee National Forests, USDA-Forest Service. 1985. Draft environmental impact statement, land and resource management plan. U.S. Government Printing Office. 587p.

Jordan, J.K. 1983. Application of an integrated land classification. In Proceedings. Artificial Regeneration of Conifers in the Upper Great Lakes Region, Michigan Technological Institution, Houghton, Michigan, October 26-28, 1982.

Marty, R. 1964. Analyzing uncertain timber investments. U.S. Forest Service Research Paper NE-23, Northeastern Forest Experiment Station, Upper Darby, PA, 21p.

Mills, Jr., W.L. and W.L. Hoover. 1982. Investment in forest land: aspects of risk and diversification. Land Economics 58(1):33-47.

Nelson, D.O., W.E. Russell, and G.W. Stuart. 1984. The ecological classification system in the national forest system, eastern region. In Proceedings of the Symposium Forest Land Classification: Experiences, Problems, Perspectives, University of Wisconsin, Madison, Wisconsin, March 18-20, 1984. pp. 270-276.

Pregitzer, K.S. and B.V. Barnes. 1982. The use of ground flora to indicate edaphic factors in upland ecosystems in the McCormick Experimental Forest, Upper Michigan. Canadian Journal of Forest Research 12: 661-672.

Ramm, C.W., J.B. Hart, Jr., and K.S. Pregitzer. 1984. Summary report on a vegetation and soil survey on the Huron-Manistee National Forests: Mason and Manistee Counties, Michigan. Report submitted in fulfillment of contract number 53-56A1-2-00724. 154p.

Rose, D.W. 1983. Benefit-cost evaluation of the Douglas-fir tussock moth research and development program. Journal of forestry 81(4):228-231.

Sander, I.L., P.S. Johnson, and R.F. Watt. 1976. A guide for evaluating the adequacy of oak advanced reproduction. USDA-Forest Service General Technical Report NC-23. USDA-Forest Service 1982, Timber appraisal handbook. Forest Service Handbook 2409.22. U.S. Government Printing Office.

Waring, R.H., and W.H. Schlesinger. 1985. Forest ecosystems. Orlando, FL: Academic Press, Inc. 350p.