Proceedings of:

SYMPOSIUM ON FOREST AND LAND INVENTORY FOR MANAGEMENT

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FOREWORD

The pages following contain the technical papers presented at a symposium on forest and land inventory sponsored by the Canadian Forestry Service in Edmonton, Alberta on February 12 and 13, 1970.

Specialists in different fields often presented opposite points of view, and it is clear that there is not a simple answer for "Forest Land Inventory for Management". Accompanying a rapidly developing technology is a society whose needs and values are changing. Environment is a very important consideration to this society; as a consequence, this symposium appears to be merely the first "getting together" in Alberta of a multi-disciplined group to consider how we may better manage our environment.

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PURPOSE OF SYMPOSIUM ON FOREST-LAND INVENTORY FOR MANAGEMENT

by

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February 12 and 13, 1970

A new decade is before us. As we look ahead, we see strong evidence that new approaches to forest management are required. Changes in forest cover resulting from growth, fire, cutting, insect and disease attack, road building, and oil and mineral exploration have to a large extent made existing provincial inventories obsolete. Adequate management of forest lands today requires more information than has been previously recorded. Up until the last ten years, our methods for forest-land inventory, the main tool of management, have had few alterations. Changing technologies, such as infra-red and radar sensors, cameras, films, computers for data compilation, storage, retrieval and mapping, as well as changing values placed on forest land, have all descended upon us. Mindful of society's demands and armed with the new technologies, we are challenged to provide forest-land inventories that will meet the needs of today.

We foresters have been conditioned to think of planning in terms of rotation age of trees, which is 50 to 100 years in Alberta. At the present rate of change, I believe we're not going to be allowed this luxury of time again. Never before have specialists in different disciplines been so willing, or has the need been so urgent, to sit down and discuss renewable resource problems.

Exploitation without regard for environmental degradation is being challenged on many sides. Mr. R. Steele, Director of the Alberta Forest Service, in a letter to the Chairman of Alberta's Task Force Review of Forest Inventory stated:

> "We are daily experiencing significant progress resulting from technological advancement. It is a responsibility of industry and government to take advantage of newly gained knowledge to progress accordingly. The old concept of carrying out programs independent of associated interests is being replaced by a total analysis approach. This you have strongly recommended for our Timber Survey Programs."

The nation's railroads have long been reconciled to the uncertainties of a changing world. All schedules, they have warned, are subject to change without notice. In a new forest-land inventory program, the order of emphasis upon some problems will change; requirements for some types of information will intensify while the demand for other types may decline. New problems will emerge from what now appears to be the beginning of a keener appreciation of the importance of our forest resource not only for the production of wood but for the production of water, wildlife and recreation. Managers and researchers must avoid becoming slaves to a program based upon past conditions (or traditions). Their schedules, like the railroads may be subject to change without notice, and should be brought up-to-date whenever necessary. At the same time many of the problems in the prairie region will remain the same. There can be no getting away from the poorly stocked, slow growing, unoperable stands that occupy a large part of our forest land. The needs for intensive and extensive planning for various forest-land uses are evident.

It is difficult to state explicitly the objectives of forest-land surveys. Dollar return to the economy is not the only criterion for setting priorities. The quality of the environment is also important.

Let us all take this opportunity to state what we would like from a new forest-land inventory. Once we are past this stage we can get down to the details of design that will be an integration of knowledge of forest cover, habitat, climate, topography and logistics.

A choice between different sampling plans may mean a choice between one survey cost of 10,000 dollars and another amounting to one million. The importance of finding a rational basis for such a choice cannot be overemphasized. On practical matters wrote Aristotle, "the end is not in mere speculative knowledge of what is to be done, but rather in the doing of it".

FOREST REGIONS OF ALBERTA

by

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INTRODUCTION

This introductory paper to the Symposium examines the general geographic framework within which "Forest Land Inventory for Management" in Alberta will take place. My remarks are directed to problems involved in establishing such a biophysical framework, though with the full realization that social, political and economic factors must also be considered when appraising the utility of any tidy technical scheme.

It is usual, in forestry studies, to stratify the larger landscape into Forest Regions, Forest Zones, Forest Sections; these being the more or less "natural" subdivisions of land wherein vegetation, climate and terrain show a general uniformity. By dividing into such major units, the amount of diversity in nature is reduced to more manageable proportions, so that extrapolations and predictions having to do with ecological relationships can be made with greater accuracy. Of course, the farther we go down the scale in dividing and subdividing the landscape, the more homogeneous the ultimate units become. At successively lower levels then, our abilities to predict should increase, even as the scope of those predictions become more and more limited.

It is obvious that the primary stratification of the landscape into major units at the small scale is important, for the initial decisions carry on down through the entire hierarchy of subunits. Therefore it is worthwhile examining the basis for the Forest Regions and Forest Sections that have been defined and mapped in Alberta, following the Halliday scheme.

FOREST REGIONS AND SECTIONS

Alberta shows a nice latitudinal and altitudinal zonation of vegetation and associated soils (Figure 1). Generally speaking, there is a gradual change from prairie and associated brown soils in the south, through aspen parkland with black soils, to mixed conifer-deciduous forest with gray wooded soils in the north. A similar sequence occurs along the gradient of increasing altitude from southeast to northwest within the province, or is visible from the basal slopes to the summits of isolated highlands such as the Cypress Hills and the Pelican Mountains.

to the latitude of Calgary. The Lower Foothills Section, B19a, usually below 4000 feet altitude, is characterized by the prominence of Pinus contorta latifolia, and it is the presence of the lodgepole pine that defines three disjunct but similar forest areas in the Caribou Mountains, the Pelican Mountains and the Cypress Hills. The Upper Foothills Section, B19c, from about 4000 to 6000 feet altitude, is predominantly coniferous. Companions of Picea glauca are Pinus contorta latifolia and Abies lasiocarpa, while Picea mariana is less abundant than in the lower-lying adjacent Section. Thus a good argument could be made for relating B19c to the Subalpine rather than to the Boreal Region. Again note that it is the presence of Picea glauca that places it as Boreal.

In the northeast we distinguish three physiographically-distinct Sections. The Athabasca South Section, B22b, is a Pinus banksiana-Picea mariana complex on the Precambrian Athabasca sand plain. The Upper Mackenzie Section, B23a, includes the productive alluvial-lacustrine plains and deltas of the Peace, Athabasca and Slave Rivers, characterized by discontinuous forests of Picea glauca and Populus balsamifera, with Pinus banksiana and Picea mariana on the adjacent terraces and uplands. In the extreme northeast corner of Alberta, on crystalline rock of the Precambrian Shield, there is a limited area of the Northwestern Transition Section, B27, a subarctic open woodland dominated by Picea mariana and Pinus banksiana with prominent lichen undergrowth.

The remainder of the province, from the center-east to the northwest, is occupied by mixed boreal forests which have been badly depleted by fire and latterly by seismic crews! A distinction is made between the Mixedwoods, B18a, in the south and the Hay River Section, B18b, in the northwest; the latter has a somewhat lower relief than the former, and there is a consequent increase in the prominence of Picea mariana over Picea glauca.

How useful are these Forest Regions and Sections for stratifying the landscape? Do they reflect real differences that can be useful for inventory, for research and management of forest lands? The answer is equivocal; it is "yes and no"!

THE ENVIRONMENTAL SIGNIFICANCE OF VEGETATION

The question of the indicator significance of vegetation boils down to the reasons for the presence or absence of individual species in a particular place. Following are some suggestions as to the interpretations of observed forest patterns.

It seems commonly to be taken for granted that each plant species is present in a certain geographic location because of present environment to which its fixed tolerances are nicely matched. Every ecologist would like to believe that this relationship exists and is the

In the western foothills and mountains, however, the relatively simple relationships of the adjacent plains are complicated by abrupt changes both in relief and in geological materials and by rugged topography. More tree species enter the picture too, complicating the vegetation-physiography patterns.

Forest Regions were conceived by Halliday as "climax" formations in the sense of Clements, i.e. as major climatically-controlled units accurately defined by wide-ranging climax dominants. So the Boreal Forest is almost synonymous with *Picea glauca* and *Abies balsamea*, and the Subalpine Forest with *Picea engelmannii* and *Abies lasiocarpa*. Subclimax species such as *Pinus contorta* were not considered as important, which accounts for the foothills areas and some other uplands being classified as parts of the Boreal Region despite their extensive lodgepole pine stands.

Forest Sections were conceived as distinctive patterns of associations, and in my reinterpretation of Halliday I suggested that they frequently coincide with physiographic units of land in terms of which they may be conveniently defined.

Now consider the criteria for the forest geographic divisions in Alberta. I have already mentioned the floristic distinction between Boreal and Subalpine Regions viz. the presence of *Picea glauca* in the former and of *Picea engelmannii* in the latter. Taxonomists are at present blurring what is at best a vague boundary criterion, by treating *Picea engelmannii* as a subspecies of *P. glauca*. Nevertheless, the Subalpine Forest will continue to be differentiated from the Boreal Forest because of its distinctive mountain terrain, correlated with the scarcity of black spruce and broadleaf trees, and the presence of such characteristic species as *Pinus albicaulis* and *Larix lyallii*.

Mention should next be made of three patches of Montane Forest which have been defined below the Subalpine; in the Waterton-Porcupine Hills area, the Bow River valley west of Calgary and the Athabasca valley near Jasper. Again the criterion is floristic, viz. the presence of *Pseudotsuga menzesii*, with *Pinus contorta*.

Turning now to the subdivisions of Regions, only the Boreal Forest in Alberta is divided into Sections. From the prairies on up beyond Edmonton, and east to the Saskatchewan border, lies the B17 Aspen Grove Section, patches of which occur on uplands within the Grasslands to the south and on lowlands within the Mixedwoods to the north. The B17 boundaries, defined in terms of poplar groves and forests, are notoriously unstable. They have changed greatly with settlement in the last 60 years due to the virtual cessation of fires. The forest has invaded the grassland, and one assumed "climatic" boundary has lost its reputation!

The Foothills forests occupy two areas; one around the Notikewin River in the Chinchaga and Clear Hills, west of the north-flowing section of the Peace River, and the other a productive triangle that extends from the Swan Hills to the B.C. border and south most important one, for what it postulates is a simple, straightforward cause-effect link between aerial and soil environment and associated plants. From this it is an easy step to suppose that if either the aerial climate or the soil is held constant then the vegetation will vary dependently with the other. If aerial climate is reasonably constant over an area, vegetation should by its variations indicate the substratum environment, or if the substratum environment (soil) is constant, vegetation should indicate the aerial climate. This is the situation devoutly to be wished, but unfortunately it is too simple for nature. Plant species do not have fixed, definable tolerances, and neither soils nor climates stay constant over areas of any size.

One of the traps for those who unwarily postulate a close tie-in between vegetation and environment, is precisely this variable, mutable characteristic of plants, soils and climates. Here we are at the mercy of taxonomists; those who identify plants, those who identify soils and those who identify climates. If I were to observe that there is a good 3-way correlation between lodgepole pine, gray wooded soils, and microthermal climate in Alberta, you would do well to ask: "What kind of lodgepole pine, what kind of gray wooded soil and what kind of microthermal climate?" These taxonomic classes embrace a wide range of phenomena and the extremes within each class may be only distantly related to one another.

An appreciation of the differences in precipitation, temperature and evapotranspiration regimes between the far northern and far southern parts of Alberta makes it difficult to believe, for example, that lodgepole pine on the Caribou Mountains is the equivalent of lodgepole pine on the Cypress Hills, or that the gray wooded soils associated with both signify similar ecological conditions. Our taxonomy tools are too blunt to help us make ecologically significant subdivisions. Unfortunately, rather than honing them, their designers often seem more interested in renaming them or reshaping them, (the equivalent of adding a new set of tail fins)! So species such as lodgepole pine, Engelmann spruce and alpine fir are merged with their boreal congeners, luvisols like the phoenix rise from the podzolic ashes of gray wooded profiles, while climatic classifications and maps ring the changes on the Meteorological Branch's computerized data.

Another upsetting influence is competition or interference between plants. Only by its presence can a species or individual indicate something of environment; the reasons for its absence - pathogens, fire, lack of seed mobility, etc. - are usually too conjectural to be of much use. It should however be realized that an organism may be well adapted to a certain range of climates and soils from which it is excluded by more aggressive competitors. Looked at another way, adaptable genetically-diverse species may drive out good indicator species, i.e. organisms of narrower ecological tolerance. By the very fact that aggressive species win the battles, they disqualify themselves as good indicators. Widely-distributed species are very apt to deceive, just because they tend to conceal the broad range of environments which they successfully colonize.

Then again the answer to the problems of species presence or absence may be hidden back in the glacial and post-glacial history of the land. Why are there three small patches of Douglas fir-and-lodgepole pine forests, with associated grasslands, in the Waterton Lakes area, the Bow Valley west of Calgary, and the Athabasca Valley near Jasper? Are these the only suitable warm and dry sites up and down the front ranges of the Rockies, or has Pleistocene climatic change played a role in fragmenting a once-larger vegetation of this type? Again, why does balsam fir cut out south of the Peace River, reaching its farthest north limit in the alluvial-lacustrine lowland of the Athabasca delta? Does this only represent the current temporary limit of a steadily progressing northward invasion? The historical element in present vegetation patterns merits close attention, as the following paragraphs suggest.

According to the speculative map of Prest (1969) showing the retreat of the last continental ice sheet, the southern foothills in Alberta were not ice-covered, Calgary was ice-free by 14,000 BP, Edmonton was clear by 12,000 BP and the remainder of the province was clear by 10,000 BP. As Drury (1956) has suggested, plant species must have surged in like chemical compounds in a giant chromatography experiment, each migrating at a rate determined by seed size, dispersal efficiency, mobility, and aggressiveness in competition.

In the Riding Mountain of western Manitoba there is evidence (Ritchie 1969) that a spruce forest followed hard upon the withdrawal of the ice, then came a prairie vegetation about 10,000 BP, and finally the modern spruce-aspen-pine assemblage about 2500 BP. If we assume that the prominence of grassland indicates a drier or warmer climate (although it may simply indicate the advent of the fire-drive by hunting aborigines) then presumably a good part of Alberta, like Manitoba and Saskatchewan, experienced a 7500-year Calgary-type climate. Prairies might then have developed up into the Territories, following the rain shadow of the mountains, with Douglas fir and lodgepole pine spreading northward along the foothills. Climatic reversal 2500 years ago, favoring the spread of boreal and subalpine spruces, may have fragmented dry-land communities which today are represented only by the last shrinking patches.

Such conjecture is indulged in only to suggest how distribution patterns may reflect conditions long past, a warning that present vegetation may give us misleading clues to the present environment.

CAN ECOLOGICALLY HOMOGENEOUS REGIONS BE IDENTIFIED?

One hypothesis as to how the landscape can be divided into major units of environmental significance has been put forward by G. A.

Hills (1960). He defines site regions as "Regions within which the effectivity of macroclimate is assumed to be relatively uniform since these regions are established through comparing the natural succession of vegetation on similar landforms, rather than by meteorological data". And he says: "From the standpoint of forestry practice, the most pertinent feature of a site region is that it is an area in which similar responses may be expected from similar natural disturbances and forestry practices, within similar combinations of landforms and forest types".

What this means in effect is that the identification of stages of similar successional series on similar landforms identifies climatic similarity too. When, in moving outward from the core of a region, one encounters different successional series on previously identified landforms, then climate has obviously changed (for substratum is a constant) and a site region boundary is indicated.

All resource people owe a debt of gratitude to Angus Hills for drawing attention years ago to the importance of physiography as a chief determinant of biological productivity. However, implicit in his "macroscopic" approach to site region definition are all the difficulties previously outlined. First the approach assumes we have that desirable accuracy in the taxonomy of species and of landforms which would assure the user that the plant-substratum relationships he observes have a precise indicator significance. Then too it assumes that history and chance play only a minor role in the distribution patterns of vegetation visible today, so that presence or absence of species can be attributed to the "now" environment. Finally, it postulates identifiable recurring plant communities linked in predictable time series, making possible the identification of similar successions.

The last postulate derives from an organismal interpretation of succession-to-climax and carries the following set of sub-assumptions:- That vegetational successions are directional, predictable, observable; that successions are equivalent in scale (time and space) and hence in meaning; that different observers will perceive in nature the same successional series and will interpret them similarly, and that agreement is therefore possible on the bounding of site regions in terms of succession-landform relationships. Unfortunately, none of these assumptions is widely accepted.

THE ONLY "GOOD" ENVIRONMENTAL BOUNDARIES ARE PHYSIOGRAPHIC BOUNDARIES

The foregoing suggests that many of the boundaries of Forest Regions and Forest Sections have only vague environmental significance, particularly when they have been identified primarily by the presence or absence of certain tree species, but I make haste to point out that the description of the forests in "Forest Regions" was supposed to be just that; a geographic description. To read climatic significance, for example, into these broad divisions is to assume a simple one-to-one relationship between vegetation and climate, a trap that has caught as many climatologists as botanists.

The "good" environmental boundaries are much more likely to be physiographic; those of relief, topography and geology. The reason is that major landforms actually "make" the climates that adhere to their surfaces. It is the elevation of the land, its exposure and topographic roughness that influences what precipitation falls or accumulates on its facets, what radiation and heat budgets characterize its flats and slopes.

A good base for an environmental stratification of the landscape is a map of its major geologic-relief features. We know intuitively that uplands differ from lowlands, plateaus from dissected terrain. So the boundaries of large physiographic units and their subdivisions often suggest themselves to us; by abrupt breaks in relief, in topography, and in rock type. Obvious changes in vegetation and soils can, of course, be used with caution, to indicate where biologically significant boundaries should be set.

I suspect that if this were done in Alberta, many of the divisions arrived at independently would fit with the boundaries of the Forest Regions and Forest Sections - which would be A Good Thing!, but no one should expect the two sets to coincide, or should be disappointed if they do not.

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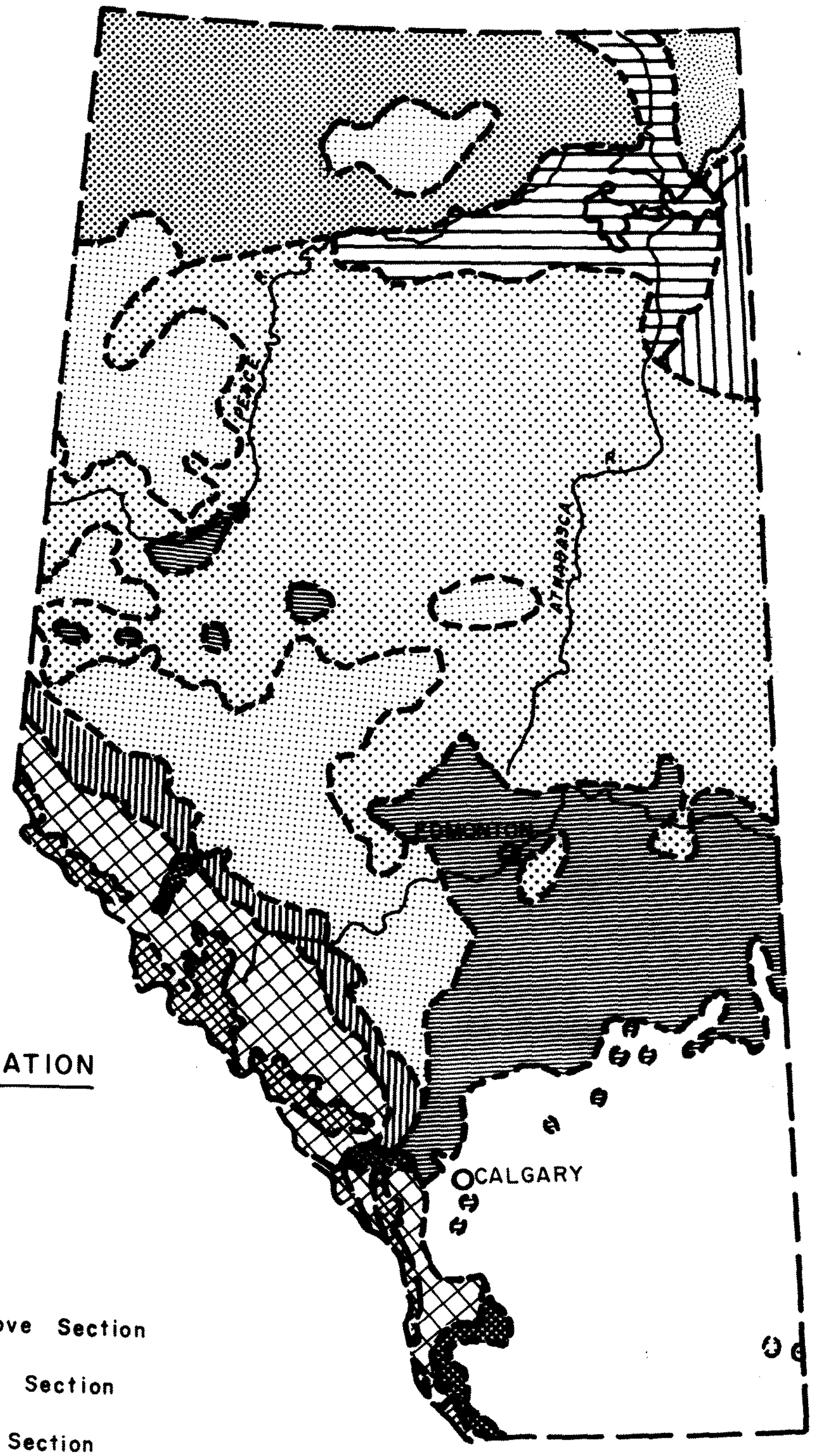

FIGURE I

FOREST CLASSIFICATION

	Tundra
	Subalpine
	Montane
17	Aspen Grove Section
18A	Mixedwood Section
18B	Hay River Section
19A	Lower Foothills Section
19C	Upper Foothills Section
22B	Athabasca South Section
23A	Upper Mackenzie Section
27	Northwestern Transition Section
	Grassland

SOIL-HABITAT INFORMATION FOR FOREST LAND

by

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My intention this morning is to remind you of some of the bits and pieces of information that can be collected, and, with the help of the panel, tell you something of how it is collected, and, finally, we will have some discussion on the interpretation and use of the data gathered.

I wish to start with two assumptions or problem areas: first that we do not know everything that there is to know about the landscape, and secondly, that land use and management of the land is the ultimate goal. The latter objective is achieved by the maximization of net revenue, income, profit, utility, and satisfaction. However, if the first assumption is valid, then we require more and more knowledge of our landscape if we are to reach the goal of rational land management. I wish to confine my remarks mainly to the first problem and leave the second problem (management of the land) to some future date.

For my purpose, a landscape is defined as being composed of "all of the characteristics that distinguish a certain area on the earth's surface from other areas". This definition is very close to what I would use for environment - "the complex of climatic, edaphic, and biotic factors that act upon an organism or an ecological community and ultimately determine its form and survival". Note that the word community refers to "area". The surveyor's job, or profession, is to describe the landscape, produce maps of it, and if the work is advanced beyond the inventory stage into the interpretive stage, then he is constantly making comparisons - of one area of land with another, or with many other areas of land. The collection of inventory data and its interpretation is necessary to provide an adequate base for most of the resource-management decision that must be made, whether the decisions are for broad multi-use planning or for specific decisions on a small project plan.

Well - what are the components of the landscape?

1. Minerals and rocks - these are permanent features of the landscape; the kind of mineral influences the rate of weathering and the physical and chemical properties of rocks. e.g., compare granites with limestones, sandstones, shales, etc. For comparison, see examples of geological and surficial geology maps, i.e., St. Onge, Roeds, Stalker, Westgate, and others.

2. Landforms - these are obvious features of the landscape - e.g., plains, hills, deltas, floodplains, moraines, terraces, etc.

These landforms may be subdivided further into various kinds of hills, plains, moraines, etc.

3. Soil - soil develops from many kinds of parent material and is modified by plants and man. The important functions of soil are:

    (1) to serve as a rooting medium for plants

    (2) to supply a primary source of mineral nutrients and water.

It is axiomatic that an understanding of soil properties and an evaluation of the soil resource must be among the first steps in land management. More on this subject later on.

4. Climate - climate is part of our landscape and we all know about wet years, dry years, cold and warm ones. Landscape areas are described as humid, subhumid, arid, cool-humid, etc. Climatic records are usually expressed as averages, but it is climatic extremes that cause difficulties in management. Land managers cannot do much about the overall characteristics of climate, but we can affect the microclimate of an area by management; e.g. - drainage of a swamp, tree removal, fire, overgrazing, shelterbelts, etc. Thus the suggestion that we give more attention to the microclimate component of the landscape than in the past.

5. Living components - these are the most transient features of the landscape. There may be seasonal changes, or yearly changes, or changes over a long period of time. The plants and animals are manageable, some features may be quite extensively and/or intensively manipulated - others may not.

6. Man - is the final component of the landscape - roads, trails, houses, towns, cities, dams, powerlines, bridges, seismic lines, pipelines, pulpmills, etc.

I am now assuming that most people agree that "Soil-Habitat Information for Forest Land" means that we require a system of collecting data (inventory) that describes the components of the landscape, and locates these components on maps, and that the system has sufficient merit to permit "interpretation" for management purposes.

A number of different methods have been developed by various agencies to inventory and interpret the components of the landscape. One of the better summaries available is a "Review and Comparison of Site Evaluation Methods" (Jones, 1969), and I wish now to provide you with a brief look at these 8 methods of site evaluation. The methods I will refer to, are:

The Site Index Approach

The Vegetation Approach
- (1) Vegetative Classification
- (2) Vegetation Ordination

Environmental Approach
- (1) Factorial Approach
- (2) Holistic Approach
  - a. the Soil Survey Approach
  - b. the German System of Site Mapping
  - c. Angus Hills' Physiographic Site-Types
  - d. Environmental Ordination

I will be followed by Mr. Mike Romaine, who will describe the Biophysical Land Classification system, a fifth holistic approach to description and analysis of the landscape. He will be followed by Mr. Julian Dumanski, who will add to what I have to say about soil survey and will describe a system of mapping the soil chemical components of the landscape. This latter methodology is important because most of the holistic systems emphasize the physical base of landscape inventory and tend to ignore the chemical properties, or to treat them superficially. This approach points out that the soil materials vary chemically throughout the landscape and any inventory map has to be evaluated accordingly. Dr. Pluth will conclude the panel with a paper on soil-survey limitations, soil parameters and their interpretations. A short summary will then conclude the panel's efforts.

THE SITE INDEX APPROACH

Assumptions are:

(1) The height-age curves produced are harmonic.
(2) The site index given by any stand will not change during the life of that stand.

Suggestions to reduce errors from these assumptions are to use "natural" site index curves or stem analysis. Another method is to develop separate site-index curves for different soil or landform categories. This is really superimposing a site index classification on an environmental classification. Some problems with using the site index approach are:

(1) That the assumption that height-growth is not importantly influenced by stand density is not valid; e.g., lodgepole pine is strongly influenced by stocking over a wide range of densities and the height-age relationship is largely useless as an index of site. (Dog-hair stands of lodgepole pine near Hinton)

(2) For valid results, the site must bear an even-aged overstory where heights of dominants have not been strongly influenced by stand history, e.g., by thinning or disease.

(3) The species present on a site may vary with different combinations of environmental components.

(4) Site index is an index only to yield potential and is not generally suited to other purposes of silvicultural prediction, e.g., one

site with a high site index may be easily regenerated and another may not.

(5) One cannot use site index in the absence of a satisfactory stand to measure.

However, site index is a good tool for estimating productivity and for practical purposes it may be close enough to predict future height within 10 ft.

A need remains for the classification or ordination of sites based on environment, or vegetation, or both, not to replace the site index approach, but to supplement and refine it.

THE VEGETATION APPROACH

The vegetation approach or the use of vegetation to define the ecosystems, the difference between the use of the term "vegetation" vs. "ecosystem" being the degree of emphasis given the environment in deciding upon the defining vegetation. The approach may be subdivided into classification and ordination methods.

Classification

Early attempts were made to classify forest ecosystems according to vegetation but with the explicit consideration of habitats. This meant subdividing the habitats into forest site-types. Growth studies, yield-prediction tables, and site-types were techniques used by some people to provide a frame of reference for forest management and research.

Coile (Jones, 1969) pointed out that climax vegetation cannot be recognized after severe disturbance, and that shallow-rooted vegetation may not reflect the deeper soil conditions.

The Swedish conclusion was that their site-types had too much growth variability and suggested that growth is more sensitive than vegetation composition to differences in elevation, slope direction, and past stand treatment. In Latvia, explicit attention was given to the soil profile.

I hesitate to talk about Rowe's classification especially since Dr. Rowe is here this morning and is quite capable of defending himself should I say the wrong thing. However, I think it is fair to say that Dr. Rowe's classification is based on community-habitat relations and reflects differences in climate and physiography.

Krajina's system is another classification of ecosystems according to vegetation.

Ordination

The composition of vegetation can be viewed as a response to variations in environment and history. This means that the environment may be regarded as a continuum, much along the lines of climatologists who use isotherms, isohyets and so on. Thus, ordination is the arrangement of vegetational data along axes, e.g., theoretical gradients of moisture and nutrients.

Bakuzis (Jones, 1969) developed an operational system of vegetation indexes to forest environments which he calls "synecological coordinates" - (moisture, nutrients, heat, and light). A list of forest plants of Minnesota was compiled, and each species was assigned a value for heat, nutrients, light, and moisture. Maximum values were 5 and minimum, 1. The first values were approximated on geographic distribution and known ecology of the species, e.g., a species in its northermost occurrence on an exposed south slope in southern Minnesota would be assumed to have a high heat requirement for that state and would be given a maximum heat index value.

Pluth and Arneman (Jones, 1969) found that Bakuzis' moisture and nutrient ordinates strongly correlated with such soil factors as moisture-holding capacity, silt-plus-clay fraction, and exchangeable potassium.

The presence and abundance of each plant species expresses a set of environmental factors unique to that species. A community of plants should express pretty much all of the biologically relevant factors and interactions. Vegetation ordination uses communities to express that integration of factors more flexibly than classification does. However, the ways in which plant communities integrate factors are hidden, and are relatively unamenable to analysis. Improved systems of vegetation ordinations will likely come mainly from aiming ordination at narrowly defined purposes, and from improved index values based on instrumented field studies of species.

ENVIRONMENTAL APPROACHES

The environmental approaches to habitat description and evaluation are either factorial or holistic. The factorial approach uses one or more environmental factors believed limiting to the biological point or process of interest. The holistic approaches subdivide or ordinate the environment as a whole.

Factorial Approach

Where locations do not have stands suitable for site index measurements, the attempt is made to approximate site index relating it to one or more limiting factors, e.g.,

> silt + clay to estimate site index for a particular species.

The following steps are required to apply this technique:

(1) Select environmental factors which might limit or be related to site index.

(2) Select factors of major importance that are practical to work with.

(3) Definition of a study universe which will restrict as many of the other factors as feasible to a reasonable degree of uniformity.

(4) Location of plots in stands suitable for site index determination on habitat sampling the range of variability of the factors being studied.

(5) Collection of site index and environmental data.

(6) Regression analysis.

Usually, soil factors or topographic factors that influence moisture supply are important, e.g.,

soil depth
stone content
soil texture
water values
depth to mottling
degree of slope
slope position
aspect
concavity or convexity of slope

Other features are:

chemical analyses for nutrient regimes
climate (temperature
(precipitation
climate (latitude
(elevation

The coefficient of determination or standard error is used to evaluate the suitability of an equation for estimating site index. Equations for estimating site index from habitat variables seldom account for more than 50 to 60% of the site index variance.

The factorial approach is good when used within narrow subdivisions of a regional environment. However, in areas with a complex of environmental variables, even with a single cover type, these variables may limit biological behaviour in a variety of combinations, may interact ecologically and may be difficult to analyze statistically. Thus, it appears that one may have to use a holistic classification as a framework for the factorial approach.

Holistic Approaches

The environment is classified by classifying the landscape as a whole, e.g.,

(1) the soil survey approach

(2) the German system of site mapping

(3) Angus Hills' physiographic site-types

(4) environment ordination.

Soil Survey Approach. Soils information has been collected and presented to the public by the Soil Surveys of this province since 1921. Alberta has more soil survey coverage than any province in Canada, excepting Prince Edward Island and Nova Scotia, which are only good-sized counties in any case. There is not sufficient time today to discuss in detail the principles, procedures, and activities involved in soil classification and mapping. I wish to remind you that soils are 3-dimensional segments of the landscape and have external and internal characteristics. Soils people use mainly the internal characteristics for classifying and mapping soils (e.g., horizons, color, texture, structure, mottling, water storage, etc.). Some of these characteristics are quite easy to measure; others are not. I am not sure, for example, if a good method of determining available boron has been developed or not. External characteristics are topography, slope, elevation, exposure, stoniness, rockiness, and are used as guides to help locate soil boundaries during mapping. Soils are identified by their shape and form or morphology and classified by a taxonomic system based on their observed and measured natural characteristics. Soil classification is simply a man-made arrangement to assist people in remembering the many soil characteristics encountered. Why? The obvious answer is so people can make interpretations, and draw better inferences and make better predictions for management purposes. The taxonomic soil classification is an objective arrangement of soils based on their natural identifiable characteristics. It is a study of significant soil characteristics or properties and their arrangement in the soil. The reasons for taxonomic soil classification are:

(1) to recognize and remember many kinds of soils

(2) to assist in determining the suitability of soils for different uses

(3) to assist in accumulating and organizing data relating the response of a certain kind of soil to kinds and levels of management. This prediction behaviour of soils to proposed kinds of management is an important use of the soil survey.

A real logistics problem in soil classification is that the soil worker characterizes relatively few plots in comparison to the forester.

Different systems of soil classification exist - since we are in Canada, we use that system and for details I would refer you to the appropriate publications.

Besides soil classification or taxonomy, land resource inventory also includes soil mapping. A soil map shows where soils occur in relation to each other and to other landscape components. Each soil mapping unit is composed of natural soil areas of the landscape and is enclosed by a line on a map. There are several kinds of mapping units, depending on:

(1) purpose of the map

(2) scale of map

(3) intensity of coverage

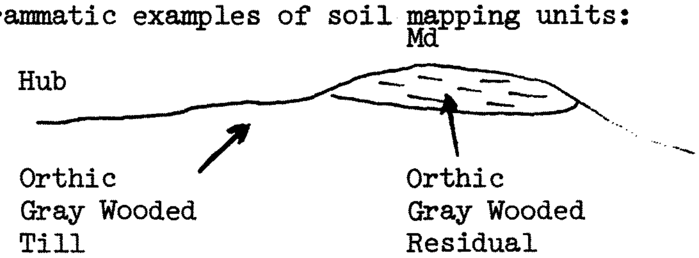
(4) time available for the survey

(5) the combinations of soil units that occur in association with each other, e.g., the following soil legend —

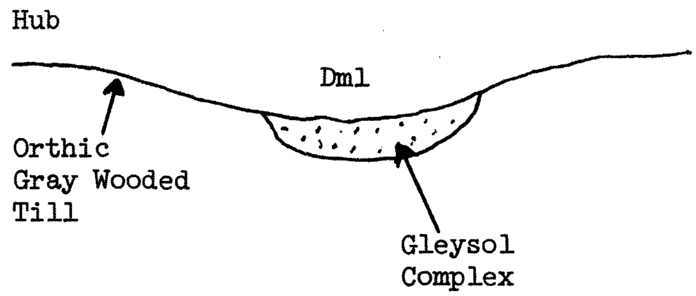
Parent Material	Soil Sub-Group	Soil Series	Map Symbol
Modified Tertiary Gravels	Bisequa Gray Wooded	Judy	Jy
	Gleysol Complex	Mayberne	Mbn
	Degraded Eutric Brunisol	Barbara	Bar
Residual	Degraded Eutric Brunisol	Levi	Lvi
	Orthic Gray Wooded	Modeste	Md
	Orthic Eutric Brunisol	Warden	Wan
Continental Till	Orthic Gray Wooded	Hubalta	Hub
	" " "	Breton	Bn
	Bisequa Gray Wooded	O'Chiese	Oh
	Gleysol Complex	Dismal	Dml

— may give rise to these diagrammatic examples of soil mapping units:

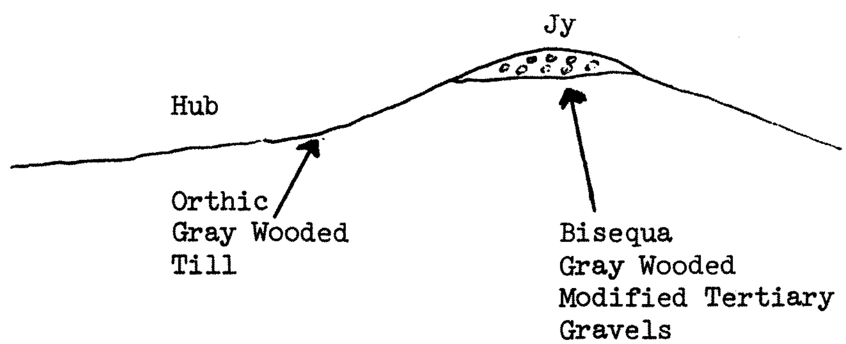
$\frac{\text{Hub}}{\text{cb}} + \frac{\text{Hub}}{\text{sn}} + \text{Md.d}$



$\text{Hub} + \frac{\text{Hub}}{\text{cb}} + \text{Dml. c}$



$\frac{\text{Hub}}{\text{cb}} + \text{Jy. c-d}$



Identification legends identify each area on the soil map by means of a symbol. They may be on the map, or in the accompanying report. The descriptive legend is an expansion of the identification legend and is a written record of the soils mapped. Since soil is an expression of the environment, the soil may be used to develop an environmental-ordination approach. It has the advantage of being a relatively stable component of the landscape, but soil survey as a habitat classification in forestry has a large and cumbersome number of mapping units (e.g., 50 to over 100 in some cases), and soil survey classification is not an ecological classification, but is the base for one. Thus, the multiplicity of mapping units gives the system versatility, but the mapping units must be interpreted for silvicultural or whatever purposes.

Interpretive data may indicate a certain grouping of the mapping units for a classification of timber productivity and a different grouping for reforestation purposes.

Other interpretations might be:

(1) evaluation for erosion hazard

(2) trafficability

(3) regeneration problems

(4) forest disease and insect problems and so on.

For a system of pedological classification for wild-land management, it may be better if pedological mapping ended with great soil groups or subgroups, which could then be sub-divided into ecologically defined phases.

Interpretative legends are used in some surveys (e.g., the Canada Land Inventory) that map interpretative classes such as capability classes for agriculture, forestry, and so on. Usually, the classes are defined by physical factors that limit or impose retrictions to a kind of land use and/or an index of a crop, group of crops, or some other criteria, for example, a suitability rating of soil and rock material for road construction. The limitations to the type of survey using the interpretative legend are as follows:

(1) it assumes that enough is known about the intended use of the soil so that no serious errors are made. Let us remember that we live in an age of rapid technological change.

(2) the lines plotted on this type of map do not separate basically different soils, but are based on certain soil characteristics assumed to be of significance to the intended use

(3) the response of a certain kind of soil results from the particular combination of characteristics in that soil; thus, the relevance of any one characteristic varies from soil to soil, e.g., texture

(4) no reinterpretation of the information on the map is possible, as would be the case if different kinds of soil had been mapped

(5) when new information is needed it is necessary to make another costly survey of the same area.

The standard soil survey has a much broader base and many contrasting interpretations can be made from the same basic soil information. Reinterpretations may be made for new crops, improved soil-management practices, and urban planning, etc. (See Soil Suitability Guide for Land Use Planning in Maine).

Do not understand from this that I am against interpretative classifications. On the contrary, I advocate more of them, provided they are interpretations made from an adequate inventory base. For this reason, I have asked Mike Romaine to speak on the Biophysical Land Classification system, with emphasis on the inventory and interpretive possibilities.

The German System of Site Mapping. The German forest-soil maps are prepared with a first level of classification that recognizes genetic soil groups equivalent to "great soil groups". The second level of classification reflects the effects of soil, parent material, and topography on the forest, and is therefore composed of ecological criteria rather than primarily pedological.

Angus Hills' Physiographic Site-Types. This system (Jones, 1969) is the "total site" classification, total site being defined as "an integrated complex of climate, relief, geologic materials, soil profile, ground water, and communities of plants, animals and man". The vegetation helps to set physical definition and field identification of the physiographic site-types. The 3 main environmental regimes are climate, moisture, and nutrients. Macroclimate is held essentially constant by working within geographic sections. The other regimes have 10 intensity classes and some of the environmental elements can occur in more than one regime; e.g., topography is significant to both climate and moisture regimes.

The problem with Hills' system is that of classifying uniformly, or consistently according to the practitioner's judgment. Thus, it is using insight and trained judgment for integrating factors subjectively.

In soil survey, the soil profile is of key importance, whereas with Hills', different profiles may occur within the same physiographic site-type. The physiographic site-type has use as an integrating framework for vegetation, soils, local climate and site. From these data, one may obtain a productivity evaluation and silvicultural prescription.

Environmental Ordination. Where one or more environmental gradients are defined and each ordinate integrates relevant habitat factors by means of a theoretical model and the available data. e.g. Thornthwaite and Mather's annual "soil moisture deficit" is a moisture regime ordinate that integrates experimental data on precipitation, evapotranspiration, soil moisture storage capacity, etc.

Loucks (1962) attempted to demonstrate methods through which the structure and composition of diverse forest ecosystems may be described and the relationships between community variation and gross environmental influences assessed. He applied scaling to Hills' environmental regimes. Whereas Hills integrated factors subjectively, using insight and trained judgment, Loucks integrated them using theoretical but defined relationships of factors to one another and to plants. Thus, he related the composition and structure of forest communities to the resulting environmental ordinates, or "scalars".

Loucks realized, as most people do sooner or later, that it is virtually impossible to express the degree to which each and every part of the environment influences the nature of forest communities. So he followed Hills' suggestion and evaluated what appeared to be the most significant components of the primary environmental features, namely, moisture supply, nutrient supply, and local climate. Three major factors are considered for the Synthetic Moisture Regime scalar, six in the Synthetic Nutrient Regime scalar, and four in the Synthetic Local Climate scalar; e.g., the Moisture scalar combined the water-holding capacity of the soil, depth to water table, and a run-off scalar.

Jones (1969), working with aspen, developed moisture regime and temperature regime ordinates, but not a nutrient regime. The temperature and moisture regime ordinates were calculated for each plot and the multiple regression of site index on the two environmental ordinates was computed. Both partial regression slopes were statistically significant and, combined, accounted for about 30% of the total site index variation. He suggests that genetic, clonal variability and the various assumptions used in constructing the ordinates caused much of the unaccounted for variation in site index.

Jones further points out:

(1) that an environmental ordination reflects how we believe the environmental factors act together to influence plants. Therefore, the success of that ordination is limited by how correct our understanding is.

(2) As we improve our understanding of how environmental factors interact to influence plants, we can provide improved environmental ordinations.

Loucks emphasizes that the need exists to recognize the ecosystems as functional systems of interacting physical and biological processes. This view also emphasizes the continual variation of the system geographically, as well as historically. If a general system theory (Ashy) or information theory (Margalef) is to be applied to a variety of ecosystems, models in multiple dimensions will be required.

CONCLUSION

Of the forest evaluation methods discussed, all but the soil-survey approach are biased toward productivity, thus limiting their usefulness of interpretation for other purposes. This does not imply that these methods are of no use for forest land management, but that the limitations must be recognized. The method of Loucks attains a closer realization of environmental ordination by attempting to use a systems-analysis approach to treat the environment as a whole so that management criteria can be imposed as desired.

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T H E   B I O P H Y S I C A L   P R O G R A M

by

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Since the beginning of time, man has attempted to understand and classify the environment and its influence around him. One of the first assumptions apparently was that the environment was composed of three essential factors for survival - earth, fire, and water. Over time, man has devised increasingly comprehensive systems of classifying the environment. Probably, one of the most notable works in this regard was by Jenny (1941), who drew attention to the variables of the natural environment. In doing so, he also pointed out that some variables are independent and control the nature of other variables that are independent. He enumerated these variables when he stated that soils are a function of organisms, climate, relief, parent materials, and time. (See figure 1).

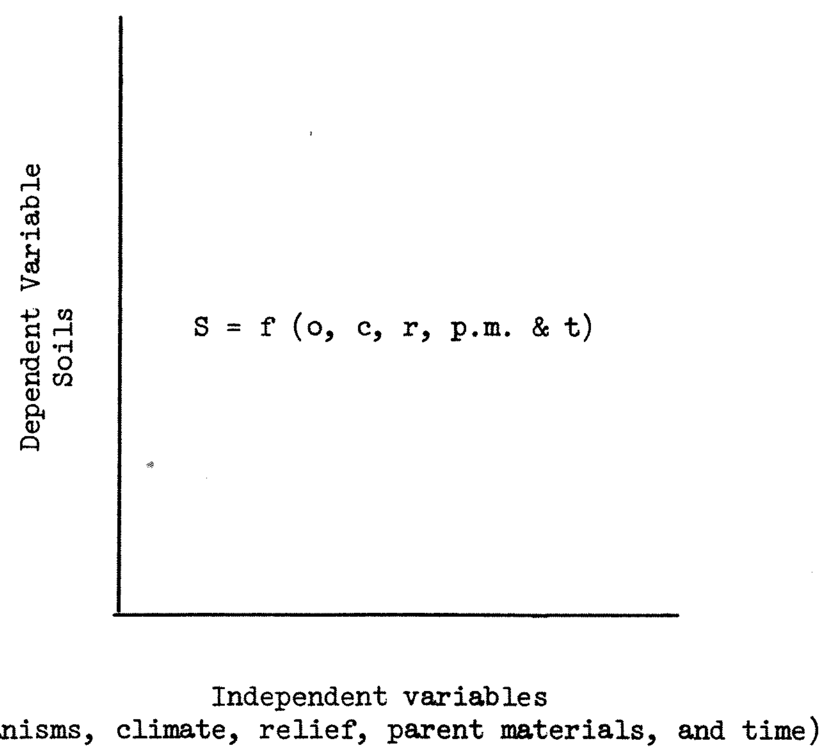

Figure 1 - Soils expressed as an independent variable.

Similarly, other classification systems for other needs and uses have been developed. This has often resulted in the development of single-use classifications and surveys based predominantly on one or other single factor such as soil alone or vegetation alone. When this has occurred, there has been a tendency to treat other environmental features as separate and not as interacting factors. This has resulted in a rather rigid and uniform use of different criteria and categories for each different level and kind of inventory that has developed.

Such approaches have resulted in the collection of a great deal of information and has given us an insight into the understanding of many aspects of the environment. For example, those factors that influence soil development as well as their effect on the productivity of certain crops are now fairly well known and understood. (See figure 2).

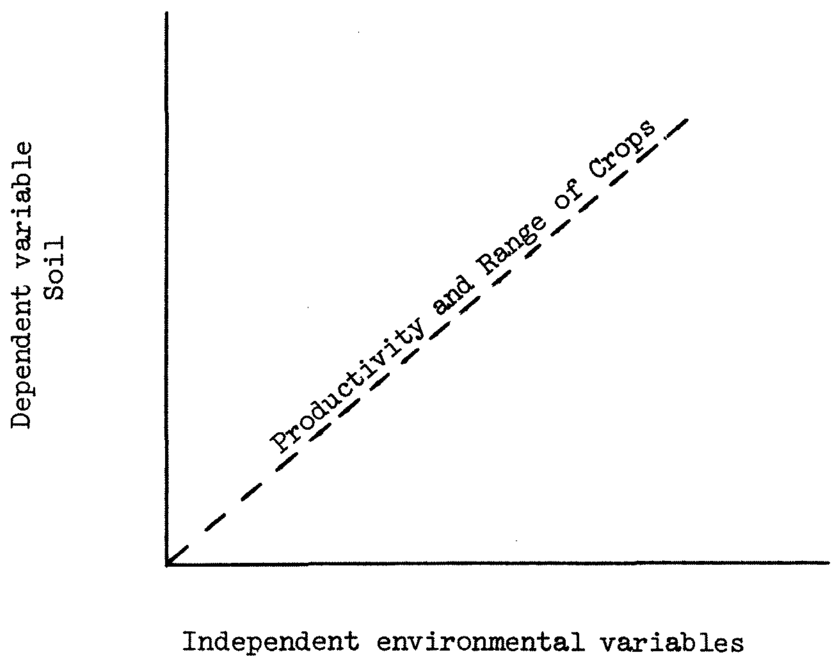

Figure 2 - Generalized graph showing effect of independent variables on types of crops and their productivity.

Similarly, such a forest investigation as on site index has resulted in the development of site maps, which relate species productivity to various environmental factors. (See Fig.3).

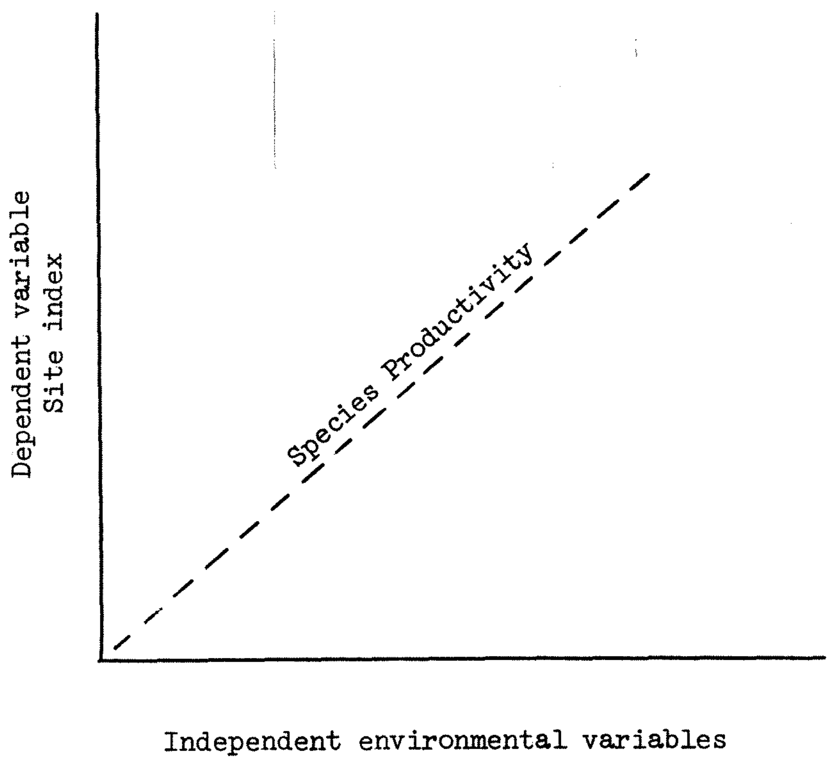

Figure 3 - Generalized graph showing relation between tree-species productivity, site index, and selected independent environmental variables.

As can be seen from the above two examples, classification systems have in fact resulted in parallel systems, each of which measures those environmental factors with the greatest significance to the use concerned. (See Fig.4).

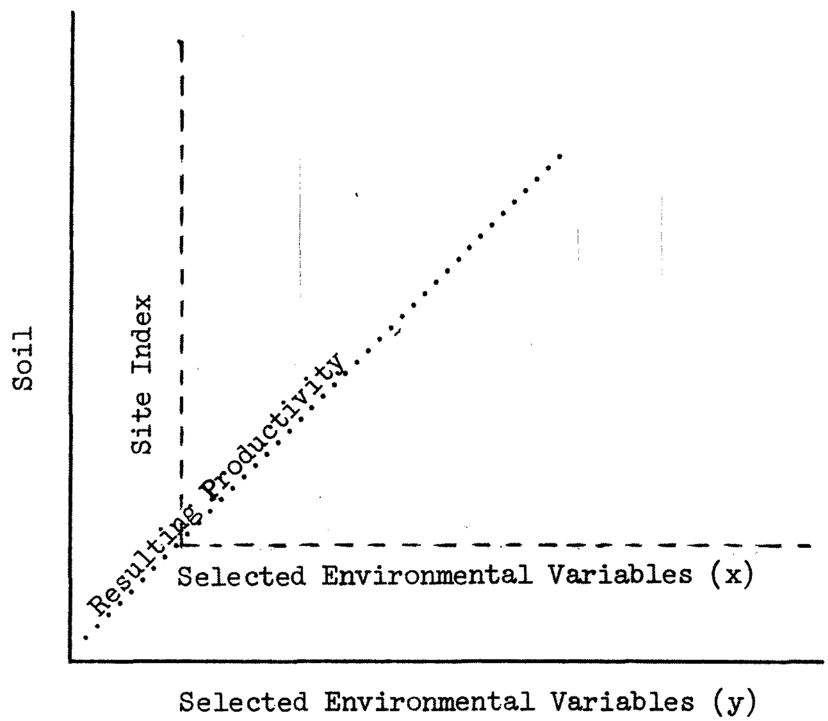

Figure 4 - Generalized relation between different purpose classification systems and selected environmental factors.

These stratified classification schemes therefore suggest that what is really required is a classification scheme that not only incorporates findings and techniques from systems such as those mentioned above but also assists in the understanding of the relationships and interaction between significant environmental features. Such a system must consider those features of the environment that are relevant to land use such as the independent factors, climate, parent material and topography, the dependent factors soil and vegetation, and the dependent attributes such as potential productivity, problems, hazards, incidence of erosion, and methods of development. (Gibbons and Downes, 1964).

It is believed that the Biophysical Land Classification system is an approach that can satisfy the above-listed requirements. This classification system is broken down into the following levels of generalization (Lacate, 1969). See Figure 5.

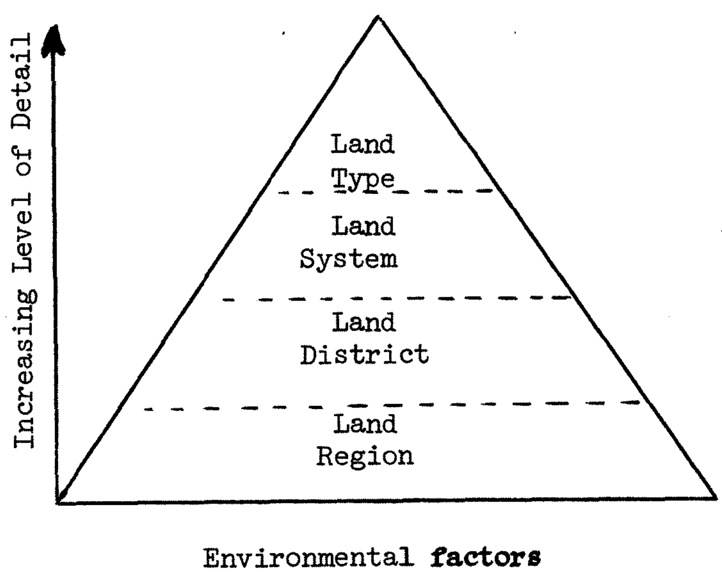

Figure 5 - The four levels of classification in the Biophysical system.

The first level, the Land Region, is defined as an area of land characterized by a distinctive regional climate as expressed by vegetation. The Land Region is usually of large areal extent and is inevitably more or less heterogeneous.

The second level, the Land District, is an area of land characterized by a distinctive pattern of relief, geology, geomorphology and associated regional vegetation. The Land District is a subdivision of the Land Region based primarily on the separation of major physiographic and/or geologic patterns which characterize the region as a whole. Land Districts have a common pattern of relief, structure, or comparable geomorphic evolution.

The Land System or third level is defined as an area of land throughout which there is a recurring pattern of landforms, soils, and vegetation.

The fourth and final level, the Land Type, is presently defined as an area of land on a particular landform segment, having a fairly homogeneous combination of soil and chronosequence of vegetation.

The Biophysical Land Classification system, then, is a means whereby the land surface is stratified into different hierarchical levels, the division of which is based upon environmental criteria. The difference between the four levels of the system is dependent upon the patterns and homogeneity of conditions. Since patterns of environment are recognized at different levels, the information collected at any stage is immediately relevant to the next stage for an area of any size and therefore provides for the required assessment to be carried out at various levels for the various resource users concerned. Since resource use and hence management and planning is dependent upon environmental limitations, the degree of limiting factors for a particular use can be matched with that level of detail provided by the classification system.

Since the objective of this symposium is to deal with the subject of "Forest-Land Inventory for Management", an attempt will be made to show the application of this system mainly to the forest resource.

The two broadest levels of the system, the Land Region and Land District, can provide an initial prestratification of an area into vegetational zones. These zones can, in turn, for example, provide the basis upon which data collection and the resulting stand-volume table construction can be achieved in order to reflect major forest regions in the province as described by Rowe (1959).

The third level, the Land System, is the most significant and important level for resource inventory. At this level, it is possible to delineate the predominate capability of certain areas, the major related management problems, as well as a description of many of the environmental factors resulting in these applied ratings. Such a level will provide stratification which will allow the definement of significant and representative areas for much of the study area. These delinations will not only provide generalized areas for follow-up forest investigations but will also point out kinds of expected land-use conflicts.

The detailed level, that is, the Land Type, provides a homogeneous base upon which to collect forest-site data and upon which to carry out detailed forest management investigations and other land-use studies.

Data collected at any level can not only be related to other levels of the system, but also to other areas of the province where similar environmental conditions or limitations exist.

Listed below are the most important requirements for the successful implementation of a Biophysical Classification System.

1. Recent high-quality aerial photographs and well-qualified specialists for their interpretation.

2. Sampling procedures that will yield adequate information with the broadest possible application for the various resource fields.

3. An interdisciplinary coordinated approach by a team of various resource specialists who will be able to collect and interpret the resulting data and who will be able to evaluate and recommend required changes to the system used.

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SOIL AND SOIL DATA SUMMARIZATION

by

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ABSTRACT

The high degree of variability peculiar to analytical soil-survey data has generally precluded their systematic characterization. This paper deals with the application of the Statistical Prediction Technique to such data and contains two contour maps of surface, mineral horizons to illustrate the results.

INTRODUCTION

There are many methods of data collection pertinent to earth sciences. Data presentation, however, is difficult because of the high degree of local variability common to such data. This paper outlines a procedure of data summarization - a procedure that has been applied in summarizing soil chemical data (Dumanski, Newton, and Lindsay, 1970), and one that was found to be quite interesting. The results of this procedure must be viewed in terms of the type of information that they are trying to convey and, therefore, a few pertinent observations on the nature of the soil are necessary.

A basic law of soil science states that the soil is a function of parent material, climate, topography, vegetation, and time. To that can often be added a sixth factor, and that is man. The intensity of the effect of any individual factor is variable in terms of both time and space. For example, topography exerts a greater influence on soil profile development in the highly dissected regions of the mountains and foothills, than it does in the relatively gently undulating to rolling forested tracts of the plains. Concurrently, the passage of time alone, if associated with some particular change in conditions, may result in the intensification of the effects of one factor with a corresponding emasculation of others.

Soil formation, therefore, is a complex process involving the interaction of a number of different factors. The individual factors may not only contribute to the development of soil, but also react to each other. Hence, it is often unwise to pay undue attention to any one factor (Moss, 1965).

Soil formation involves not merely a differentiation into genetic horizons, giving to a soil a certain morphological profile, but also differentiation in a horizontal plane. This makes the soil a patterned, spatial system. It has been said (Nikiforoff, 1959) that dissection of this system on the basis of abstract soil species has no scientific justification. Although this is essentially true, the solution of various practical problems dictates that soil areas be delineated, and this is called a soil survey.

A particular arrangement of soil layers is called the soil profile, and the recognition of different profiles forms the basis of modern soil classification and mapping. The pedologist in the field is faced with the problem of delineating homogenous areas within a medium that shows continual variability in three dimensions. He does this through the application of a concept called the soil series, which is a soil body such that any profile within this body has a similar number and arrangement of horizons whose color, texture, structure, consistence, thickness, reaction, and composition are within a defined range (N.S.S.C., 1968). Unfortunately, this eliminates only part of the problem since it is only in certain areas of the world, e.g. the tropics, in which one can map individual series, and that only on detailed surveys.

The general ecosystem in Alberta is such that combinations of series present themselves in recurring patterns over the landscape. This has been accommodated in the field by the use of mapping units which are complexes of series, created by listing the individual components of the complexes in decreasing order of occurrence. A full realization, on the part of the user, of the complexities involved in preparing a soils map would eliminate much of the misunderstandings involved with this type of data.

The major part of the preceding preamble was intended to indicate that the soil is a complex, dynamic system. Therefore, there are definite, inherent dangers where users apply this information to purposes for which it was not intended and without sufficient background information on their part. It was also intended to show that soils are the resultants of various variables, all of which are continuous. It follows, then, that soil itself, and most of its natural properties, must illustrate continuous variation over the landscape.

Soil surveys in Alberta began in 1921 (Bowser, 1969). During the past half century of survey activity, tremendous amounts of physical and chemical soil data have been collected. Considerable portions of these data have been incorporated into the 26 reconnaissance survey reports and 11 exploratory reports published to date, but major amounts have remained basically uninterpreted. This paper discusses the results of an attempt to interpret these data by the Statistical Prediction Technique developed by Newton (1968).

MATERIALS AND METHODS

A total of 745 virgin-soil sites (Fig. 1) were used in this study. Of these, 620 were taken from soil-analysis cards kept by the Alberta Institute of Pedology and 125 were specially sampled. All soils used were from upland sites regardless of profile types or series; Gleysolic and Organic soils were excluded from this study.

When each soil site is located in terms of x and y coordinates, and each datum value is expressed as a z coordinate, then the result is a three-dimensional surface over the map area for each analysed function. The local variability of the data is such that only a form of statistical analysis allows one to draw contour lines representative of such surfaces. The Statistical Prediction Technique attempts to accomplish this.

Two basic assumptions are inherent in this procedure. The first is that each datum value is representative of the area sampled, or if the value is out of proportion with neighboring ones, then its importance is downgraded. The second is that the value for each analytical variable is uniform throughout the thickness of the horizon.

Any sample value, which consists of the location site and the analysed data value, is not unique. If the region of that site were repeatedly sampled and analyses that yielded that particular value were accepted, then the proportion accepted would effectively define some form of spatial-probability function. Thus a complete data map should include not only a mean data value for any location on the map, but also an associated probability function that that value could be found elsewhere on the map. Therefore, there is a probability $P(x,y;x_i,y_i)$ that the datum value V_i, sampled at the location (x_i,y_i) could also be found at location (x,y) on the map. If this is repeated for every datum value and the results are summarized then a value Vp

$$Vp = \sum_i V_i P(x,y;x_i,y_i) / \sum_i P(x,y;x_i y_i)$$

could be assigned to (x,y) as the most probable on the basis of the sample values measured. In this study the assumed probability function is of the form

$$P(x,y;x_i,y_i) = \exp(-Ar)$$

where r is the distance between two points and A takes the form

$$A_i = A(1+dV_i/S).$$

dV_i is the difference between the measured and predicted value and S is the standard error of the measured values. In this way the value of A is modified for each value to A_i, and adjusts the effect

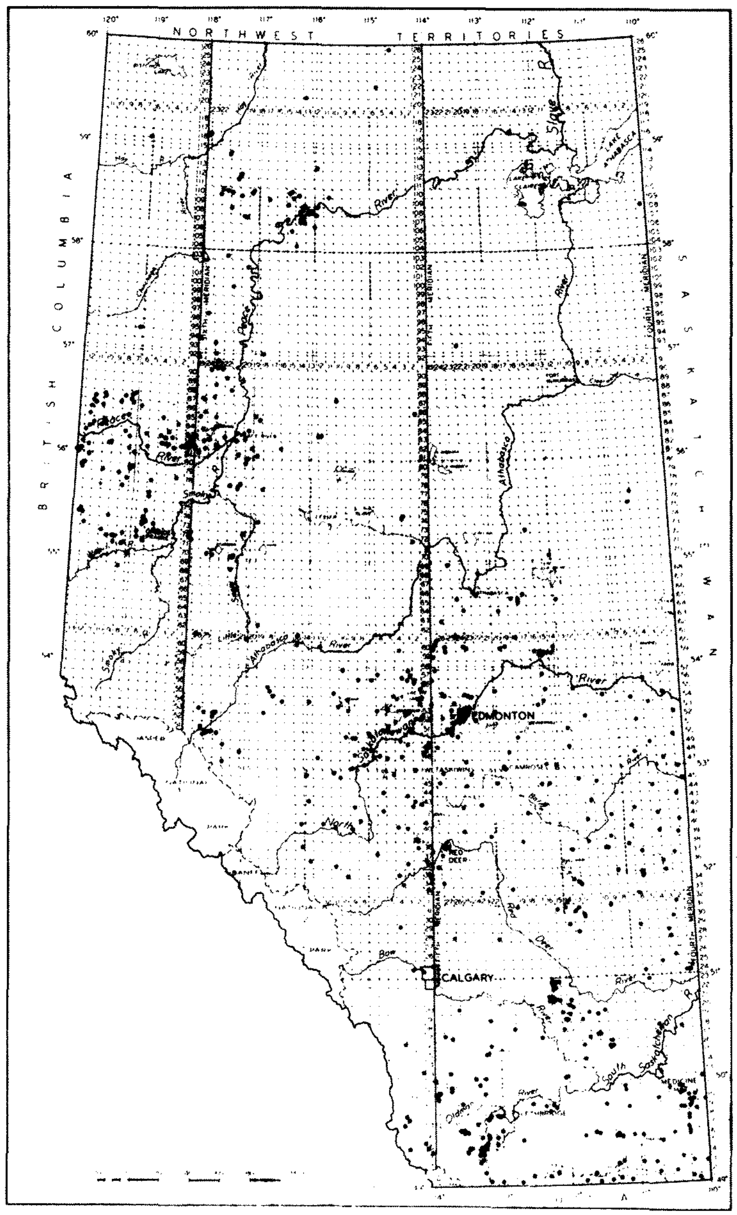

FIG.1 SOIL SAMPLING SITES

of those values that show greater apparent error. Two contour maps illustrate the results of this study. A full discussion may be found in Dumanski, Newton, and Lindsay (1970).

RESULTS AND DISCUSSION

The geographic distribution of total base saturation of the cation exchange complex in A horizons is shown in Fig. 2. This plot reflects general similarities to the soil zones of Alberta (Odynsky, 1962), to the agro-climatic areas of Alberta (Bowser, 1969), and to the general distribution pattern of Great Soil Groups. Thus it can be seen that surface horizons of Chernozemic soils have base saturations generally in excess of 80%, whereas surface horizons of Podzolic and Luvisolic soils are generally less than 80% base saturated. On the other hand, Solonetzic soils have base saturations that range from 75 to 90%. Within these large groups there may be considerable further geographic zonation, probably related to a combination of climate and soil material factors.

Of interest are four small areas in the 85 to 90% range. The first of these is in the Cypress Hills region, the second east of Hinton, the third around Bonanza, and the fourth near Fort Vermilion. The decrease in base saturation in the Cypress Hills region reflects an abrupt climatic and vegetative change caused by an increase in altitude; the increase in base saturation around Hinton is due to the presence of a calcareous loess deposit originating from the floodplain of the Athabasca River. The last two areas directly reflect the influence of higher amounts of calcium and magnesium in the parent material. These areas illustrate the ability of the technique to delineate regions of local extent where sampling is adequate.

In A horizons, pH values (Fig.3) range from less than 5.0 in the dissected uplands of northern and western Alberta to greater than 7.0 in the Foremost and Majestic areas. Between these extremes, pH in surface horizons of Chernozemic soils is generally greater than 6.0 whereas in Luvisolic and Podzolic soils it ranges between 5.5 and 6.5.

CONCLUSIONS

The Statistical Prediction Technique was used to condense and homogenize soil-chemical data, so as to overcome the high degree of local variability encountered. Although the maps produced give well-defined, regional distribution patterns, it must be kept in mind that these patterns are modal in character; within the confines of local areas, considerable variation from the mode could be expected. Soil samples collected during a survey generally represent dominant soils common to a mapping unit, with the result that

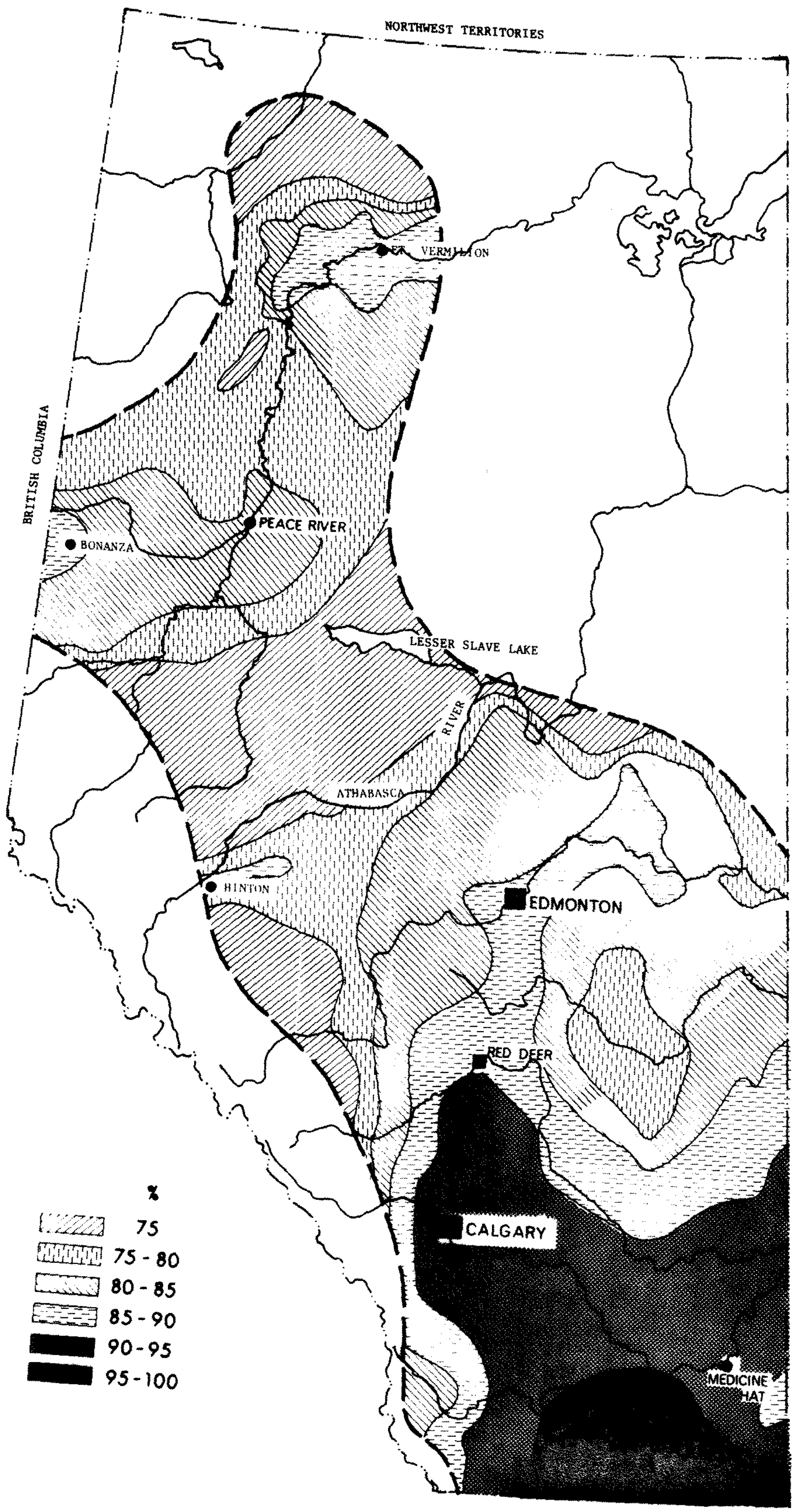

FIG. 2 BASE SATURATION OF EXCHANGE COMPLEX IN A HORIZONS.

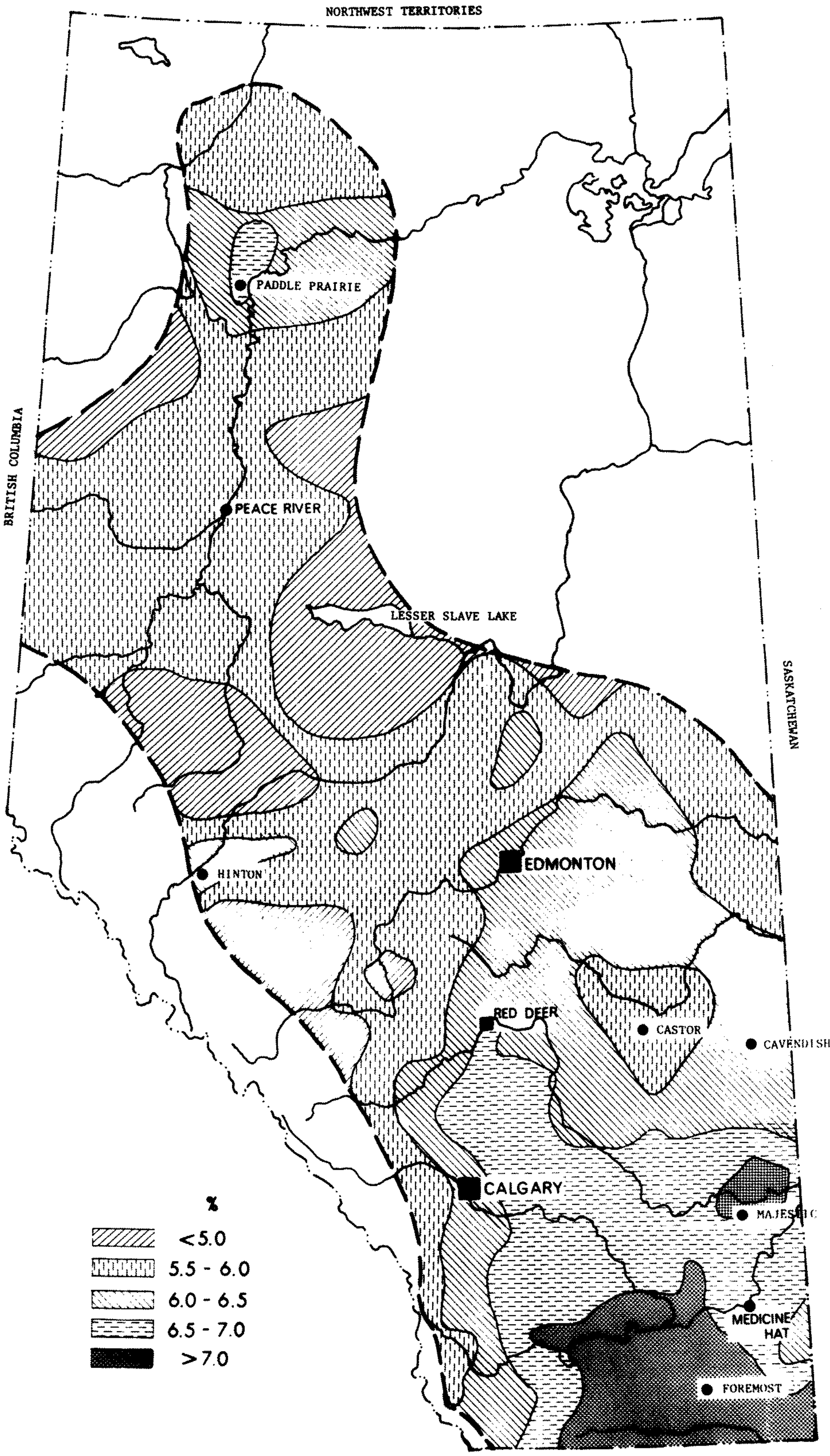

FIG. 3 pH IN A HORIZONS.

associated sub-dominant soils may not get proper recognition. Maps of this nature, therefore, are most useful when used in conjunction with, and supplementary to, available soil survey maps.

ACKNOWLEDGMENTS

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CRITIQUE OF SOIL-HABITAT INFORMATION: SOIL SURVEY LIMITATIONS, SOIL PARAMETERS, AND THEIR INTERPRETATION

by
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The previous speaker noted the multiple number of factors and their interactions that influence the development of soil. Further, a brief resume of soil-survey technique was presented.

Soil survey represents an inventory of a primary resource, soil, and must include in its production observations on other associated land features such as land form, topography, and vegetation. The major product of a soil survey, the soil map, consists of delineated areas identified by soil mapping units. Mapping units are named after classes from some level of abstraction, commonly soil series, in the natural or taxonomic soil classification. Hubalta, Breton, and Caroline are classes at the soil series level of abstraction. Soil series as classes from taxonomic classification are concepts defined by soil characteristics. Definition of soil series emphasizes soil morphology, the physical make-up of soil: color, structure, texture, consistence, and reaction of horizons. Since soil exists in the landscape as a continuum, a soil mapping unit identified by a soil series name is mostly but not entirely composed of that soil series as defined by its concept as a class in taxonomic classification.

Although soil survey and taxonomic soil classification are veritable Siamese twins, the initiation of a soil survey is usually for a practical purpose. Soil-survey interpretations are necessary to solve practical problems in the planning as well as in the management phases of land use. This relatively new field of specialization in soil science is known as "interpretive soil classification".

One objective here is to critically examine soil survey as one inventory of soil-habitat which may be interpreted for the classification and management of forested land. Needless to say, some of you as professional foresters have been critical of soil-survey information when applied to your practical problems! Next a summary of interpretive groupings useful in forest management is presented. Additionally, a few soil parameters and their interpretations will be suggested as improvements for site evaluation and forest land classification in Alberta.

CRITICISMS AND LIMITATIONS OF SOIL SURVEY

Following are assorted criticisms and limitations of the soil survey approach and soil-survey information which I have obtained from both the literature and personal communications. The statements are in part paraphrased from the original sources.

1. Soil surveys were originally designed to serve agricultural needs, and therefore the information collected is not entirely relevant or is not correctly interpreted to fit forestry needs. I believe this is a valid criticism. For example, large differences exist between the rooting habits of tree species and agricultural crop species. Soil interpetations for crop species originally focused on characteristics of the plow layer and immediately below the plow layer. For some tree species a depth up to 10 ft. must be evaluated for soil-moisture retention. Further, interpretations for fertility requirements of tree species frequently are made from soil-test results. Analytical methods for "available" plant nutrients developed through soil test-agricultural crop yield correlations may not adequately measure the chemical form of the nutrient element "available" to tree species. Phosphorus is a classical example, where different chemical solutions extract different chemical forms of phosphorus.

2. In practice, in soil mapping, morphology is observed in two dimensions (the soil profile) when significant variability in soil and other land features occur in the third lateral dimension (Rowe, 1962). This may be true under a small number of soil observations without recognition of correlations between soil morphology and land features. But airphoto interpretations for land form, drainage, topography, and vegetation (floristic composition and density) are necessary to establish soil boundaries by extrapolation and interpolation in reconnaissance soil survey. This using of correlations between soils and landscape features in soil mapping provides a 3-dimensional indirect inventory to the landscape including the soil continuum. Still, the mapping units are identified by classes (e.g., soil series) from soil taxonomic classification rather than by classes from a land form or vegetational classification.

3. The characteristics selected and their limits of variation to define soil series are decided upon according to man's subjective judgments, in terms of interests and importance attached to portions of the soil continuum and associated landscape features (Mulcahy and Humphries, 1967; Rowe, 1962). The characteristics selected (largely morphologic) and their limits of variation are in part affected by the practical necessity in mapping to identify and at best semi-quantitatively describe soil characteristics by simple field tools and techniques. A better and perhaps idealistic approach to selection of soil characteristics and their limits of variation would be to initially determine relationships between soil characteristics and the appropriate response such as wood fiber produced per year (e.g., by factor analysis). The basis for selection of soil characteristics and

their limits to classify soils into different soil series is largely considerations related to soil development. Many of these soil characteristics are also important to plant growth. The limits of variation for a soil characteristic related to soil development may not be the same limits significant to plant growth. For example, from the standpoint of chemical weathering the proportion of particles $< 50\mu$ in diameter is significant, whereas for moisture-holding capacity related to plant growth the proportion of particles $< 75\mu$ is significant.

4. The available methods of observation and measurement influence the soil characteristics chosen to separate soils (Mulcahy and Humphries, 1967; Rowe, 1962). For example, nutrient-ion activities near the root surface would be ideal characteristics if they could be reliably measured. Recently, methods to quantitatively describe soil fabric have led to using soil fabric as a characteristic for soil taxonomic classification. Still, the soil characteristics must be easily observed or be correlated with other easily observed soil characteristics for use in mapping and classifying soils.

5. Morphologic characteristics may not be the "real" characteristics (direct physiologic or genetic relation) upon which to develop a classification of soils (corollary of #4). An important role for research is to identify cause-effect relationships and physiological mechanisms affecting plant growth. Thus "real" soil characteristics are discovered through research, and such discoveries eventually lead to changes in soil classification for improved interpretations.

6. Soil maps present too large of a number of mapping units (series, types, and phases) for extensive land classification (Jones, 1969). I consider the large number of mapping units an advantage if meaningful criteria are used to separate soil series. This provides possible flexibility in soil interpretations for forest management. Fewer soil-mapping units presumably results in greater variation within mapping unit. This variation may be acceptable for some soil interpretations and unacceptable for others.

INTERPRETIVE SOIL CLASSIFICATION FOR FOREST MANAGEMENT

Soil survey interpretations may take the form of either interpretive maps or groupings of soil series that comprise the mapping units. Most interpretive groupings will be devised for a single purpose only, and as such few soil characteristics will be used. Whereas taxonomic classifications use many characteristics, and therefore classes contain a maximum amount of information. Some interpretations for forestry purposes are groupings of soil series based upon a measured parameter of the soils, e.g., permeability. Other interpretations are for soil qualities that are synthesized from soil parameters, field observations, experimental results and inferences drawn from experience or known responses from similar soils. Productivity, fertility, and erodibility are examples of soil qualities frequently interpreted for forestry purposes.

Soil survey interpretations specific for forest management purposes and provided either in the form of interpretive maps or as interpretive groupings of soil series include:

1. Species suitability - selection of the commercial tree species best adapted for soil conditions.

2. Regeneration - based upon plant competition and seedling mortality.

3. Windthrow hazard - based upon root-restricting layers, stoniness, droughtiness and wetness.

4. Logging equipment usage (restricted seasonal use of equipment or use of equipment in stand thinning) - based upon slope gradient, wetness, soil compaction and trafficability.

5. Suitability for planting - based upon texture, thickness of solum, internal drainage, moisture-holding capacity, fertility, microclimate (cold air drainage), and past history (cultivation, fire).

6. Rooting volume - based upon bulk density and porosity.

7. Hydrologic - based upon infiltration rate, percolation rate, and retention and detention storage capacity.

Site evaluation requires further soil observations. Suggested soil characteristics (parameters) and their possible application in forest management follow. These parameters could be used to phase soil series. Their inclusion in a land inventory could improve the precision of inventory information applied to forest management problems.

1. Organic horizons

   Chemical and physical properties of soil organic horizons affect soil qualities related to forest management for both water yields and wood fiber production. Soil infiltration rates, fertility, erodibility and productivity are influenced by the nature of organic horizons. For example, the extremely high cation exchange capacity of H horizons sometimes equaling on a volume basis that of all mineral horizons combined, suggests the importance of organic horizons when evaluating soil fertility. Roots of tree species are frequently concentrated in organic horizons and the upper mineral horizon. Thickness and the type of organic horizons are recognized factors affecting success in regeneration and controlled burning in Alberta.

2. Stoniness

Soil interpretations for moisture retention and detention capacities, and suitability for mechanical planting could be improved by more information on stoniness. Phases of soil series for stoniness parameters such as content by volume, rock type, and orientation aid these interpretations.

3. Soil temperature

Soil temperature influences initiation of cambial growth and winter and spring retention storage capacities. Perhaps, interpretations for soil temperatures would be inferred from soil-habitat information such as thickness and kind of horizons, soil texture, and climatic factors.

CONCLUSION

Soil survey interpretations from the fundamental soil-survey report and its map can be utilized in forest land classification, site evaluation, and forest management. The interpretations in the form of maps or groupings of soil taxonomic units are best developed in co-operation with other disciplines such as forestry, ecology, micro-climatology, and geomorphology since total environment is usually involved.

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PANEL SUMMARY

The panel described 10 methods of evaluation and comparison of components of the landscape. An attempt was made to provide a view of the advantages and disadvantages of each. Some components of the landscape received more emphasis than others and it is realized that not all questions were answered. The panel indicated that much information is available, or can be made available, and suggests that the concerned authorities study in more detail the various methods described and choose what best suits their purposes. It is obvious that individual panel members hold different views, which is probably a good thing, and it appears obvious that more than one agency will be involved in future landscape inventory and interpretation. It is hoped that cooperative efforts can provide the benefits being sought.

FOREST-HABITAT INVENTORY REQUIREMENTS FOR REGENERATION: THE SILVICULTURAL NEEDS

by

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Because Mr. Dermott will specifically describe most of the inventory needs on a Forest level, and since for long-range plans what we should have are the means of satisfying those needs on a broader basis, that is, expand them to meet the needs of our 11 Forests; because of all this, I've taken what I feel is the directly related but perhaps more demanding need from the overall planning point of view in order to go about setting up the requirements for a complete and purposeful inventory to enable us to adequately plan our silviculture program.

The bio-physical inventory requirements such as land form, soil, moisture regime, vegetation class, eco-climate, etc. and maps associated with these data can be met given adequate staff, proper photos, and sufficient ground investigations. Mr. Dermott will refer to those needs, the details, etc., but the basic scale of photographs to use and the type of photographs is a primary requirement of an inventory and these requirements must meet the needs of all concerned. When I say all I make reference to the fact that we are sitting somewhat in the drivers seat, so to speak.

We can see the trees, we can set up an operating plan and have them harvested, we can reforest an area but our review of the literature may not be complete and in our silvicultural programs we can go in many directions when considering spacing, species, size of harvest cuts, etc. If you, other specialists make your needs known we'll do our best to see that the silvicultural treatment of stands consider those needs. If you don't tell us - we may overlook your guidelines, as it is difficult enough to keep up-to-date in our own field.

That then brings me to what I feel must be considered as the necessities of a silvicultural inventory in order that we can get the information needed to carry out a totally adequate job of Silviculture. What do we need in the way of an inventory? Well, among various things, participation from you. Without this participation, the normal forest inventory, beginning with the present type of photos, would likely be carried out. As time goes on we will get the material that the field Forester will require and that we will utilize in a broader form for our planning. However, is this enough for the fully co-ordinated Silvicultural program: I say no - far from it. It is only a beginning and maybe not even adequate enough to give the correct guidance to us.

What we need besides, are statements from you on the resource values you see in your specific responsibility, as they apply to the levels and space that trees and stands are established, maintained, and harvested on our forests, and more specifically in our Management Units. In order to plan a Silvicultural program properly as I see it, we want to know what the other values and needs are - knowing them we will try to satisfy them in our cutting techniques and our reforestation programs.

So what do we need?

Statements on:

- Fish & Wildlife Resource Management policy/Forest and preferably by Management Unit to indicate to us such things as production, manipulation, the present values, the future potential values and needs.

- Recreational opportunities, future needs and predicted values.

- Water Resources, values, future values and needs, manipulation.

- Other users.

How you get the resource information needed to supply us with the guidelines is your job. but how can you be involved in a new inventory to aid you in getting this information? You alone know this, and you must tell us.

The above are basic requirements and can be derived only from a total inventory of resources - not just an inventory of timber. Hopefully, the means of carrying out a total and useful inventory will then take all your needs into consideration but you'll also have to be involved in the economics of the inventory.

Basically the inventory will start with photos. For your purposes and mine the type of photography can be very important. Until all multiple needs are known, this basic requirement cannot be decided upon - you are needed here with your statements of values and needs. Perhaps, for watershed, recreation and silvicultural planning we should consider the "thermal infrared imagery" which I understand can be utilized very well to show both surface and subsurface moisture. I really don't know whether timber typing can also be done from a photograph of moisture conditions (from examples seen it looks like it) but if it cannot, then perhaps certain areas are worthy of being flown twice or possibly both cameras can be in the same plane. I don't know but I'm sure someone here can tell us.

"Indications are that the false-color infrared photography can provide the image analyst with more information on vegetation types than conventional black and white panchromatic photography especially when attempting to locate and identify those forest types having similar image characteristics: In addition to providing more accurate results, the analysis of false-color infrared photography requires fewer man-hours of interpretation time than the black and white photography. Considering big labor costs, this factor is extremely important, particularly when salaries dominate the costs of large survey jobs" (D. T. Lauer - Rapid Advances in Remote Sensing Make It a Useful Tool for Foresters).

Before deciding on the type of photography, perhaps the needs of each Forest and Management Unit have to be considered, e.g., the Eastern Rockies Area with its watershed/recreation requirements should have a larger scale of photography in order to adequately plan for your purposes and in order that you can supply us with adequate guidelines. Costs must be considered but perhaps here higher initial costs are justified.

As I said earlier, I'm not following what we might consider as the usual approach to defining the basic needs for an inventory for Silvicultural Planning but I sincerely believe the approach I've outlined is what we should consider.

Our work does affect yours, in many ways, both good and bad. Unless we know your needs we can't include them in our planning. For example, High Watershed Value - (1) immediate planting with perhaps larger stock and with a change in spacing, etc., or (2) thinning stands to a greater or lesser number per acre than optimum for harvesting; in other words for us to "give" a little.

This may cost us more but if we as a Division of this Department know that this is the only way to satisfy the total needs, the public and the rest of you will stand behind the higher costs.

Any inventory done now should be economically all inclusive, by that I mean your values need to be assessed and a price put on them; where your values are high your needs should be included in the inventory approach.

That is how I see the inventory needs of a complete silvicultural planning program. Mr. Dermott will outline the more intensive practical requirements. From these we will also glean the necessities to be included in our broad silvicultural planning.

FOREST-HABITAT INVENTORY REQUIREMENTS FOR REGENERATION

Ecologically Limiting Factors

by

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INTRODUCTION

Conifer-regeneration status in Alberta's forest lands was reported by Candy (1951) for 3 major Sections - Mixedwood, Foothills, and Sub-alpine. A total of 100,620 milli-acre quadrats were examined, about 40,000 each in the Mixedwood and Foothills forests and 22,000 in the Sub-alpine. Candy considered that reproduction of conifers is generally very unsatisfactory after any of three types of disturbance examined: logging, fire, and logging and fire. In the Foothills Section only, logging and fire produced areas well stocked to lodgepole pine. Candy theorized that the Mixedwood type was being gradually converted to hardwood. To repeat this regeneration survey as part of a forest inventory would assuredly produce the same order of results with the exception of those areas where cultural treatments for regeneration have been carried out since 1951 and Candy's survey. I feel that such an inventory would be a waste of money.

However, since Candy's report was published there has been a growing effort to restock the cutover and burned-over lands, and the forest management planners can look back on 15 years' experience in seedbed scarification, seeding, and conventional planting; and on 8 years' experience with container planting. Factors limiting survival and growth of regeneration are now more fully understood. Site factors dictating silvicultural prescriptions in the Mixedwood, and by inference in the Foothills, are now documented from a variety of practical trials (Jarvis et al., 1966). Problem areas such as mountain microclimates (Day, 1963) and wetlands (Lees, 1964) are well defined. Long-term effects such as increasing summer temperatures and lower rainfall levels are now appreciated (Sutton, 1969). Three outstanding limiting factors have emerged: the unsuitability of organic-soil seedbeds, summer drought, and vegetation competition. Thus, soil moisture regime and microclimate information are vital to any silvicultural decision regarding regeneration.

REGENERATION CHANCE

A forest inventory can provide information on the ecological factors that will limit the choice of regeneration treatment and drastically affect subsequent survival and growth. This information can then be used in formulating silvicultural systems. The same classes of factors affect the survival and growth of natural seedlings, and artificially seeded and transplanted stock.

Fortunately, the most easily collected information will often provide the most useful knowledge about limiting factors. The location of the area to be regenerated with respect to surrounding land forms is the largest single piece of information. Is there a hill above the regeneration area or a slope below it? Is it exposed or sheltered? Elevation and aspect affect local climate; slope affects drainage, cold air flow and incidence of light.

Soil type and soil physical characteristics will determine growth factors such as effective rooting depth and wind stability. The nature of the organic overburden and its depth determine whether the trees will be rooted in organic soil or may be expected to penetrate to mineral soil with or without scarification. The moisture status of the rooting zone in our Alberta soils is vital to regeneration success. The growing season is short and droughty. Organic soils quickly dry out and temperatures peak at near lethal levels and above (Day, 1963). Moisture conditions favorable to conifer-seedling growth, and in particular growth of white spruce, are most favorable to competing herbs and grasses. These factors combine to present a certain set of physical conditions that influence machine application in cultivation and planting.

What factors tell us most about regeneration chance and how may they be assessed in a forest inventory? Here is a partial list:

1. Elevation
2. Aspect
3. Slope
4. Land form
5. Soil type
6. Depth to mineral soil
7. Nature of organic material
8. Moisture regime in rooting zone during the growing season
9. Forest cover type
10. Vegetation competition.

Information about the physiographic factors 1-5 is generally available together with forest cover type data and therefore will not require further survey input. For regeneration chance the next most important factor is depth to mineral soil. How much work is required to produce the preferred mineral soil seedbed. The nature of the organic overburden may be logging slash, fire-killed material, litter, or organic soil in various degrees of decomposition. How wet is the area? Drainage and depth to ground water help to explain the soil water balance. The physiographic situation, moisture conditions and local climate determine the severity of vegetation competition which plays such an important role in seedling survival.

What can be assessed from the air? Aerial photos tell us about land form, forest cover type, and a great deal about local climate, drainage, and soil type. We can recognize cutover and burned-over land from its physical appearance and can deduce the nature of the organic overburden. Can radar scan the organic horizons? Soil moisture and depth to ground water may be sensed from the air. How much ground testing is required?

Vegetation competition may be assessed on the ground on an extensive scale with the use of a cover board. Here, a visual estimate of percentage and height of ground vegetation is obtained by sitings on a standard chequered board. In greater detail, vegetation from a milliacre quadrat can be clipped, measured, dried, and weighed.

With this information together, it becomes possible to develop a series of limiting values for each factor. Interpretation of the data will eliminate certain choices of species, silvicultural systems, and site-amelioration treatments such that proper prescriptions may be applied well within the limiting range.

We understand that regeneration stocking levels are generally unsatisfactory, whether understocked or overstocked, without engaging in an expensive survey. Let us use the survey resources to collect information that helps decision making. What are the requirements for seed and seedlings, for site amelioration, and cultural treatments such as weeding and cleaning?

Priority should be given to

1. Depth to mineral soil
2. Soil drainage) moisture regime
Depth to ground water)
3. Vegetation competition.

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A FOREST INVENTORY: NEED FOR INPUT RELATING TO DISEASE AND INSECTS: WHY AND HOW

by

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Closer utilization of forest stands is occurring each year. Losses, tolerated today, from insect and disease will not be acceptable to the forest manager in the future. I use the term 'forest manager' in the narrowest sense, i.e., that person whose responsibilities are to manage, for greatest productivity, areas of forest land reserved primarily for wood fiber production. More on that selection process later.

Within the prairie region the principal problems that will likely confront the forest manager include dwarf mistletoe on pine, defoliating and bark mining insects on spruce, cankers on pine and aspen, decay in aspen, root insects, and needle cast diseases in regeneration. Significant damage from these agencies presently occurs in some regions.

It is important, therefore, that a certain level of insect and disease information be recorded during the course of the Forest Inventory operation. The forest manager will need to know, and be specifically alerted on, location of presently or potentially damaging organisms. Where such organisms occur, he will need to assess their impact on his prospective management plans.

Many present and potential problems on diseases and insects can be eliminated or greatly reduced with current knowledge in silviculture-control methods. These methods do not necessarily entail expensive, restrictive, or elaborate silvicultural treatments. They consist mainly of the requirement that infested or infected areas be cleanly logged early in the cutting program and no trees harbouring residual sources of reinfection be left standing to affect the regeneration. Other pest problems, of course, cannot be so simply resolved.

If it is acknowledged that there is a need for intensive disease and insect information and that that information be integrated into the Forest Inventory - the question is - How?

The Canadian Forestry Service over the years has amassed a great amount of information on the distribution and intensity of insects and disease populations within the forest stands of the region. Examination of these records for providing input into the Forest Inventory operations is essential.

It is unlikely, however, that available information will always be sufficiently complete or be in a usable form for a direct plug-in.

In addition - it is unlikely that the Canadian Forestry Service or provincial agencies responsible for the Inventory would have sufficient resources available for an intensive disease and insect detection and appraisal survey for the total forested area of the region. Nor is an intensive survey necessary for the total region.

Some stratification of the forested region must be made. This stratification should take into consideration present use, future use, and period of use. From the point of view of need for intensive detection and appraisal of insect and disease, I suggest that the forested lands be fitted into three categories, with different priorities for intensive survey needs.

Category 1: Designated areas, under Federal and provincial jurisdiction,

Watershed and recreational forest land,

Forest land presently or likely to be designated Agricultural,

Forest lands known to be non-productive for wood fiber.

Category 2: Forest land managed principally for wildlife,

Forest land considered marginal for wood fiber production,

Forest land known to be productive but not likely to be utilized within several decades.

Category 3: Forest lands presently with productive forests, being utilized - or potentially productive land with young or advanced regeneration. All these lands designated for utilization of wood fiber,

High-use recreational areas where maintenance of a certain type of forest cover is necessary for aesthetic or recreational needs.

I recognize that there are many problems associated with defining the forested areas I have described. Nevertheless, by categorizing in some way - a great reduction can be realized in the forested areas that deserve an important disease-insect input into the Forest Inventory.

Forest lands in Category 1 are unlikely to ever require an intensive insect-disease survey; Forest lands in Category 2 have a somewhat higher priority and in special cases may require a heavy input from insect-disease detection and appraisal surveys.

A high level of input is required on those forest lands described within Category 3, i.e., productive forest land maintained essentially for wood fiber productions, and lands of high recreational values.

I believe the Canadian Forestry Service is willing and able to provide a considerable input into disease-insect detection and appraisal surveys specifically designed to satisfy important needs of a modern forest inventory. The mechanics of providing that input should not be difficult to resolve with consultation between the Canadian Forestry Service and the various management agencies carrying out the Forest Inventory.

FOREST-HABITAT INVENTORY REQUIREMENTS FOR FOREST FIRE PROTECTION AND SUPPRESSION

by

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Each year in Canada, some 6,700 forest fires occur and burn over two million acres. The direct-suppression costs exceed $20 million and values lost are greater than $100 million. In Alberta, 496 fires each year burn, on a 10-year average, 148,000 acres. This high figure is due to the disastrous fire year of 1968 in which almost one million acres were burned. The average cost of Alberta's fire-control organization including the cost of suppression is approximately $5.5 million per year.

There is an increasing national interest in improved fire-control techniques that will reduce fire losses. A multi-use forest inventory could supply a fire control agency with valuable information not now available.

1. Fuel Hazard Rating

The most important input to fire control from such a forest inventory would be a fuel-hazard rating preferably related to forest-cover types. We want to know how wildfire will react under various fire danger levels in different combinations of tree species. The arrangement of the fuel, the quantity of the fuel in tons per acre, and other factors will also have to be considered. Separate studies would have to be initiated to determine the behaviour of fire in the types defined by inventory.

Fuel hazard inventory and mapping is required for two levels of use.

a. A broad inventory would be a valuable aid to pre-suppression planning. For this purpose, the present broad inventory with minimum cover types of 160 acres should be satisfactory. On a provincial or forest basis, concentrations of the most dangerous fuels could be accorded a higher action priority and a greater degree of protection. Conversely, savings might be made by a lesser degree of protection on large areas that are found to be low in rate of spread and resistance to control.

b. A more detailed micro-habitat inventory might be desirable to provide data to fire-suppression operations. However, the smaller and more numerous the forest cover types, the more difficult it becomes for a fire boss to forecast the fire behaviour and the rate of spread. Before a detailed fuel inventory, operations research would be necessary to define minimum type size and to find out if inventory data would be beneficial and capable of application in suppression action.

2. Forest Land Values

A second and important input required for forest-fire control from inventory banks is a dollar value for the resource land that is to be protected. As resource managers, we recognize and allow an ever increasing number of land uses including recreation, watershed protection, industry, grazing, and wood production. I do not believe there is a province in Canada that has been able to relate its protection budget to the value of the many forest land uses it is protecting. The Canada Land Inventory is a step forward and does indicate the areas of different uses to a limited degree; however, use priority and values have yet to be determined. The dollar-value factor is a necessary and valuable tool to all planning agencies in resource management and it is not presently being considered in a serious or co-ordinated manner in Canada.

AN OUTLINE OF CLIMATOLOGICAL INFORMATION AVAILABLE FROM THE FOREST SERVICE

by

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1. What Climatic Data are Gathered?

(a) Temperatures

Maximum
Minimum
Dry Bulb Temperature
Wet Bulb Temperature

(b) Humidity

Relative humidity (or dew-point).

(c) Sky Condition

Clear	Overcast
Partly Cloudy	Obscured
Cloudy	Undercast

(d) Present Weather and Obstructions to Vision

Rain	Smoke
Rain Showers	Snow
Fog	Drizzle
Haze	Hail

(e) Visibility (Miles)

(f) Winds

Direction
Speed
Gustiness (Character)

(g) Precipitation

Rain
Snow
Total Precipitation

(h) Clouds

Layer Type	Vertical Development Type
High	Cumulus
Middle	Heavy Cumulus
Low	Thunderstorms

(i) General Information (Recorded Irregularly)

Stage of grass development
Stage of deciduous leaf development
Damage by heavy winds
First killing frost in fall
Freezing up of lakes and rivers
Break-up times
Large hail stones
Exceptional heat waves or cold spells

(j) Thunderstorm Data (Summer Only)

How many storms in an area
Where they travelled
Intensity

2. How are Data Gathered?

(a) Where and When?

Summer - All data under Item 1, previously referred to, gathered at all towers and nearly all Ranger Stations twice daily at 0730 Hrs. and 1300 Hrs.

Winter - Precipitation, maximum and minimum temperatures and present temperatures only, gathered daily at 34 Ranger Stations in mornings between 0800 Hrs. and 100 Hrs.

(b) Using What Equipment?

Standard Stevenson Screen *
Battery-fan Psychrometer *
Maximum and Minimum Thermometers *
Standard M.S.C. rain gauge *
Three Cup Amemometer and Flashing Light

(* meets D.O.T. Specs.)

3. How are Data Extracted?
Where are They Stored?
How Available are They?

(a) Data are transmitted daily by teletype and transferred within 30 days to punch cards and magnetic tape.

(b) Data are stored in both Edmonton and Toronto on punch cards and magnetic tape.

(c) Data stored in Edmonton are readily available on both magnetic tape and print-out sheets. Data stored in Toronto are not readily available except in published form (monthly records).

User should be prepared to write his own computer program when requesting large volumes of data.

4. Has Forest Service Weather Data been published yet in any other form other than raw data? No.

Have climatic data been correlated with topography or vegetation in Alberta? No.

What other agencies collect climatic data in Alberta? What data do they collect?

Federal Energy Mines and Resources	Federal Agriculture
Federal Defence Research	University of Calgary
National Parks	University of Alberta
Eastern Rockies Conservation Board	Alberta Wheat Pool

Precipitation, Temperature, Wind, Humidity, Sunshine, Soil Temperature

What Alberta climatic data have been published:
Many publications have been published but the main ones are:

1. Climatic Maps for Alberta - University of Alberta
2. Temperature and Precipitation Tables for Prairies - Meteorological Branch
3. Climatic Normals - Volume 5, Wind - Meteorological Branch
4. Climatic Normals - Volume 3, Sunshine, Cloud, Pressure, and Thunderstorms.
5. Climatic records for the Saskatchewan River Headwaters - Eastern Slopes Watershed.

CLIMATOLOGICAL NETWORK IN ALBERTA - SUMMARY

Upper air network incomplete

More information needed by water resources on snow depth, snow melt, times of melt, freeze-up, etc.

Meteorological Branch suggests perhaps a network of one Station per 1,000 square miles desirable, but the density would vary depending on the parameters. (Forest Service network with a station radius of 25 miles means one Station representing 1958 square miles; with a proposed tower spacing of 35 miles and this would be equal to 3,850 square miles; with the actual spacing in northern Alberta closer to 50 miles, this means one Station represents 7,857 square miles).

Requests have been made for depth area duration analysis curves for individual storms.

Requests have been made for more information on soil temperatures and evaporation from forested areas, ideally from each major vegetation type in the Province.

Requests have been made for data on net radiation from all areas of the Province. This briefly summarizes some of the demands that are now being made by researchers in fields such as Micrometeorology, Biology, Agriculture, Forestry, and Hydrology for climate information in Alberta.

In addition, the following types of information would be useful -

Density of overstory canopy (tenths).
Kind of understory vegetation or ground cover.
Density of understory vegetation (tenths).
Dead surface fuel,
- (a) Amount of dead fuel (light, medium, heavy).
- (b) Horizontal continuity of fuel (continuous, intermittent, patchy).
- (c) Vertical continuity of fuel (continuous, intermittent, broken).

Number of snags, (number per acre).

FOREST-HABITAT INVENTORY REQUIREMENTS FOR FIRE DANGER RATING

by

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INTRODUCTION

Forest-fire danger is a comprehensive concept and includes all constant and variable factors that affect fire inception, spread and difficulty of control of fires, and the damage they cause. For example, for fire danger to exist, there has to be a risk, the fuels have to be dry enough to burn, and there has to be a potential for damage to resource values. Fire-danger rating is a management system that integrates the effects of selected fire-danger factors into qualitative or numerical indices of current protection needs. The objective of forest fire danger rating is to indicate the danger now and what it might be in the future.

Many factors affect fire danger, usually in combination. The currently variable factors must be considered in relation to more fixed factors and integrated into a management system to serve as a guide to fire behaviour and control action. The variable factors include such items as weather, fuel moisture, foliage growth and condition, variable man-caused hazard, and variable risks of ignition. Fixed factors include values at stake, normal risk, topography, kind of fuel, and exposure to prevailing wind. Practical considerations limit the number of factors that can be included in a forest-fire-danger rating system.

A detailed description of the concepts and nature of the problems involved in developing a practical fire-danger-rating system is clearly outside the scope of this paper. A general discussion of development and present status of fire-danger-rating systems in Canada, however, is basic to further consideration of forest-habitat inventory requirements for fire-danger rating and fuel-type classification.

DEVELOPMENT AND PRESENT STATUS OF CANADIAN FOREST FIRE DANGER RATING SYSTEM

The systematic development of fire-danger rating in Canada dates back to the late 1920's when development of concepts and field experimentation commenced at Petawawa Forest Experiment Station. The Canadian system[1] is unique in that the indices are based on the flammability of toplayer-duff as measured by small-scale test-fires. This flammability rating is correlated with duff moisture-content which, in turn, is correlated with those weather factors found to govern it. The final table, the Fire Danger Table, is determined from codes for fine and heavy fuels.

The system requires the use of a number of fire weather stations where simple noon-time observations can be made of wind speed, relative humidity, temperature, and precipitation. Using the weather data and the appropriate danger table(s), the observer computes the danger index which expresses the ease of ignition, rate of spread, and fire intensity.

Although the Forest Research Branch technique of developing fire danger and fire hazard tables has changed little over the years, the tables themselves have gone through a number of important phases. The most recent changes were made in 1956, 1961, and 1962 when three additional tables were issued, one for the British Columbia Coast, one for the interior of British Columbia and one for the District of Mackenzie, Northwest Territories. The tables for the District of Mackenzie introduced separate summer tables for hardwoods and conifers.

Increasing sophistication in fire-control planning and operations in recent years has pointed to the need for a more refined fire-danger-rating system than that represented by existing Forest Research Branch Tables. This need was recognized at the 1965 meeting[2] of Forest Research Branch fire researchers in Victoria, British Columbia, at which time a number of recommendations were made to aid in developing a new Canadian fire-danger-rating system. It was generally agreed that the danger index scale should be expanded and that the expanded scale should bear a numerical relation to fire severity. Furthermore, the same weather conditions should result in the same index numbers across the country.

On the basis of these and related considerations, work on a new Canadian Forest Fire Danger Rating System started in 1967. Co-ordinated by the Forest Fire Research Institute and involving fire researchers from across Canada, work on the new System has progressed

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1 Williams, D. E. 1963. Forest Fire Danger Manual, Department of Forestry Publication No. 1027.

2 Minutes of fire research staff meeting, Victoria, B. C., March 22-26, 1965.

rapidly and the final Tables will be available for field use during the 1970 fire season.

The basic index in the new System is called a Fire Weather Index and it is a numerical rating of potential fire intensity in a standard-fuel type. This index is dependent only on weather and is independent of differences in fuels; it is the basis for describing fire weather on a national scale. The Fire Weather Index is related to the ease of ignition and general behaviour of wildfires and if ignition occurs it is a relative measure of the daily fire control requirements.

The three basic building blocks of the new System represent the moisture-content functions of fine (about 1/10 lb/sq ft), medium (1 lb/sq ft), and heavy (a soil layer with an 8-inch water-holding capacity) fuels. The fine-fuel function is combined with wind to give an Initial Spread Index. The medium (duff) and heavy (drought) fuel-moisture functions are combined into an adjusted duff-moisture code by the harmonic mean. The Fire Weather Index is determined from the Initial Spread Index and the adjusted duff-moisture code. The format of the system allows for the addition of a risk factor to produce a fire load index.

BURNING TABLES FOR MAJOR FUEL COMPLEXES

Increasingly, a fire-danger-rating system must satisfy the needs of both headquarters administrators and fire-control field staff. Administrators are generally satisfied with a relative index to reflect differences between large regions whereas the fire-control officer or fire boss requires more precise guidance from one or more indices. Both groups agree, however, that rate of spread and fire intensity indices for a few well-defined fuel types would be most valuable tools in aid of fire-prevention publicity, closure of forest areas for public use and logging, and decision-making relative to dispatch and suppression activities during going fires. Determination of fire spread and intensity in specific fuel types is often difficult and time-consuming but this information must be known if there is ever to be a significant improvement in rating and predicting forest-fire behaviour.

The development of burning indices should proceed along the following lines. Firstly, when burning conditions are moderate and predictable, the required data can be collected from experimental fires in standing timber. The data will include fuel moisture, fuel consumption, fire-behaviour parameters such as linear rate of spread, flame width and flame depth, and measurement of fire weather, and precipitation. Information from standard forest fire reports, and observation and measurement of wildfires and wildfire effects by fire researchers appear to be the most satisfactory methods for obtaining the data when burning conditions preclude laboratory and field experimentation. One of the most demanding tasks facing the fire researcher is for him to determine the point when a ground surface fire crowns and assumes the characteristics of a "blow-up" fire.

FOREST-HABITAT INVENTORY REQUIREMENTS FOR FIRE DANGER RATING AND FUEL-TYPE CLASSIFICATION

Fires burn in trees, shrubs, herbs, mosses, and the underlying organic soil. Past experience with forest-fire behaviour lends weight to the assumption that the fuel characteristics of forest stands which determine fire behaviour are also closely related to forest cover types. Thus, the forest cover type appears to provide the best basis for the development of burning tables and for fuel-type mapping. In the foreseeable future at least, any delineation and ranking of fuel types according to fire hazard will have to be based on available aerial photographs and forest-cover-type maps for the simple reason that an operational fuel survey is economically impractical.

The development of rate of spread and intensity tables for a few selected fuel types depends on meaningful quantitative fuel descriptions. The fuel parameters known to exert an important effect on fire behaviour include fuel weight, energy content, size, surface area-volume ratios, a measure of horizontal continuity at different levels above the forest-floor, and moisture content of selected fuel components. These factors are difficult and time-consuming to measure but it appears that they can be reliably estimated from one or more standard tree or stand parameters. Studies to identify and determine the relationships between stand and fuel parameters have been initiated in Alberta and results indicate that this approach has considerable promise as a method for developing a statistical description of important fuel complexes. Only the forest stands selected for the development of burning tables need be intensively sampled.

Fuel weight is an important measure for developing a mathematical basis for fire-hazard rating and considerable effort has been expanded in estimating it from tree and stand parameters. Results indicate that the weight of individual crown and stem components can be estimated from one or more tree parameters such as diameter at breast height, crown width, crown length, and tree height. Alternatively, the weight of the entire fuel complex can be estimated from stand parameters such as basal area, age, and height. Having determined the total biomass in each major fuel type, it is a simple matter to calculate its total-energy content.

The introduction of fuel moisture into fire modelling deals with the effects of fuel and weather variables on fire behaviour. Fuel moisture is known to exert a pronounced effect on burning rate of fuel but the mechanisms by which water affects the burning rate are poorly understood. A meaningful assessment of fuel-moisture relationships depends on a thorough knowledge of the total water-holding capacity of the fuel and an understanding of its wetting and drying characteristics. The development of a meaningful numerical indicator of moisture status is particularly important for deep organic soils and crown foliage in conifer stands such as lodgepole pine and black spruce. The new System incorporates a modified Thornthwaite method to reflect moisture levels in deep soil layers, but little is known about the effect of this moisture on rate of burning in deep organic layers and tree foliage.

Forest-habitat inventory requirements for a broad fuel-type classification are similar to those for a standard forest-cover-type map. Stand parameters such as age, basal area, height, volume, crown density, and average stand diameter are sufficient to outline a few broad fuel types. Physiographic features such as elevation, slope, and aspect should also be recorded. Such an initial relative rating of fire behaviour will gradually be converted to a mathematical basis as fuel and fire-behaviour factors are quantified. The fuel-type classification should thus be changed periodically to incorporate new knowledge and to provide the fire control officer with practical information about fuel and fire behaviour characteristics in each type.

The development of burning tables and fuel-type mapping should proceed simultaneously but the effort expended on fuel-type mapping should be dictated by considerations of what is theoretically possible and practically desirable. For example, it would be a waste of effort, time, and funds to initiate a large-scale fuel-type mapping program if fire-control organizations are not prepared to implement such a scheme. It is important to recognize that calculation of fire-danger indices and preparation of fire-hazard maps are meaningless unless the fire-control officer or fire boss uses these tools to add to his own knowledge and understanding of total fire danger.

In conclusion, the development of burning indices for selected major fuel-complexes appears justified and will require a statistical description of each type. Intensive work will be required to clarify fuel-moisture relationships and their effect on fire behaviour, but this work can proceed independently of a forest-habitat inventory. A broad fire-hazard rating scheme can be developed on the basis of available forest-inventory data but allowance should be made to convert this to a mathematical basis as fuel and fire behaviour factors are quantified. The initial approach might be to classify major fuel types according to total-energy content, followed by fire-hazard maps and guidelines for rating fire behaviour in terms of rate of spread, fire intensity and blow-up potential for a range of burning conditions as determined by burning indices. Much of the information for developing and updating a fuel-type mapping scheme must necessarily be available from a standard forest-habitat inventory. In addition to topographic and stand parameters available from existing forest inventory records, aerial photographs and cover-type maps, forest-habitat inventory requirements for fire control should include depth and weight of the forest-floor, a measure of crown density, average distance from forest-floor to base of live crown, and an expression of the water-holding capacity of each major fuel type.

INFORMATION REQUIREMENTS FOR TIMBER MANAGEMENT IN ALBERTA

by

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This paper does not attempt to deal with information required for multiple- or integrated-use forest management. The information requirements described are only those considered essential for timber management, that is, management of the forest cover to achieve a sustained yield of wood products at the maximum possible level of utilization.

Of course, actual timber-management practices are not limited to consideration of timber management as described above. Integration and co-ordination of timber management with watershed, wildlife, recreation, and grazing management are essential. A limitation has been imposed because information requirements relative to other aspects of forest land management are the subject of other submissions to the Symposium.

In the remarks that follow, emphasis is placed almost completely on the management of coniferous timber, as inventory information is sufficient for the management of poplar at its present low level of utilization, except perhaps for more work on the area of determining recoverable volume from the many decadent poplar stands existing in the province.

Information requirements for timber management can be placed within six general classifications. They are:

1. Accurate Base Maps

Good planimetric detail, particularly topographical features and access information, is a first essential requirement. Forest-cover maps must provide accurate location of the timber resource in relation to land survey, topographical features, and all forms of access such as railways, highways, and secondary roads, seismic lines, and industrial rights-of-way. This information is essential for proper field surveys, accurate appraisals, adequate cut programing and planning, and proper layout control of harvesting and reforestation operations.

Fortunately, this requirement has already been met as a result of mapping associated with the first provincial forest inventory which commenced in 1949 and was completed in 1962. This information has been up-dated periodically by both re-photography and survey plans. There will be some advantage in re-mapping forest management units that have experienced heavy industrial activity, as not all plan submissions have been absolutely accurate. Since some maps are now more than 20 years old, re-mapping will avoid minor problems resulting from slight inaccuracies of plotted information.

2. Extent and Distribution of Stocked Coniferous Lands

The stocked coniferous acreage within each management unit is a basic requirement both from the viewpoint of establishing an allowable cut and in assessing the age class-area distribution of the coniferous species. The location of stocked coniferous lands must be known to facilitate fire control and timber management.

The degree or adequacy of coniferous stocking is a fundamental consideration in the planning of reforestation projects. In short, maps and inventory statements must show and summarize the acreage of coniferous stocking, by age class and with some measure of the degree or adequacy of the stocking. Maps must show the distribution of stocked coniferous lands within a management unit before meaningful timber management plans can be established.

Past forest inventories have established approximately the extent, location, and distribution of coniferous stocking. The information has not been complete because regeneration and coniferous understory were not photographed where brush cover or forest growth obscured the ground. Cost considerations did not enable field crews to check understory conditions in all types. Furthermore, there has been a substantial ingrowth in many of the units inventoried in the early 1950's. The present coniferous-stocking-reconnaissance program which is limited to one or two management units per year has indicated that substantial acreages now inventoried as brush land or deciduous forest cover types actually support adequate to full coniferous stocking as an understory.

One objective for any proposed re-inventory would be to integrate stocking reconnaissance into the inventory procedure to ensure that existing coniferous stocking is recognized and recorded.

3. The Age and Condition of Coniferous Stocking

As indicated in the preceding discussion, it is necessary to have reliable information on the age and condition of coniferous stocking. Coniferous age-class distribution by volume and area is essential for the establishment of allowable cuts, for proper assessment of fire control problems, for the planning of reforestation and/or stand improvement projects and for adequate planning of timber-harvesting operations. The oldest timber must be cut first.

It is also necessary to have reliable information on the condition of all age-classes.

Past-inventory information has been inadequate for detailed planning because field sampling costs dictated age assessments based on stand height with light field sampling. Reliable information on the condition of particular stands is not available from previous inventories. Decadence, stagnation, past fire history, physical damage such as snow breakage, all have an effect on the height-age relationship in addition to the influence of site quality. These are all observable factors influencing stand condition. Particularly in lodgepole pine, stagnation must be noted. This information influences decisions relative to silvicultural planning for the unit, and must be considered together with age to formulate an age-condition classification.

Proper age-class distributions must be constructed having regard to stand condition and age. Accurate age-condition information should be collected in any future timber inventory.

4. Site

An allocation of productive versus non-productive lands is essential if consideration is to be given to establishing annual allowable cuts by an area volume approach. In addition, any stand-treatment program requires consideration of site. This aspect will be discussed by others in much greater detail. Discussion of stand age and condition relative to timber-management planning and cut programing must also give consideration to site because of the influence of site on volume-age relationships. Although considerably more attention will have to be paid to site in the future, site classification for this purpose may remain fairly broad with eventual productivity classes of a simple and meaningful nature. A significant difference in forest productivity should exist between each eventual site class in any classification adopted for these purposes.

There is every possibility that Canada Land Inventory classifications can be related to forest productivity within any given management unit thereby filling timber management needs for site information. If not, the biophysical system seems to hold promise on a more detailed basis. These are problems which will have to be assessed prior to the implementation of any new inventory program in Alberta.

5. Wood Volume and Merchantability Classes

Wood volume would be collected for each tree species and expressed in the following ways:

(1) Total wood volume in cubic feet.

(2) Pulpwood volume in cubic feet. Diameter (b.h.) from d.6" to a 4.0" top d.i.b.

(3) Saw and peeler log volume in board feet and cubic feet. Diameter (b.h.) from 9.6" to 6.0" top d.i.b. Board foot volume may be arrived at by application of conversion factors to cubic foot volume.

Past experience has shown that these three volume-statements are not sufficient by themselves. Each forest stand should be placed in an appropriate merchantability class. The sawlog volume available in sawlog stands would be the figure applicable in the calculation of allowable cut volumes for sawlog operators. Minor sawlog volumes in pulpwood or post stands cannot be economically harvested for sawlog operations, and should be eliminated from consideration for this use. It should also be possible to determine the amount of pulpwood that might be developed as a secondary product from sawlog stands in addition to that available from those stands classified as pulpwood stands. Merchantability classifications for forest stands or types would perhaps be: (a) sawlog and peeler log, (b) pulpwood, (c) post, and (d) unmerchantable. Unmerchantable stands would be identified on maps, and any volume contained therein would be excluded from cut-programing calculations.

An operability classification would be applied to each stand so that the volumes contained in stands that are inaccessible or unoperable owing to watershed or other management considerations can be deleted from cut calculations.

As each forest stand would be allocated to an age-condition class the volume contained in all stands of a particular age-condition class should also be accumulated and should be retrievable as total cubic volume, pulpwood volume, or sawlog and peeler-log volume within that maturity class. With this information it will be possible to construct age-volume tables and to establish the year in which particular stands will be harvested at various levels of allowable annual cut. As Industry requires increasing security of supply and extended tenure, it is becoming necessary to project cut levels into the future for longer periods. A volume breakdown by age-condition class is therefore becoming more necessary as time goes on.

Previous inventories have provided good total volume information by height class and by species, but allocation to an age-condition class has been arbitrarily based on height class, leading to errors depending on site, stocking intensity, past stand history, and others. Merchantability breakdowns in past inventory records have been by arbitrary diameter class, with material from 4-9" classified as pulpwood and material 10" and larger being classified as sawlog. The improvements available through actual stand classification are obvious. In spite of the above, the main requirements for a new inventory originates from the fact that in some units the most recent inventory information available was collected 20 years ago. Changes in stand composition as a result of growth and depletion have altered the stand considerably.

Some attempt has been made to maintain past inventory figures by deducting cut volume and fire loss and adding an arbitrary growth-figure. After 20 years, minor errors in these calculations may have accumulated to the point where limited confidence can be placed in the volume information.

6. Growth

Once an inventory has been obtained, there remains the problem of keeping it up-to-date. Even with a continuous program that enables re-inventory at 10-to-15-year intervals, it is necessary to apply an annual growth correction besides deducting known volume losses. Complete stocking information enables area-volume cut calculation, which can be refined as site productivity and growth information is made available. An analysis of volume increment on various sites, and at various stocking levels, should be developed for application to various age-classes as a part of the inventory program. Data from the present provincial permanent sample plot program might be useful in this regard, as should some work already undertaken relative to yield-table construction in Alberta.

In addition to the development of the usual series of forest-cover maps, the many stand classifications proposed, such as stocking, age-condition, merchantability, and operability, should each be mapped at appropriate scales. Inventory statements should be available to provide the volume and acreage contained within each such classification, to facilitate construction of age-class area, and age-volume models for different economies for each management unit.

Conclusion

Past inventory information has provided a reliable total-volume figure. It has been possible to calculate allowable annual cuts by the Von Mantel formula as a first step towards balancing depletion with growth in each management unit. But Von Mantel regulation is limited in its usefulness in many parts of Alberta where age-class distribution is badly out of balance because of past fire history. Further limitations to proper calculation and programing of cut are imposed by the lack of knowledge of coniferous stocking in most units. Further restraints are placed on timber management by the lack of reliable information on age class and stand condition, which affects both the overall rate of cut and the actual planning of silvicultural projects and harvesting operations.

A new provincial forest inventory should provide all of the information required for more precise calculation of allowable annual cuts, using an area-volume method that recognizes the volume of wood actually available for cut in various merchantability classes, the total amount of coniferous stocking in the unit, the distribution of the coniferous stocking by age-condition class, the merchantability and operability of the timber, and the growth potential of the productive forest lands in each management unit.

Finally and most important, it should be stressed that true forest management can be practised only on permanent forest lands. In the province, top priority should be assigned to the identification and organization of permanent forest-management units that would not be subject to agricultural disposition on demand. Lands scheduled for agricultural development should be identified and placed in an orderly development program outside of forest management units. In permanent forest-management units, expenditures can be justified and management plans and silvicultural projects can be developed which will be meaningful and applicable for many years into the future.

FOREST-HABITAT INVENTORY FOR WATERSHED MANAGEMENT

by

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WATER MANAGEMENT AND WATERSHED MANAGEMENT

Managing a forested area for water is different in principle from managing it for any other forest product. Precipitation occurs on the land area. It then becomes surface runoff, soil water, ground water, or a sizeable amount is returned to the atmosphere through evaporation. Manipulating the distribution between these components rather than adding growth increments is the substance of watershed management. The desired course of action is the one which satisfies the water management objectives.

Water management embraces the entire water resource from precipitation to user and ultimate disposal back in the ocean. While the water is still suspended in the atmosphere, it is not an inventoriable resource. Normally, less than 2% of the available atmospheric moisture precipitates. Predictive methods in meteorology do not now include even estimates of how much precipitation a particular storm or series of storms will yield. Thus, in the atmosphere, water is an intangible resource whose inventory and subsequent management await further scientific development. However, its disposition on or very near the earth's surface is a manageable parameter.

Watershed management is land management to satisfy water-management goals. Water is needed for use in localized areas at specific times. Cities need a sustained yield of high-quality clean water. Farmers need irrigation water during the growing season. Recreationists demand the right to have specified water-surface areas in scenic settings. Silviculturists irrigate trees in some areas. These are specific water requirements that demand planning to obtain. Watershed management can be directed toward these objectives.

All land-management practices influence the hydrologic cycle. The importance of such an influence depends upon the objective for the watershed and the extent of the practice. Timber removal does increase runoff or groundwater. It does so in at least two ways: by localizing the precipitation input, thereby reducing surface-area-governed losses to the atmosphere; and by increasing the soil-water level through reduced loss by transpiration. The increased water may not be needed nor even wanted. It may come at an undesirable time - for instance speeded up snow melt in northward flowing rivers is not desired.

Plans for forest management are usually not drawn up to include water-management objectives. They should be. However, the information necessary to include these objectives is not ordinarily available to the forest manager. Forest inventories in the future can correct this.

WHAT IS A WATERSHED AND WHICH OF ITS CHARACTERISTICS ARE IMPORTANT IN WATERSHED MANAGEMENT

A watershed is a land area. It serves as a catchment for precipitation and it is usually well defined by surface topography. There is only one surface-water outlet. However, there may be any number of ground-water outlets. These latter may or may not be defined by the surface topography.

It subtracts from the amount of precipitation that falls and later becomes either streamflow or groundwater. Precipitation is intercepted by vegetative canopy where it either evaporates or concentrates to run down the stem. At the ground surface, some water is retained in the litter and duff. Much of this may also evaporate. Water that survives these first two loss-points then enters the soil to become soil water or runs along a saturated soil surface to a low spot or established drainage. That which ponds or becomes part of a stream is subject to surface evaporation. That entering the soil water is subject to transpiration withdrawal. What finally percolates through into the ground water table is often a very small fraction of the original precipitation. Some normal ratios for total outflow, both surface and subsurface, as a fraction of original precipitation are from 0.20 to 0.80. The magnitude of this ratio is highly dependent upon watershed vegetation and the underlying soil mantle.

Therefore, a watershed is also vegetation and soils. These are products of the local climate and microclimate. They also influence their own climate. The most susceptible to management is vegetation.

The watershed properties or characteristics that can be inventoried are many. Catchment area, its location with respect to uses and users. Access to each area, that which now exists and that which will be installed as part of existing plans. Soils and parent material, especially such parameters as texture, porosity, erodibility, compressibility, total depth, infiltration capacity, and so forth. Topography such as slope and aspect. Drainage patterns, types, lengths, channel area and volume, gradient, and so on. Last but not least, vegetation; the type, volume, vigor, arrangement both horizontal and vertical. These many characteristics should all be included in drawing up watershed management plans. Some are now available from existing surveys. Some could be gathered by new or different analyses techniques. Some require new technology.

An important difference between watershed management and other management systems: it is highly localized. One may be able to manage, with a fair to good degree of success, most lodgepole pine wherever it is found under one silvicultural system. Not so with lodgepole pine watersheds. The hydrologic system is so complex that it is impossible to generalize about it. Most problems of mismanagement arise from small, poorly managed areas. A good plan for a general area on the average may be a flop in a local situation simply because it did not behave as predicted. A highly erodible soil type among several very stable ones is an example. They do occur.

Watershed management then is a manipulation of microclimate and local situations to meet specified water-yield objectives. Its application depends upon a detailed inventory of the important characteristics.

WHAT PARAMETERS SHOULD BE MEASURED TO DESCRIBE WATERSHED CHARACTERISTICS

Some are obtainable from existing photography and surveys with present techniques. Watershed boundaries, thus delineating watershed management units, could be obtained. Total area with potential for watershed management - that is, those with certain types of vegetation - or lack of it - can be identified from such maps. Existing timber-type maps drawn 1 inch to a mile are probably about the smallest scale useful for this purpose. This really involves a re-thinking for most of us. We are used to working in a square-shaped management unit of uniform size. Such would not be if watersheds were used as management units.

Another would be slope and aspect maps. Steep slopes need different management from shallow ones. Likewise for various aspects. For instance, a northerly aspect might be managed for maximum snow accumulation and late-season runoff while a nearby southerly exposure might be clear-cut to reduce snow accumulation on the slope itself and transpiration early in the season. Similarly steep slopes require different harvesting techniques from shallow ones. Slope-aspect maps in conjunction with watershed boundary maps would be highly useful tools in watershed management.

A third would be maps or inventories classifying drainage type, drainage density, drainage length, drainage direction, average flow distance to permanent streams, areas in flood plains, channel volumes, and stream gradient. These parameters describe most of the flow characteristics: whether a stream is sluggish or flashy, carries a large or small sediment load; whether the area is subject to periodic flooding or not, how well the drainage pattern is developed - essentially how mature an area is. Geologically mature areas require different management techniques from those younger. Drainage patterns tell us quite a bit about parent-material origin and past use history.

Vegetative parameters other than board foot volume are also quite important in watershed management. The standard survey items of timber type, density, and height class should be supplemented by ft^3 volume, areal extent of type, crown area, and crown volume. An entirely new parameter dealing with roughness - a determinate of wind stability - should be introduced. One suggestion for this is an environmental index consisting of two functional parameters of tree height[1]. These involve the intersections of a hypothetical line at some height (h) with the tree crown. These parameters are important in describing the influence of opening size upon snow accumulation. Those indicating roughness may be important in silviculture as well since windfall and blow down are probably functionally related to induced turbulence near a clearing edge.

A last characteristic that is often left off existing maps is access - both that now existing and that already planned for. Access is certainly important in drawing up management plans for any purpose. Watershed management is no exception.

The foregoing characteristics are all obtainable with existing techniques and in many cases from existing survey data. However, some new and exciting developments are taking place in remote sensing - resource inventory. The use of satellite reconnaissance may soon be commonplace. Improvements in existing sensors and the occasional invention of a new or different type, is responsible for a continual flow of new and improved data gathering capabilities. For instance, information on the thickness of the soil mantle and the position of the ground water divide may possibly be obtained from passive microwave data.

Groundwater divides often do not coincide with topographic divides. Where they do not, management in one watershed may have a marked influence on runoff in an adjacent one. One good example is found in Streeter Basin near Nanton where three local and regional groundwater systems operate to create a complex system that has little or no relevance to the surface topography. Surveys made by passive microwave may indicate such non-conformities. These operate by sensing the emissions from specific objects. Such emissions are unique for a particular type or state of substance. Thus, free water looks different from that found in vegetation, soil, snow, or groundwater. This is an exciting technique that has a tremendous potential in all land management - but especially in watershed management.

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[1] Brown, R. A., G. E. McVehil, R. L. Peace, Jr., and R. W. Coakley. 1969. Characteristics of forest vegetation analogs. Rep. CAL No. VT-2408-P-1, Cornell Aeronautical Laboratory Inc. of Cornell University, Buffalo, N.Y.

The vegetative-roughness parameters can be described with existing techniques, but the laser radar is capable of doing it better and faster. These parameters are taken from line profiles of the vegetation after topography has been "normalized". Laser radar can easily do this normalizing because of its fine beam. Only a foot or two of open canopy is required for the beam to "see" the ground surface.

New techniques are coming into being almost daily. Research into how to use these better for all forest inventories should be continued. Further, these new techniques should be adapted to existing inventory whenever they do a better job than previously.

CONCLUSIONS

Watershed management is land management oriented toward a specific water-use goal. These goals, not necessarily maximum water production, become the objectives of watershed management when properly planned and applied. Watershed management is broad in its influence but often local in its application.

Present inventories giving timber in board or cubic foot volumes are helpful but could be improved by fuller use of photographic data. Other characteristics that should be inventoried and delineated by mapping are:

1. Watershed management units (basins).
2. Stream and stream-channel data.
3. Topographic features such as slope and aspect in greater detail.
4. Vegetative characteristics such as canopy volume and horizontal and vertical arrangement.
5. Present and future access.

Surveys conducted in the future should look at the potential use of passive microwave measurements for groundwater and soil-mantle information. Also, the use of laser radar to resolve vegetative roughness parameters would be useful.

Future work should also include research into new and better methods of evaluating stand and topographic features from remote-sensing devices. One note of caution. Watershed research cannot support inventory work. Only active land management can. If the information on watershed parameters is not needed, desired, nor intended to be used in preparing management plans, then there is no sense in taking it. At present, there are no areas in Canada where watersheds are actively being managed for a water objective. This may change in the near future as the general public becomes more aware of their environment. If inventory-methods research is continued, then when management does become concerned about water, proper techniques will be available to assess the land's potential and put it to proper use.

WILDLIFE CONSIDERATIONS
IN FOREST INVENTORIES

by

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The forests of Canada constitute the habitat for a large part of our wildlife. In Alberta, our forest regions contain almost all of our moose population, and a large part of our deer, black bear, and elk populations. Not only do the forests serve as important areas for producing wildlife, they also provide Canadians with the opportunity to harvest them or otherwise to use the wildlife resource because they are Crown-owned and open to the public. The importance of the forest zone to wildlife users in Alberta is quite evident to people of the Edmonton region who witness the great autumn migration of hunters to the northern forests, designated as "Zone 1" by the hunting regulations. I have noticed that not only hunters but also local birdwatchers make frequent excursions to the forests to enjoy the variety of birdlife to be found there. In view of the variety of animals and the growing flood of recreational users, it is not surprising that a large proportion of the wildlife biologists in Canada work in forests.

We thus have here one of the natural meeting grounds of two branches of applied ecology; forestry and wildlife management. In the description of forest stands, the interests of both of these disciplines coincide with that of the plant ecologist. While plant ecologists sometimes have time and funds to linger on small study-areas and search out much interesting information, the wildlifer who wants a general knowledge of an extensive area for immediate practical use must turn to the forester and his inventories. For instance, one area in the Maritimes, classified by plant ecologists as part of the "Red Spruce-Eastern Hemlock-Pine Zone" can be traversed by road in all directions without seeing more than an occasional eastern hemlock (*Tsuga canadensis*) or pine (*Pinus* spp.). The reason is, of course, that the region has been enthusiastically cut and burned by white settlers for the past 200 years. The hemlock and pine are found in the few obscure patches that can be considered near-climax forest at the present time. This region is indeed distinct and the spruce is there, but if one were to think of the area in terms of the influence of hemlock and pine on wildlife, serious errors might result.

Here are some examples of the sort of information that wildlife biologists derive from forest inventories. For a reconnaissance survey of forage production and understory biomass in the forests of New Brunswick and Nova Scotia, it was necessary to stratify the area in some meaningful way. For quantitative information on the areal extent of the various forest condition classes, the most recent New Brunswick and Nova Scotia inventory reports were consulted. By integrating age class, stand density class, and cover type acreages, the most extensive forest condition classes were determined.

The Nova Scotia inventory also included a province-wide series of forest condition class maps at a scale of 1 inch equals 20 chains. These were area stratifications for purposes of the inventory rather than detailed type maps. Since wildlife biologists are interested primarily in the classification of extensive areas, these maps proved very helpful. For my own work I used the maps to choose sites for field study and to compile acreage estimates for land classes other than those reported in the inventory report.

I have mined other information from provincial inventory-reports as well. An estimate of the species composition of sapling and seedling-sized forest stands providing food for browsing mammals was deduced from an examination of species composition of young age-classes and height classes under 20 ft. From this information, the nature of the lesser vegetation could be inferred. The status of mast-producing trees such as red oak (Quercus rubra) and American beech (Fagus grandifolia) was also estimated from inventory stand and stock tables.

A geographer once remarked that every geographical study becomes a historical document as soon as it is published. Forest-inventory reports are very much geographical studies and old ones are valuable for comparative studies of changing ecological condition. I have used this method to document an important decrease in browse-yielding capability over a large region in Nova Scotia. One of the oldest provincial inventories in Canada was conducted in 1909 and 1910 in Nova Scotia (Fernow, B. E., 1912. Forest Conditions in Nova Scotia, Commission of Conservation, Ottawa). Study of Fernow's maps and descriptions of forest types made it possible to establish condition classes that could be correlated with information on the areas of land classes provided by the next province-wide inventory completed in the 1950's. This correlation showed a sharp decline in the area of types with a high browse-yield potential.

It may be asked if the needs of wildlife managers for information on land condition will not be met by the Canada Land Inventory in the future. In my opinion, they will not. The Land Inventory will provide two sets of wildlife maps - one showing land capability for the production of ungulates, the other showing waterfowl capability. These maps are designed especially for long-term planning. Vegetation is the bridge that joins land capability with animal populations. Without proper vegetation for food and cover, land capability for wildlife production remains only potential. It is quite obvious, as an extreme example, that the land upon which the city of Edmonton is built has high capability for producing bison, moose, elk, and other ungulates. However, it is covered with concrete and asphalt rather than vegetation which provides food and cover for these animals. For wildlife researchers and managers interested in immediate problems, it is essential to know what the vegetation is, on particular areas right now.

Since forest inventories often prove so useful to wildlife workers, it seems reasonable to look at some of the things that might be done to make these inventories of more value for wildlife studies. Some of these things are described in the following paragraphs.

(1) Maps. The presently available forest-cover maps produced by the Alberta Forest Service are useful, but are limited in their coverage. I believe that a province-wide coverage by a series of vegetation maps at a scale not smaller than 1 inch = 1/2 mile would be highly useful. These maps should follow a uniform classification system. Such a series of maps would have to be prepared through the co-operation of all land-oriented agencies in the province, including the Alberta Department of Agriculture and the Federal National Parks Branch.

(2) Collection of additional field data for wildlife purposes, When ground sampling for forestry is being carried out on an extensive scale, it is often possible to collect additional data on wildlife habitat at slight extra cost. In the provincial inventory conducted in Nova Scotia in the mid '50's, cruisers were asked for a subjective assessment of browsing on trees growing on the field sample plots. Browsed trees were recorded by species and diameter classes. This represents a minimal effort in the assessment of wildlife habitat. At the opposite end of the scale, the United States Forest Service in the southeastern states has worked out techniques for combining a deer browse survey with its forest inventories (See Deer Browse Resources of North Georgia by T. H. Ripley and J. P. McClure, U. S. F. S. Res. Bull. SE-2, 1963). At each inventory sampling location, 20 mil-acre sample plots were selected for regeneration studies. These plots were also used for the browse study. Stems of all woody plant species on the plots were tallied by species. An ocular estimate of the weight of twig new growth was also recorded, as were estimates of browse utilization.

(3) Information useful to wildlife managers may be obtained by reworking forest stand data collected strictly for forestry. In this day of computer processing, programs can be modified to summarize data in additional ways at moderately extra cost. As an example of what might be done in this regard, I will

mention another eastern example. In my work on the use of habitat by deer in winter in New Brunswick, I found that deer preferred mixed stands of spruce (Picea spp.), balsam fir (Abies balsamea) and northern white cedar (Thuja occidentalis) having over 150 sq.ft. of basal area per acre. Changes could be introduced into the computer program for compiling the inventory data to give an output of the acreage of stands of this sort. The extent of stands providing potential concentration areas for deer in winter could thus be estimated.

The incorporation of wildlife aspects in a forest inventory depends on close co-operation between the foresters involved and local wildlife-management staff. In Alberta, this would mean inter-agency co-operation between management biologists in the Fish and Wildlife Branch and foresters in the Forest Service, both of the Department of Lands and Forests.

The forest ecosystem contains much more of value to man than merchantable cellulose. These other values of forests are growing in importance. The concept of forest inventory can therefore be justifiably enlarged in scope from timber-volume studies to cover measurement of other attributes of the forest community and the land resource of the province.

FOREST-HABITAT INVENTORY REQUIREMENTS FOR FOREST RECREATION

by

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It has been stated that the fastest growing use of our forest lands is for forest recreation. I agree with this statement, for the meaning of forest recreation is changing constantly for many people.

More people are using the forests, in more different ways, requiring greater flexibility and prompter response by forest management.

For foresters, this is a social challenge of the most basic type. It is not tomorrow's challenge. It is in the forests now, demanding consideration if not answers, competence if not perfection, and a strong sense of social responsibility if not a complete awareness of social change.

Any new forest inventory proposed for the Province must recognize this challenge and attempt to provide as much information as possible that can aid foresters employed in forest recreation programs.

It is rather obvious to me that a high-quality, up-dated forest inventory will lead to a higher-quality management of forest land and consequently can do nothing but improve the quality of outdoor recreation particularly in the long term.

There are basically a half-dozen ways by which forest recreation managers could benefit from a new forest inventory. These could be considered as possible requirements but could not be construed to mean that a new forest inventory was a prerequisite in order to carry on with forest recreational planning.

As I see it, a new forest inventory, if it were designed to be a "multi-purpose" inventory instead of a single-use timber inventory, could be beneficial in the following ways and would be desirable:

1. Although we now have single use capability inventories of our land resources, i.e., forestry capability inventory, outdoor recreation capability inventory, all under the Canada Land Inventory program, a truly designed provincial multi-purpose forest land inventory would make all resource people involved in the inventory aware of all resource uses of land. For an example, photo interpreters would no longer be "mechanical robots" for lack of a better word, drawing lines around forest types and estimating heights and densities. They would necessarily have to broaden their knowledge

of the resource base and think or interpret in terms of several uses for one area of land knowing the timber volume, quality, and species for the area.

Canada Land Inventory information could be fully utilized for this purpose by way of overlays, etc.

2. A new forest inventory would certainly help in the pre-selection of priority recreation sites because dominant tree cover is very important in site development. Understory, assessed as an inventory requirement, could be utilized and found to be of significant value in recreational evaluations of land for intensive use.

3. New photographs that would be a requirement of the inventory would certainly be of tremendous use in recreational planning. The mere fact that all new access would be known would indicate reason to re-evaluate areas already identified by Canada Land Inventory on the capability basis.

4. A new forest inventory could reveal what the predominant species composition is on large tracts of forest land previously denuded by fire, etc. This perhaps could aid in the recreational assessment of this land.

5. Established recreational amenities e.g., ski resorts and campground developments would be identified with new forest inventory.

In summary, it can be said that it is difficult to state specific practical requirements in forest recreation which would justify the need for a timber (single use) inventory or a forest (multi-use) inventory. If anyone here today can convince me that there are specific requirements needed, then I've learned something at this seminar.

FOREST-HABITAT INVENTORY REQUIREMENTS FOR MULTIPLE LAND USE

by

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Assuming that everyone agrees on the definition and the objectives of multiple-use management, I will only state that the Department of Lands and Forests is committed to this principle in its administration of Alberta's forested public lands.

We all know that agreeing with the multiple-use concept and making it work are two quite different things. In order to practice multiple use, the land manager must have some data on land capability; use priorities must be established and primary use should be allotted. Then follows the need for integration and coordination of all uses on an area with a minimization of conflicts or resource damages. Also, any working multiple-use plan must have a built-in flexibility to allow for future needs and changing land-use pressures.

Obviously, there are many constraints to the practice of multi-use management in high-conflict areas. These are greatly magnified by either the lack of data or the fact that existing data are not in a readily usable form.

What information, then, could a forest-habitat inventory provide that would benefit multiple-use planning? The following suggestions would demand more intensive photo-interpretation combined with some additional field checking:

1. More complete land-use details re: trails, seismic lines, saltgrounds, millsites, campgrounds, fences, etc.

2. Accurate delineation of forage types.

3. Fairly precise definition of watershed boundaries and drainage patterns.

4. Mapping of critical or most sensitive watershed areas (mantle stability, damage).

5. Periodic photography of intensive-use areas (Prairie Creek oilfield, etc.)

6. Protection zoning - for aesthetics, fire, watershed management (improvement cuttings, snow accumulation, quality protection).

In general, an up-to-date record of all land-use activities could be provided as a flexible base for multiple-use evaluations.

There are examples of inventory systems designed for multiple land use but, to the best of my knowledge, they are few. In Arizona, Ffolliott and Worley[1] described a multiple BAF (basal area factor) inventory system designed to use stocking levels as a basis for determining the effects of timber management on other resource values. Again in Arizona, the Comprehensive Hydrologic Survey of the Salt-Verde system[2] is being conducted to provide a base for an intensive watershed program that will help achieve multiple-use objectives. Closer to home, a watershed inventory just being completed by the Eastern Rockies Forest Conservation Board provides an excellent example of what a comprehensive hydrologic survey can offer for management planning.

EAST SLOPES WATERSHED INVENTORY

In 1962, the Board initiated a hydrologic analysis and watershed land use survey of the 9,000 mile Rocky Mountains Forest Reserve. This inventory was designed to provide a guide for detailed management planning in the form of:

1. An assessment of the effects of past and present land use upon watershed and stream conditions.

2. A hydrologic analysis that offers a means of comparing basins or areas.

3. A classification of land by broad-use zones for multiple-use planning with water specified as prime resource.

4. A management problem analysis.

Time permits only a very brief description of the inventory, the results of which are compiled in the form of Conservation Unit Guides. Each guide covers one or more conservation or management units and uses sub-basins of major watersheds as the survey unit.

The hydrologic-analysis section of each guide includes a detailed description of the physical and hydrological characteristics of the unit, using all available maps and data. Elevation and slope-gradient curves are drawn for each sub-basin and mean values are calculated. Slope is also mapped by gradient classes to afford a ready means of detecting those parts of a unit in which gradient might be a critical factor in management planning. Local aspect is mapped into four classes - cool, humid; intermediate, cool; warm, dry; intermediate, dry. A determination of drainage characteristics includes the measurement of miles of streamcourse and the acreage in lakes and reservoirs. Drainage density is expressed in miles of streamcourse per square mile of area. Stream profiles are drawn for major streams in each unit, and average stream gradients are calculated.

A summary of available information on geology is provided. General information on soils in the Reserve is limited to a preliminary soil survey which was conducted by the Board in the early 1950's. The lack of a soil survey and information on surficial deposits of the East Slopes creates large gaps in the inventory which, hopefully, will some day be filled.

From available climatological and hydrometric data, a rough water balance is calculated for each major basin. A precipitation zone map is drawn up from existing storage gauge and snow-course network data. Streamflow records (when available) are analyzed by the "half-flow date" method.

The management section of each guide includes a description and mapping of general watershed condition and those areas damaged either by land use activities or natural causes. Watershed condition is rated by sub-basins as good, fair, or poor. This is combined with a classification of damage hazard as low, medium, or high.

The watershed damage map also includes an initial classification of land-use potential. This is intended only to act as a foundation upon which more precise classifications may be developed in the future.

Seven land-use zones or landscape-management units are delimited in relation to such factors as precipitation, elevation, topography, soils, vegetation, location, and use. The first three classes are broad geographic zones and the remaining four are special-use areas that fall within the larger zones.

1. Headwaters Zone (Alpine and Upper Sub-alpine)

    This zone contains the upper headwaters areas that produce a high proportion of the streamflow from the East Slopes. High precipitation, with over half the total falling as snow, is the outstanding feature of this zone. Annual precipitation ranges from approximately 40 to 70 inches.

    The most important use in the Headwaters Zone is water production and other uses should be closely regulated or prohibited. It is possible that future harvesting of the limited commercial timber stands in the zone will be confined to carefully controlled and subsidized operations for the purpose of snowpack management.

2. Intermediate Zone (Lower Sub-alpine and Boreal)

    This zone, which is intermediate in elevation and precipitation, is the largest and usually has the most use. It produces much of the available timber, considerable forage for livestock and game, and a good portion of the recreation potential. Gas, oil, and mineral activities are also important in this zone.

    Water yields are not as high as from the upper zone, and other land uses play a more important part. This places the emphasis on the need for multiple-use management in the intermediate Zone.

The protection of watershed values should be ensured and, where serious damage has occurred, restoration programs should be required.

3. Valley Zone (Montane)

Mountain valleys and the lower valleys of the foothills along the eastern edge of the reserve make up this relatively small zone. Precipitation may be only slightly lower than in the Intermediate Zone, but higher temperature and wind make the zone more arid and the water yield lower.

Grass is the important cover type and aspen dominates the forest cover. Livestock grazing and game production are of high importance in the Valley Zone. Heavy recreational use is attracted by easy access and the availability of game animals and productive fishing waters.

Erosive soils are common in this zone and protection against watershed damage is most important.

4. Water Margin Zone

The margins of lakes and major streams constitute this zone. Its depth depends upon the nature of the area and the use to be made of it. The margins along the streams are usually too narrow to be mapped.

The objectives of management of this zone should concentrate on protection of streambanks, the fish resource and other recreational values. Careful, long-range planning is required here.

5. Travel Zone

The Travel Zone is delineated along roads and trails and varies considerably in depth. Most camps and recreational facilities lie within this zone. It may correspond to the Water Margin Zone in some places.

Aesthetic values will require special attention but the purposes which the road serves should dominate. Watershed protection needs as related to road location, construction and maintenance are of extreme importance in this zone.

6. Geophysical Zone

Land areas affected by oil and gas wells, mines, quarries, pipelines, and seismic exploration are included in this zone. Although the total area involved is quite small, it can exert a major influence upon watershed and other land values. The control of damage and the restoration of proper watershed conditions are the major objectives here.

7. Special Zones

Single-use areas such as wilderness areas, parks, and experimental watersheds fall into this class. The special purpose for which they were created will obviously dictate their use and management.

Each unit guide contains an analysis of current multiple-use management problems in each land-use zone along with a prediction of future problems and a statement of goals for watershed management condition.

In conclusion, I feel that the information gathered from this type of resource inventory could be a valuable input to future integrated land-use planning.

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SOME REMARKS ON PLANNING A FOREST INVENTORY

by

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In planning a forest inventory a miscellany of problems arise, of which most of those mentioned have in common that they can be solved if the purpose of the inventory is defined. Few serious technical difficulties remain once the exact purpose is known.

One method of ensuring that the purpose is clearly understood is to draw up an outline for the final report on the inventory, that includes a table of contents and a list of required tabular summaries showing headings for all rows and columns, and to specify the allowable errors. Managers, inventory experts and users should all be deeply involved at the planning stages, for it is the man at the end of the line, the user, who has to live with the inventory results.

ALLOWABLE ERRORS

At an early stage of inventory planning the desired accuracy will be discussed. Statisticians usually emphasize high precision and take pride in low variances and standard errors; users are more interested in accuracy. Accuracy is not the same as precision, being an expression of the difference between estimates and true values. Precision is an expression of consistency, of the repeatability of the results; but even great precision may be liable to strong systematic errors. Thus it is possible to reach a precision of ±2 per cent with a volume table that has a bias of -20 per cent; it is, however, hardly possible to come within 2 per cent of the true values, while using this table. When planning a forest inventory it is, therefore, not enough that "standard errors shall be ±5 per cent", but control over systematic errors must be ensured.

Accuracy is difficult to estimate, and for practical purposes some goals become defined in terms of precision, while others are in terms of maximum allowable systematic or measurement errors. It is mandatory to set these minimum standards: how great can bias be in a volume table before the table becomes unsatisfactory? What is the maximum error allowed in the measurement of tree heights and stem diameter? Every inventory should have a system for checking sample plot measurements.

In defining the populations to which the standards of accuracy and precision apply, it is necessary to be exact. Is it required to have 10 per cent precision for the volume estimate of a province, of a district, of a map sheet, or for each stratum? The answer can only come from a careful review of the inventory's purpose: is it an inventory to obtain national statistics? Is it a provincial inventory intended for broad planning, for the allocation of cutting rights, and as a guide to legislation? Or, is it a management inventory to help in locating next year's cut? The effects on necessary sampling intensity would be staggering. Who, for example, wants to know the location of every 50-acre stand in an area that will not be logged until the next pulpmill is built?

Detailed typing on aerial photographs should be avoided if it is not possible to confirm photo interpretation by ground sampling or if only out-of-date, or inferior photography is available. It is better to map broad forest types accurately, than to present inaccurate information in detail, for later, in the analysis, it is not useful to compile estimates that are probably inaccurate. In a stratified random sample, for example, the presentation of volume estimates based on less than 20 sample plots might be omitted; with the coefficients of variation usually encountered, a smaller number of plots would often involve a probable error of the mean that is greater than 20 per cent of the estimated mean.

FOREST COVER MAPS

Most Canadian forest inventories include the preparation of a forest cover map; it is almost a tradition. Many American inventories do not involve cover mapping, but concentrate on the preparation of tabular estimates. Mapping is very expensive, and the need for maps should be examined thoroughly before proceeding along traditional lines. Photo maps and mosaics are finding increasing acceptance as less expensive substitutes for conventional forest cover maps.

Whether areas of different forest conditions are determined from maps or by classifying plots, there is always an error in area estimation which affects volume estimates. This error can be assessed if area estimates are based on the classification of sample points (Meyer, 1963); whereas if area estimates are obtained by planimeter, the errors usually remain hidden.

Foresters tend to discuss specifications for forest type maps in terms of scale: "Shall we map at four inches to the mile (1:15,840), or at 1:50,000?" In the standard national topographic mapping series, exact statements of accuracy are set for each scale, and a discussion in terms of scale has some meaning, but in forest inventory, no such standards are in use.

A useful beginning at the setting of standards is to define "the minimum size of area recognized", *i.e.* the minimum area which a certain condition has to occupy to be recognized as a separate entity. For example, how large does a patch of 60-foot trees, in the centre of a stand otherwise 40 feet high, have to be before it is delineated as a separate height class?

The Newfoundland Forest Service employs the following standards on its intensive forest inventories:

	Minimum area recognized
Forest in forest	20 acres
Forest in non-forest	10 acres
Non-forest in forest	5 acres
Non-forest in non-forest	10 acres

For extensive inventories, different standards are set.

The choice of "minimum area recognized" should not be left to individual interpreters, for it affects both the effort spent in photo interpretation and mapping, and the final results. In one regional inventory in the United States, the estimate of forested area increased by 100 per cent when the minimum size of area recognized was lowered from 100 acres to 40 acres; small woodlots that had previously disappeared in other land classes emerged as a significant quantity. Such large differences are unlikely in Canada's more important forest zones, with their extensive forest stands, but significant differences could arise.

STRATIFICATION

If a forest cover map is to be prepared then a decision must be made as to what criteria are to be used in delineating forest types or strata. These criteria are any or all of species composition, height, site, canopy density, volume, and logging difficulty. The answer can only be given if the reason for stratification is known, for different motives for stratification lead to different procedures:

1. Stratification or forest typing may be intended to show the user the location and size of the stands that will be considered in management and operations. Generally, information on species composition, volume per acre and average tree size plays an important role on such a map. Considerable detail may be required.

2. Stratification is often undertaken to increase sampling efficiency. To estimate some quantity, such as volume on an area, large gains in efficiency can be achieved by delineating strata with large volume differences between strata, and with little variation within strata. In forestry, it has been shown empirically that a small number of strata, usually a maximum of 5 or 7, is enough to exploit the statistical benefits of stratification; a multitude of small or complex strata is a liability.

The two requirements are often compatible, and good compromises can be made. But the danger is that the true reasons for stratification may be forgotten and that a complex stratification system involving stand structure, site, ground vegetation and small differences in canopy density might evolve, although there may be no demand for it.

AREA ESTIMATES FROM SAMPLE PLOTS

Various errors affect surveys if area estimates are obtained by classifying sample plots. Most errors arise from sample plot locations being chosen on aerial photographs without regard to displacement and scale differences. An interesting phenomenon is the effect of plot size on the results, discussed in a recent study by Nielsen (1970).

Vegetation is not arranged at random in a forest but has a tendency to grow in homogeneous clumps; for example, there may be small islands of spruce in an aspen stand, patches of swamp in a forest. Small plots are more likely to cover only one condition than large plots. Thus, large plots are more likely to be classified as "mixedwood" than small plots, which are more often uniform "hardwood" and "softwood". Of other variables affected by plot size the strongest effect can be expected for such measures as "height of the tallest tree on the plot". This variable increases with plot size, because a large plot is more likely to include a big tree than is a small plot.

There is little reason for concern about this effect unless different plot sizes are mixed in one inventory. But it is an argument for standardizing procedures in surveys, the results of which are to be combined.

THE RELASCOPE

Point sampling is an extremely efficient technique. The main challenge with the technique lies in ensuring accuracy; errors by missing trees and mistakes in deciding whether a tree is "in" or "out" can become serious. The proper choice of instrument and basal area factor are important in minimizing inaccuracies. The Spiegel Relascope is a precision instrument with automatic slope correction; it thus has a decisive advantage over wedge prisms.

A good method for deciding on the basal area factor is to make a rough estimate of the average tree count that will be encountered with various basal area factors. A study completed in the Forest Management Institute showed that different basal area factors, used in different stands, resulted in approximately the same coefficient of variation, provided the average tree count remained the same. Furthermore, it was observed that there was a strong tendency for inaccuracies with very low tree counts (possibly five trees or less); that relascope operators were unable to repeat counts of more than 20 trees with confidence; and that a point sample containing more than approximately 16 trees was statistically inefficient, because it practically only repeated the information that could have been obtained from a smaller sampling unit at the same location. Thus, a basal area factor should be chosen that will give average counts between roughly 10 and 16.

REGENERATION, CULL AND GROWTH

Regeneration, cull and growth surveys, if required, should be fully integrated with the other goals of an inventory. Regeneration surveys suffer most from uncertainties of purpose and from difficulties in interpreting the results. Grant (1951) gives a good account of the reservations that must be exercised in interpreting a survey completed by the "stocked quadrat" method.

Cull surveys remain one of the most important unsolved problems in most forest inventories. Many inventories provide accurate information on total volume but contain no reliable data to show whether cull is 10 per cent or 30 per cent of total volume. Some success has been met in recognizing defects from external indicators, although usually the procedures developed are valid for only a small region. Investigations of electronic cull detectors have so far not been successful; cull surveys involving the sectioning of trees are extremely laborious.

On the large question of growth surveys, three points are listed which have often led to difficulties which could have been avoided:

(a) It is difficult to extract useful information from permanent plots on which trees are not individually numbered and measured;

(b) Strictest control over measurement errors is required; restrictions on measurements during the growth season are necessary;

(c) If permanent sample plots are to be established within pre-determined strata, then strata boundaries should not be defined by variables, such as stand height, which change rapidly with time. For example, it would normally be a mistake to place more permanent plots into the big timber, and less into the younger stands. If the plots are to be maintained for several decades one will soon have a sample allocated according to conditions that bear no relationship to the current situation.

OPERATIONAL TRIALS

New methods of forest inventory are being continually introduced. Recent examples are computer mapping and sampling by large-scale aerial photography. Both are promising developments but before any application on large operational projects, pilot studies are essential.

The critical problems in practical applications are often not the theoretical questions of research; they tend to be more prosaic questions of scheduling, forgotten details, misunderstood instructions, human factors, lack of experience with new instruments, and problems in data handling. The early detection of such problems may determine the success or failure of an inventory.

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A COMPUTER-ORIENTED FOREST-MANAGEMENT SYSTEM FOR REGION ONE, U. S. FOREST SERVICE

by

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The agenda for this symposium would be appropriate for any meeting about forest-resource inventory in our United States Forest Service. We are struggling with most of the same problems discussed here these past two days - problems of information for establishing policy and management direction, problems of information for program development.

In discussing the use of the computer for handling information, I want first to make it clear that our resource inventories are far from adequate, that we are still trying to determine the information we need, how to measure and how to evaluate it, and how to correlate the inventories for multiple resources into a usable information package.

Another point I want to mention, before discussing our information system, is that it is oriented toward timber production. The system was developed and activated by our Division of Timber Management. Consequently, it does not incorporate the other resource inventories nor does it adequately reflect other uses of forested lands. Other Regions in the United States Forest Service are at different stages in the development of information systems. The TRI System (Total Resource Inventory) being developed in Region 6 (Oregon and Washington) is oriented, as its name implies, to an inventory and management package for all resources. At this time, it is far from completely operational and suffers from some of the same lack of resource information that all present systems seem to have.

The "computer-oriented Forest Management System" that we are using has been operational about 4 years. We have constantly been finding new applications. Our approach has been largely trial and error.

To provide just a little background, about 12 years ago the St. Regis District of the Lolo National Forest was designated as an intensive management district. It was scheduled for a level of financing that would provide optimum resource development and use. As a part of this program, all resource inventory work was expanded. Timber inventory work was intensified to describe situations on a stand-by-stand basis which in turn would provide for the development of action programs.

With a relatively heavy inventory program, the system soon broke down. There was just no way to assimilate the information from the hundreds of field-inventory records and their summaries.

Although new inventory-techniques had been developed to provide more comprehensive information than we had ever had before, it was almost impossible to hand-compile, summarize, and store the information for ready use or to use it in establishing priorities for stand treatment. With an expanding timber-management program on the District, there was no alternative but to automate the data handling. This triggered the development of the system we are presently using.

We had other justifications for automation. Almost any management action on forested land requires carefully timed followup. For example, after timber harvest, we dispose of the logging debris and cull or diseased residual trees, prepare the site, seed or plant, and maintain control of the stocking in the new stand. It seemed obvious that if we wanted to account for management actions on an area of land and to schedule subsequent activities at the proper time, a system had to be developed that would be more reliable than a District Ranger's memory.

We also needed an automated system to summarize and prepare the report of all timber-management work accomplished for different management levels; i.e., Ranger District, National Forest, and by Forest Service Regions. We are also required to account for our activities within political subdivisions such as counties, states, and congressional districts. (Reporting on, or accounting for, work accomplished is one of your responsibilities, too.)

Finally, we needed a system of data handling that would permit us to determine the actual cost of the various types of timber-growing activities. This is necessary in order to analyze input-output information, to establish priorities, and to allocate funds to meet regional objectives.

With that as background, I would like to describe how the overall system operates and then go into more detail on each component of the system and some of the present uses.

We have three distinct timber inventories for each national forest. One inventory that we characterize as a "Stage I" is for development of the timber management plan. This is an extensive inventory to provide the basis for describing broad management situations, for calculating the allowable cut, and for suggesting program levels that will sustain the allowable cut. Until now, this type of inventory has consisted of 200 to 250 one-acre samples distributed across a national forest. I say "until now" because we are beginning to use other information as a data base for timber-management plans.

The "other information" we are beginning to incorporate into timber-management planning is a stand examination or "Stage II" inventory.

These inventories describe individual timber-stands (or homogenous units that can be delineated on aerial photography). Stage II surveys, or stand examinations, are the inventory for timber-management actions. All timber-management action programs are based on Stage II inventories. For example, these surveys serve as a reconnaissance for timber-sale preparation and for determining all reforestation, timber stand improvement, and protection activities. The information from stand examinations becomes a part of our automated resource records.

The third type of timber inventory is the timber-sale cruise, usually applied only to cutting units within the sale, and for the purpose of determining timber volumes and end-product values.

The inventory techniques and compilation of the inventory data are essentially the same for all three timber-inventories. Each has its separate computer programs, outputs, and tape storage. The stand examination or Stage II inventory information is the inventory portion of our resource recordkeeping system.

The Resource Record portion of our data combines the stand examination inventory with land-management activities that take place within the timber stand or management unit. As I mentioned earlier, timber management is a sequence of actions on a particular unit of land. As the stand is harvested, the slash is disposed of, the site is prepared, the area is planted, etc., the actions are also recorded and the required inventory changes are made.

We have two criteria for stands or management units. They must be homogenous in character, and they must lend themselves to a uniform treatment. For example, if we were to clearcut one-half an area, and seed tree cut the remainder, it would be described as two stands, although the original inventory information might have been essentially the same.

The Cost Control Portion of our system for a particular activity such as thinning combines stand examination, the management activity, and the fiscal records that relate to that job and that stand. This provides information on the cost of doing the work under various environmental and stand or area conditions, and has allowed us to develop cost-prediction equations for each type of work.

These three elements of the system - inventory, stand management records and map,and cost analysis - provide the basis for our timber-management programs.

Now, let me describe in some further detail each of the three elements and what the computer does for us.

Our stand examinations are a combination of fixed (1/300 acre) and variable plots (40 BAF) that sample the stand. We recognize four stand categories for inventory purposes:

Old Growth Stands, Immature Stands with Overwood, Immature Stands without Overwood, and Nonstocked Areas. The stand examination or Stage II inventory is designed to describe volume and risk situations in old growth, volume and individual-tree conditions in immature stands, and ground cover conditions on nonstocked areas.

After the inventory, the data are compiled by computer to provide a stand table by tree class, cubic and board foot volumes by species, numbers of trees per acre by species, basal areas, cubic and board foot growth, site index, and the accuracy with which the stand was sampled. Exhibit 1 - Most of the information for the stand is summarized and coded for "automatic" input into the permanent-resource records. The field inventory crew also includes such items as stand area, slope, aspect, physiographic site, elevation, timber type, habitat type, and soil conditions from their field observations.

This information is the inventory portion of the date recorded on tape. In addition, the examiner makes a prescription for stand treatment needs -- both silvicultural and protection. This also becomes part of the tape record. As I mentioned earlier, once my activity is either scheduled or completed in the stand, this information is also stored on magnetic tape. The major management categories include Regeneration, Stand Improvement, Timber Harvest, Hazard Reduction, Site Preparation, and Protection.

Exhibit 2 - A typical clearcut unit, for example, is coded to indicate that it was clearcut when the harvest was completed. If this cutting was completed in the spring, the Ranger would report the area harvested and schedule it for prescribed burning the next fall (Hazard Reduction and Site Preparation), schedule it for planting the following spring (Regeneration). As each activity is completed the coding is changed to indicate a "completed" rather than a "planned" job.

As you can see, work scheduled in advance becomes a part of the total planned-work program, and completed work can be included in accomplishment reports.

To describe more completely how we use the computer in forest management, I have listed some of the programs we use. These are in four basic categories of programs: Inventory Compilation, Recordkeeping, Action Plan Development, and Reporting. I'll describe briefly what each program does. This should help clarify the overall system.

INVENTORY COMPILATION

Record of Area
Edit of Timber Inventory Data (Exhibit 3)
TRENO (Compilation)

Timber Sale Cruise
Timber Traverse

RECORDKEEPING

Record of Stand Examination and Management Status (Exhibit 2)
Timber Seed Inventory
Project Work Plan (Exhibit 4)

ACTION PLAN DEVELOPMENT

Planned Work (Exhibit 5)
Precommercial Thinning
Programmed Timber Management Work Summary
Mature Stands
Overwood Removal
Investment Analysis

REPORTING ACCOMPLISHMENT

Harvest or Other Drain (Exhibit 6)
Reforestation, Timber Stand Improvement, Protection
Report of Slash Disposal Accomplishments
Project Work Plan

INVENTORY COMPILATION

The record of area program is used in timber-management planning to provide a summary of area by ownership and land class. The data are broken down on a compartment basis.

The edit program edits field-inventory plot sheets for unacceptable codes, obvious coding errors, and such things as suspicious diameter-height relationships.

The TRENO program provides the stand table, basal areas, cubic and board foot volumes by species, growth, etc., that I mentioned before.

The timber-sale-cruise program calculates volumes and end product values for the area cruised.

The timber-traverse program plots the traverse as a computer printout and provides the area and error of closure.

RECORDKEEPING

The Record of Stand Examination and Management Status is our permanent tape record of all stands examined and the status of management at a specific time. This is the source tape for Action Plan programs.

The timber seed inventory provides a running inventory of seed on hand, seed dispersal, and seed quality and value.

The Project Work Plan is a summary of all planned timber-management activities on a Ranger District for a particular fiscal year. It includes identification of the area by stand number, the type of work, the estimated cost and the type of funding. Project expense is accrued currently. At the close of the project, the computer calculates unit costs.

ACTION PLAN DEVELOPMENT

Planned work provides a summary of the acres of the various types of work to be accomplished on each Ranger District by fiscal years.

Precommercial Thinning lists those stands in need of thinning that meet predetermined criteria of site index, species, age, stocking levels, etc.

The Programmed Timber Management Work Planning Summary lists individual stands in need of specific treatments, by fiscal year in which the work is scheduled.

Mature Stands is a listing of old-growth stands by volume classes for sale preparation.

Overwood Removal is the same type of program, but lists those stands having overwood with a manageable understory.

Investment Analysis is a program that provides internal rate of return and present worth for various management alternatives within the same stand.

REPORTING ACCOMPLISHMENT

Timber Harvest or Other Drain reports the acres cutover by various silvicultural systems and other losses such as fire.

Reforestation, Timber Stand Improvement, and Protection reports the acres accomplished in these categories by administrative and political units.

Project Work Plan is also a method for reporting accomplishment currently. As each timber activity on a stand is completed, the Project Work Plan is changed to indicate this. A Forest Ranger or Supervisor at a glance can determine current status of his work programs. Report of Slash Disposal Accomplishments, as its name implies, summarizes the acres of slash hazard treated by method of treatment.

These programs comprise our computer-oriented forest-management system. With all of the benefits we have had from computer use and I'm sure that we have barely scratched the surface, there are major difficulties to surmount when adapting to computer systems.

The major problem we faced, and this can't be blamed on the computer, was to convince foresters that the information they were using to make management decisions was not adequate. There is a natural tendency for a forester to want to "fly by the seat of his pants." Subjective decisions seem more attractive than decisions based on the hard cold facts of an inventory. However, until we could handle the data by computer, too many decisions were based on opinion, rather than facts.

Once we became "computerized", however, the reverse became true. Anything that came out of the computer was right. Foresters did not take the time to check the calculations. We have discovered a number of programming errors that distorted the output, yet these were not discovered immediately. No one did any checking --- even with a calculating machine available.

I believe reliance on the computer and fascination with it has slowed our efforts to improve volume tables, growth formulae, etc. In order to develop a computer system, something has to give and with us, it was probably a failure to improve some of the fundamental aspects of technical forestry. However, we are past this period of computer application now, and we are accepting the computer as just another tool for management.

This concludes my presentation. Again, I wish to thank you for the opportunity to participate in this symposium.

Exhibit 1

STAND EXAMINATION (STAGE II) COMPILATION

STAND TABLE

Number of trees per acre by tree class and D.B.H. class

Basal area per acre by tree class

Number of trees per acre by species

Cubic foot volume per acre by tree class

Cubic foot volume per acre by species

Board foot volume per acre by tree class

Board foot volume per acre by species

Stocking percent

Average diameter for all trees, for trees 5"+, 7"+, and 9"+

Average ten-year diameter growth by D.B.H. group

Cubic foot and board foot growth per acre

Accuracy of the sample based on tree number, basal area, cubic foot volume and board foot volume

Site index calculations for selected trees.

Exhibit 2

Etc.		
Site Prepara-tion	Appropriation	
	Kind	
	Site Preparation	Date
Hazard Reduction	Appropriation	
	Kind	
	Slash disposal	Date
Harvest or Other Drain	Method or cause	
	Harvest or Other Drain	Date
Stand Improvement	Appropriation	
	Pruning	Date
	Commercial Thinning	Date
	Appropriation	
	Precommercial Thinning	Date
	Appropriation	
	Release	Date
Regeneration	Appropriation	
	Kind	
	Regeneration	Date

Exhibit 3

EDIT OF TIMBER INVENTORY DATA

1. Improper State Code
2. Improper County Code
3. Improper Sample Kind Code
4. Improper Forest Code
5. Improper Working Circle Code
6. Improper Block Code
7. Missing Point or Point Number
8. Improper Cover Class Code, Nonstocked Point
9. Missing Tree or Tree Number
10. Two Trees with the Same Number
11. Missing or Improper Tree History Code
12. Missing or Improper Species Code
13. Missing D.B.H.
14. Missing Height
15. Suspicious D.B.H./Height Relationship
16. Missing Growth
17. Suspiciously Large Growth Rate

Etc.

Exhibit 4

PROJECT WORK PLAN SUMMARY

Forest	District
XXXXXX	XXXXXX

Type of Work	Status	Area	Identification	Appropriation
XXXXXXXXXXXX	XXXX	XX	XXXXXXXXX	XXXXXXXX

Project Cost Estimate		Accrued Costs	Unit Cost
First	Final		
XXX.XX	XXX.XX	XXXX.XX	XX.XX

Exhibit 5

PLANNED WORK - ACRES

F.Y.	Regeneration Plant	Seed	Release	Thin	Prune	Prescribe Burn	Scarify	ETC.
1969	183			203		436	203	
1970	1,142	190				408	70	
1971	154			163				
1972	104							
1973								
1974								
1975								

Exhibit 6

REPORT OF HARVEST OR OTHER DRAIN

(Acres)

Forest & District	Clearcut	Seed Shelterwood	Removal	Rehabil-itation	Selection	Fire
Clearwater						
Pierce	76	197	324		126	77
Bungalow	12					13
Canyon	857		33			
Kelly Creek	998		151		32	10
Lochsa		319				
Forest Total	1,1943	516	508		158	100

ADJOURNMENT TALK

by

R. G. STEELE
Director, Alberta Forest Service
Edmonton, Alberta

Gentlemen, as the last name listed on the agenda I have been requested to adjourn this symposium but not to summarize it. However there are a few points that I would like to mention before we finally conclude this very useful and informative session.

First I would like to mention briefly the background that resulted in the excellent organization, agenda, and selection of speakers for this symposium.

A few years ago the Alberta Forest Service realized that many forest surveys of various types had been and were being conducted, many of them independent of others. A task force was requested to review all such surveys and make recommendations accordingly. An exhaustive review by an extremely dedicated group of seven persons (Chuck Kirby was one of them) resulted in a series of positive proposals which would take too long to present at this time. A key extract from the report, however, is "to define the information requirements under the present forest management system in advance of the implementation of the new re-inventory program. A certain level of intensity of management with full consideration of the office and field costs involved as well as the ultimate uses and values will have to be set." An initial phase is to apply the new inventory system on a pilot area before adopting it Province wide. Unfortunately little progress has been made since the report was submitted 6 or 7 months ago mostly because we have been unable to locate a suitable man to head up the program. If any of you are aware of anyone that may be qualified for an extremely challenging position please let us know.

This symposium has provided a great deal of useful guidance on what should be included in a truly comprehensive forest land management planning survey program.

At this point I would like to make a few observations that are really a repetition of statements made by several of the speakers either directly or indirectly.

1. A forest land inventory for management must consider that we are managing forest land for many reasons, not solely the production of trees for the fibre they will provide to industry. We must manage it for the optimum value of all uses.

2. If other disciplines expect us (the A.F.S.) to inventory and manage forest lands for total integrated use they should also expect to contribute their expertise and financial assistance towards the program. It is a simple fact that the Alberta Forest Service does not have the staff nor the money that will be required to do an adequate and desirable job. We need the help of all of you and many more people and agencies.

3. After the many presentations that have been made during the past two days, it appears quite obvious that we require a survey program that is flexible enough to accommodate different levels of management requirements as well as different types of management practices. In some areas only one, two, or three uses require intensive surveys and management at this time although all potential uses will require recognition. In other areas of more intensive multiple use, we should include the numerous surveys that have been proposed during this seminar. Robby Reid referred to this with respect to insect and disease surveys and it applies equally to other survey requirements. Dr. Hamill also mentioned it this morning.

We have heard that the ideal survey has not been developed as yet and in Alberta it would probably not be economically possible at this time.

4. An obvious solution, not necessarily the best one, is to develop a short term practical management planning survey or inventory which can be incorporated into a long term, more idealistic, all-inclusive inventory that can be instituted as soon as possible.

5. I would like to stress two control factors that must be considered.

Firstly, any management-survey system must be so designed that it can be carried out and applied by technicians, the people in the field that will do the survey work and ensure that the management programs are being properly carried out. The organization, the supervision, and the checking should be done by professional persons. The work load will fall on the shoulders of technicians. They must be included in the design to ensure that it is practical, or the whole system will be useless.

Secondly the cost of the management-survey program must be subjected to economic analysis to ensure that it is justified for the values derived from it. This is an easy statement to make but not an easy condition to fulfill. But we are making some headway in establishing fairly realistic values for forest land.

In closing, I would like to express the sincere appreciation of the Alberta Forest Service for the contributions that all of you have made towards this seminar. Many of you have had to find time to prepare papers and many have travelled a great distance to attend the seminar. In particular, I must single out Chuck Kirby for organizing an excellent program and the Canadian Forestry Service for sponsoring it. We are deeply indebted to them and promise that we will do our very best to utilize the valuable opinions that all of you have expressed during these past two days. And please don't forget that we hope we can count on you in the future to assist us even further in the accomplishment of a very complex but necessary and vital job.

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