The Ecological Survey: The Biophysical Basis of Forest Land Management

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Forest land management is a kind of land management. It requires estimates on the potential production of the land for the natural renewable resources which cannot be measured directly. The ecological survey is considered as the biophysical basis of forest land management because it provides the manager with a geographical framework within which the potential production can be estimated.

Though the forester is more directly concerned with trees the forest manager is becoming more and more a land manager. Land means the sum of all the features of the earth's surface which influence its usefulness [3]. In addition to a knowledge of the composition and volume of the standing crop, the manager needs a measure of the improvement possibilities to estimate the future forest composition and volume in relation to different levels of input. Forest land management therefore, requires both a measure of the actual production, and an estimate of the potential production of the land. The concept of Management Potential Production was put forward by Ford and Fraser [6] as the upper limit of production which management can achieve. This limit is set by the environmental factors outside the control of management.

Actual production can be measured accurately in the field or on aerial photographs, and mapped by a forest inventory. The management potential production of the land is not measurable directly. We are largely ignorant of how the processes work. But we know empirically, that some land units have a greater potential production than others, and we must find a method of expressing this in a way that can be mapped.

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The concept of Ecological Survey, as put forward in this paper, is suggested as the basis for evaluating the management potential production of forest lands. The ecological survey is the biophysical basis of forest land management because it provides an inventory of the land; that is, a permanent geographical framework independent of the prevailing economic and sociological conditions of a given area.

Management Potential Production And The Ecosystem

The value of land derives from its capacity to produce. Part of the land products are non renewable, such as minerals and oil. Others are the natural renewable resources such as timber products, agricultural crops, wildlife, recreational or esthetic values, and water. The latter have in common the following basic characteristics: 1) they are interdependent, 2) they grow at a certain rate, 3) their rate of growth is directly dependent on properties of the land itself, *i.e.* its ability to provide energy (quantity, quality and periodicity of solar radiations), carbon dioxide, oxygen, water, and nutrients.

We also know empirically that similar pieces of land have similar potential rate of growth, and that the variation among contiguous pieces of land is not random. Therefore, a classification of lands is effective, if it provides a means to determine which pieces of land are alike, and useful to the land manager, if all the inherent characteristics of the land itself are taken into account in the established classes. The mapping of these units would provide the manager with a knowledge of areas having similar potential rates of growth, similar successful trends and, consequently, similar management potential production.

Land includes both biotic and physical interacting components, yet it is an objective entity. In other words, land is an ecosystem which Rowe [20] defines as "a perceivable unit of the landscape, homogeneous both as to the form and structure of the land and as to the vegetation supported thereon".

The ecosystem "Land" is a kind of a manufacture which produces among other products, a certain amount of timber. The description and analysis of that ecosystem is essential to any understanding of the processes at work.

Basic Principles Of An Integrated Ecological Survey

An ecological survey of an area consists of the description, classification and mapping of the ecosystems present. The role of a survey is to memorize and communicate knowledge, and to predict relationships concerning the objectives of the survey itself.

At this point, five basic guiding principles should be emphasized to ensure the proper use of the survey by the land manager.

A. The purpose and objectives of an ecological survey must be clearly defined. This does not imply that the classes themselves must serve directly as interpretative units: but that they must be directly applicable to interpretations. Within the perspective of an ecological survey designed for the purpose of land management or planning, the objectives might well be:

1. Assessment of the management potential production of timber.
2. Assessment of the vegetation succession.
3. Assessment of the natural or artificial forest regeneration potential.
4. Assessment of the land suitability for road location and construction.
5. Assessment of the physical responsiveness to management treatment: trafficability and erosion hazards.
6. Assessment of the land capabil-

ity for wildlife management.
7. Assessment of the land capability for recreation management.
8. Assessment of the land capability for water management.

Once the objectives have been accepted as suitable by land managers the ecologists or the ecological survey team should realize that it is their own responsibility to define significant ecological units and to interpret them in the user's terms. Leaving the interpretation to the land manager unavoidably leads to confusion and ultimately to a loss of practical information.

B. The ecological classification of land must be integrated, *i.e.* based on significant attributes of both the ents of the land. Both soil and vegephysical and the biological compontation centred approaches have been used in the past, assuming that these features do integrate all the environmental factors of the land. However, we know [13] that, although these two approaches give valuable information for specific objectives, they are generally too incomplete or inaccurate to provide information relating to forest management objectives. We also know that different vegetation units of unlike potential productions may occur on the same soil while the same vegetation may colonize different soil units of unlike potential production [13]. It is only through the integration of soil and vegetation units that ecological units of lands can be considered as uniform for each of the environmental factors: regional climate, parent material, topography, organisms, and time.

C. The third principle concerns the criteria to be used in separating classes of the classification itself and of the mapping units. These criteria should be factual land properties that are actual and stable over a significant period of time. Preference should be given to those properties that cannot be destroyed by cutover, fire, or cultivation. Presumed properties of vegetation at a former or later stage of succession may help the ecologist in selecting specific criteria but should be strictly avoided as criteria because they are not factual properties. There is already enough subjectivity in the establishment of boundaries between the units of a classification without introducing other sources of subjectivity in the definition of these units.

D. The fourth principle deals with the scale of the survey. At a large scale (4 in. to 1 mi. or larger) it is often possible to map land units which are homogeneous in terms of soil and vegetation and which lend themselves to relatively narrow ranges of properties in relation with the stated objectives. As the scale decreases, the minimum area that can be shown on a map increases. Different soils and vegetation occur side by side, and it becomes impossible to map the units shown on the large scale maps. Patterns of the latter must be described, named, and mapped accordingly. The common denominator of these larger land units can no longer be vegetation or soil, but other landscape features such as geomorphology, physiography, geology, or broad regional vegetation. If these more inclusive units are described in terms of the relative percentages of land units at the lower categorical level, they will also lend themselves to generalized interpretations in relation with the stated objectives.

Therefore, the land units of an ecological survey should be separated and defined on the basis of the criteria most suitable to the selected level of generalization, but they should always be described as defined proportional patterns of units homogeneous in terms of soil and vegetation. For example, if landform is used as the criteria for separating land units, the relative percentages of soil-vegetation units should be indicated in the description.

Examples of six possible levels of ecological integration applicable to eastern Canada are shown in Table I. Accumulating attributes from high to low categories provides more knowledge about land units of lower than about those of higher categories. This is true not only for ecological relationships but also for in-

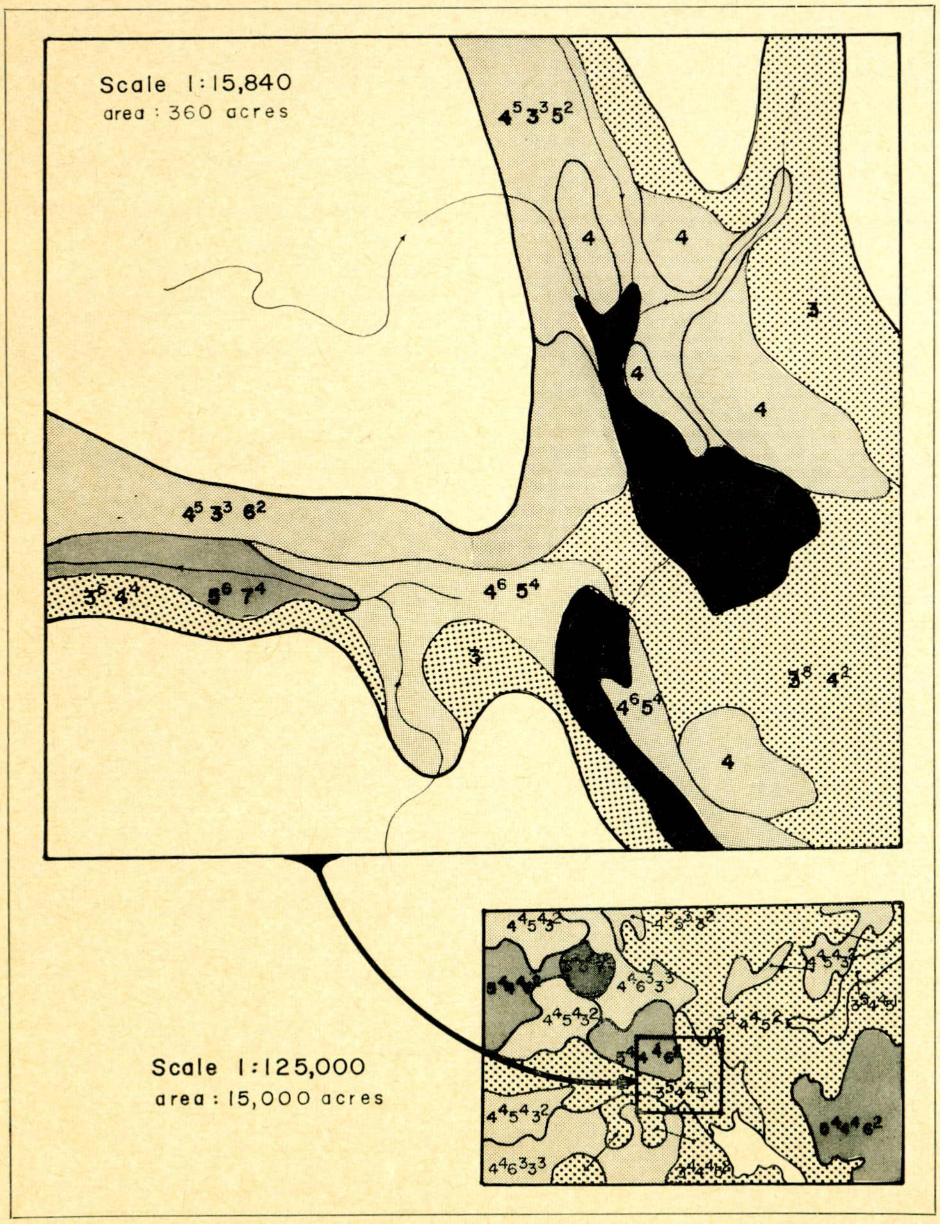

FIG. 1. Forest capability maps. Class symbols are those of the Canada Land Inventory (McCormack, 1968).

terpretations of management objectives. Therefore the most appropriate level of generalization of an ecological survey depends directly on the extent of management or of land use planning. For example, a forest company may decide to undertake an ecological survey at the level three (land system) of its 2,000 sq. mi. limit and a more detailed survey at the level two (land type) of a portion of the former which is either more accessible or more productive.

E. An ecological survey must be completed rapidly and economically. Considering the size and the inaccessibility of the areas to be surveyed, the lack of professionally ity of airphotos, Lacate [15] conskilled personnel, and the availabilcludes that land surveys in Canada should be based on air photo interpretation techniques. This makes landform of key significance in ecological surveys, a fact emphasized by Hills [8], Gimbarzevsky [7], and Jurdant [12].

Canada has a history of sustained interest for land surveys and site classification. Reviews of the work done are provided by Rowe [20] and Lacate [15]. A National Committee of Forest Land was created in 1966, and its subcommittee on Wildland Inventory and Classification is now actively involved in developing a national system of biophysical land survey. Several pilot projects have been initiated in various parts of the country: the preliminary results [1] do conform with the above principles.

Large Scale Ecological Surveys

In this instance the scale varies from 1:10,000 to 1:50,000 and corresponds to the level two (Table I). At this level one can usually delineate land types homogeneous in terms of those features of soil and vegetation which are significant in regard to potential production and successional trends. In some areas, complexes must be mapped, but they rarely exceed two or three land types whose proportions can be easily estimated.

The potential production made at the scale of 1:15,840 (4 in. = 1 mi.) shown in Fig. 1 was derived from the ecological map of a reference area. Similar maps could be interpreted from the ecological map, one for each objective of the survey.

Small Scale Ecological Surveys

The need for small scale ecological surveys was felt recently in Canada because of the growing attention to regional land use planning and to the concept of multiple use of forest and associated wildlands. If the scale is not too small, this type of survey gives valuable basic information for preparing extensive forest management plans. Also, the size of the basic mapping units do conform better to practical logging requirements. The scales vary from 1:100,000 to 1:250,000 which correspond to the levels three and four (Table I). The mapping units are patterns of the land units from the next lower level. For example (Table I), Land Systems, mapped at the scale of 1:125,000, are patterns of land types. Interpretative data in relation to the objective can be obtained since the proportion of land types within land systems is known. The relationships between potential production classes mapped at large and small scales are illustrated in Fig. 1.

The Practical Use Of Ecological Surveys In Forest Management

At large or small scale, an ecolog-

Table I. — Levels of ecological integration.

						Names of categories		
Level of ecological integration	Mapping scale (examples)	Average size of mapping unit (examples) sq. mi	Corresponding intensity of management	Dominant ecological variables	Criteria of differentiation	Lands Units NCFL[1] (English)	Territoires écologiques NCFL[1] (French)	Others
6	1:10,000,000	25,000	—	Latitude Continentality	Physionomy of regional vegetation	Land zone	Zone écologique	Zone biogéographique (France[2])
5	1: 500,000	500	National land planning	Regional climate	Regional vegetation	Land Region	Région écologique	Site Region (Ontario[3]) Ecoregion (Loucks, 1962) Forest Section (Rowe, 1959) Domiane Ecologique (Belgium[4]) Région Ecologique (France[2])
4	1: 250,000	50	National or provi cial land planning	Geology Physiography	Geology Relief	Land District	District écologique	Site distroct (Ontario[3]) Secteur Ecologique (Belgium[4]) Secteur Ecologique (France[2])
3	1: 125,000	5	Regional land planning Extensive management	Geomorphology	Landform	Land System	Système écologique	Land System (Australia[5]) Landscape Unit (Ontario[3]) Land Association (Lacate, 1965) Type de Pausage (Jurdant, 1968) Section écologique (France[3]) District écologique (Belgium[4])
2	1: 20,000	0.1	Intensive management	Topography Parent material	Vegetation Soil	Land Type	Type écologique	Edological Unit (Ontario[3]) Land Unit, (Lacate, 1965) Type écologique (Jurdant, 1968) Unité phyto-écologique (France[3]) Soil-Vegetation unit (USA[6]) Station écologique (Belgium[4])
1	1: 1,000	0.01	Very intensive management	Vegetation competition Local history	Vegetation Soil	Land Phase	Phase écologique	

1/ National Committee on Forest Land. 2/ Centre d'Etudes Phytosociologiques. (See: Long, 1968, CEPE, 1966). 3/ Ontario Department of Lands and Forests Research Branch (See: Hills and Pierpoint, 1960; Hills 1960, 1961). 4/ Centre d'Ecologie Générale, Belgique (See: Delvaux et Galoux, 1962). 5/ Commonwealth Scientific and Industrial Research Organization (See: Christian, 1952; Christian and Stewart, 1953). 6/ United States Forest Service (See: U.S. Forest Service, 1958; Poulton, 1959; Zinke, 1960).

ical survey provides ecological land units established from an integration of vegetation and the factors of the environment. Specific information on the following land features can be derived for each unit, from maps and reports:

— Vegetation: structure, physiognomy, composition, trends in succession.
— Physiography and landforms.
— Texture, petrography and depth of the surficial geological materials.
— Type of the underlying bedrock.
— Soil profile development.
— Soil fertility.
— Nature and properties of the surface organic horizon.
— Soil moisture regime.
— Regional climate
— Rate of growth of the major tree species naturally occurring in the unit.

The above basic information can in turn be interpreted in forest management terms:

1. By delineating areas which are significant in terms of potential timber production, the ecological survey provides the forester with the necessary data which allow him to delineate management units with similar productivity rather than equal terms of unknown productivity.

2. Varying levels of intensity of management in different parts of a new timber concession can be properly decided upon once the potential timber production is established by a small scale ecological survey.

3. An ecological survey provides the forester with information to know where and why intensive management practices are more likely to be effective. Frequently, the best sites remain in low actual production for a long time after disturbances such as clear cutting or fire.

4. The ecological survey is a necessary framework for regional research in forest management and silviculture, both at the planning stage and at the interpretative stage.

5. By knowing the management potential productions of a region, the forester can choose between high yields on a small land area or low yields on a large land area.

6. The ecological survey delineates areas with similar successional trends after various kinds and degrees of disturbance. This is the qualitative aspect of potential timber production.

7. The ecological survey provides a better understanding of the regional tree species-environment relationships, the object of ecology, and prerequisite to any silvicultural programs.

8. Assessment of the natural and artificial reforestation potential can also be derived from an ecological survey.

9. By assessing problems in trafficability and erosion hazards, the ecological survey provides information useful to the planning of logging operations and timber extractions.

10. The ecological survey can be used as a starting point to provide data for road locations and construction cost estimates.

Conclusions

Depending on whether the forester is a harvester of trees or a land manager, an ecological survey is useless or extremely useful. It does not tell the forester what to do, but advises him on what would result from the use of certain management practices and combinations of practices, both in crop yields, and in the long time effects on the productivity of the land.

In the past, ecological studies and surveys have contributed to much of our present knowledge on the forest-environment relationships. As land becomes more intensively managed, the ecological survey will play a greater part.

Ecological survey is, however, a multidisciplinary scientific task which can no longer be undertaken by one person. A survey unit should consist of at least an ecologist, a geomorphologist, a soil scientist, and a forester; all of them should have a solid background in air photo interpretation. Forest companies could probably not afford to support such programs. However, if small scale ecological surveys are available, the site specialists of these companies could very well undertake the detailed survey of particular areas with the information contained in the general survey.

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