A comparison of approaches to the mapping of forest land for intensive management

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Toute carte fournissant uniquement l'inventaire d'une ressource non renouvelable n'est valable que pour une courte période de temps alors que celle qui tient compte du potentiel entier d'une région sera aussi permanente que la région elle-même. L'auteur fait état de cartes exprimant, soit le couvert forestier, le sol ou l'habitat au niveau d'une zone forestière limitée en les comparant entre elles; de plus, il étudie leur valeur et leurs possibilités en regard des renseignements obtenus pour la planification des ressources en cause.

Wherever a sizeable area of natural vegetation is to be managed intensively, maps of that area are necessary. Only by means of a map can one readily comprehend what *kinds* of landscape units are present, how *much* of each there is, and their *pattern of distribution*, all of which are essential for planning management.

Landscapes can be mapped on many bases, but since mapping is expensive and only one or a few aspects of the landscape are usually mapped in the same operation, the bases for mapping should be selected to yield the most benefit from a given input of time and money. As Fenton (1947) emphasized, any map that provides only an inventory of a highly perishable resource is short-lived, whereas a map which portrays the productive capacity of the land is as permanent as the land itself. It is the purpose of this article to compare maps that have been made of the same small forested area of 2.75 square miles (7.1 km²), pointing out the advantages and limitations of each.

The locale

The value of the long series of research studies that have been made on the Priest River Experimental Forest in northern Idaho has justified three types of maps of the Forest's resources in addition to detailed topographic maps which were prepared in 1934 by ground survey procedures, and 1967 by aerial photography, the latter at a scale of 1/7920 (8 inches to the mile), with 100-ft contours. The topography of this Forest is rugged (Fig. 1a), with 3700 ft (1214 m) difference in elevation. In consequence, nearly all possible slope aspects occur over a wide elevational range, and the Forest includes vegetation types so diverse as to differ completely in their floras. Logging and small fires at varying times in the past have added to the complexity of the plant cover.

The cover type map

In 1933-34 the Priest River Experimental Forest was mapped on a cover type basis (then called "timber types", one element of which consisted of grass vegetation), the intent being to show the

distribution of vegetation types defined on the basis of the principal plants in the dominant canopy, and the broad age-class of each stand of woody vegetation. Observations were made at points over a uniform grid, then lines were later drawn on the base map to segregate units of the various types recognized. From that map most of three sections (each 1 x 1 mile) have been reproduced for purposes of this comparative study (Fig. 1b).

The soil type map

Figure 1d summarizes the results of a preliminary soil survey conducted by R. C. McConnell during one week in 1965, as they refer to the same three sections of land. The basic data consisted mainly of notes made at road cuts and descriptions of 38 exposures (over the entire Forest) which were classified according to procedures that are standard within the USDA (Soil Survey Staff 1951).

According to the report (McConnell 1965), soil profiles "of the mountain slopes are relatively uniform, but those of the benches, terraces, and bottomlands are variable." It is significant for the present comparison that the three sections under consideration are almost entirely in the mountain slope category.

The habitat type map

A map of the habitat types (hereafter abbreviated as HTs) in the Forest was prepared by the writer in 1968, with the relevant parts of that map reproduced as Fig. 1c. The equipment used was a compass set at a 22° declination, a pocket altimeter calibrated in 50-ft units, a copy of the 1967 topographic map and the key to HTs (Daubenmire & Daubenmire 1968). After all possible observation that could be made from roads and trails had been made, intervening areas were covered on foot with only the compass and altimeter guiding the location of data on the map. Based on the population structure of the trees, in combination with the character of significant indicators among the shrubby and herbaceous species of the forest undergrowth, the land was classified according to the predicted climax plant association for each site. "Habitat types"

Fig. 1a. Topography of a portion of the Priest River Experimental Forest 1 x 3 miles (1.6 x 4.8 km). Contour intervals in feet.

Fig. 1b. TIMBER TYPES: 1 *Pinus ponderosa*, 2 *Thuja plicata*, 3 *Pinus monticola*, 4 *Thuja plicata*-*Abies grandis*, 5 *Pinus contorta*, 6 *Abies lasiocarpa*, 7 *Picea engelmannii*, 8 Grass, 9 *Larix occidentalis*-*Pseudotsuga menziesii*, 10 *Tsuga heterophylla*-*Abies grandis*, 11 *Pseudotsuga menziesii*.

Fig. 1c. HABITAT TYPES: 1 *Pseudotsuga*-*Physocarpus*, dry phase (i.e., with *Pinus ponderosa* the only seral tree); 2 Undifferentiated *Pseudotsuga* *Physocarpus*, moist phase (i.e., with *Larix occidentalis* and *Pinus contorta* as additional seral trees), plus *Abies grandis*-*Pachistima* (extremely limited area), plus *Thuja*-*Pachistima*; 3 *Tsuga heterophylla*-*Pachistima*; 4 Ecotones between continuous HTs; 5 *Abies lasiocarpa*-*Pachistima*; 6 *Abies lasiocarpa*-*Xerophyllum*; 7 *Abies lasiocarpa*-*Menziesia*; 8 Ecotone between *Abies*-*Xerophyllum* and *Festuca viridula* park.

Fig. 1d. SOIL TYPES: 1 Horsehead loam (Prairie, or Molisol); 2 Jughandle silt loam, subalpine phase (Brown podzolic, or Spodosol); 3 Jughandle silt loam (Brown podzolic, or Spodosol); 4 Jughandle silt loam, southerly exposure phase (Brown podzolic, or Spodosol); 5 Saltees loam (Lithosol, or Inceptisol).

are areas of land characterized by, and named after, these associations. Seldom does the map show the nature of existing vegetation, most of which is in seral stages of differing ages, but rather it shows the potential climaxes, each of which indicates a particular range of environmental conditions. Studies of the growth rates of *Pinus ponderosa* (Daubenmire 1961) and *Larix occidentalis* (Roe 1967) have shown that there is a substantial degree of environmental homogeneity within such units, and significant differences between most of them.

Evaluation

In drafting the three resource maps (Fig. 1b, 1c, 1d) for comparison, the same mapping symbols have been used for approximately the same land units, as a means of facilitating comparison. This must not be taken as indication of equivalence. About a dozen outcrops of granodiorite rubble occur on steep slopes at high altitude in the Forest,

and to simplify the presentation these have been omitted from all maps and the areas of the outcrops assigned to the contiguous map unit.

The major value of the cover type map is that it shows the kinds of trees currently dominant (as of 1933-34) and their age-classes. The map is thus an inventory of tree resources which were harvestable at the moment, or which would become harvestable at future dates as the stands matured, providing accidental fire, insect, fungus or storm damage did not alter or destroy the stand prior to its maturity.

But such a cover type map provides extremely little information on habitat potentials. If a site supports a natural stand of *Pinus contorta* when mapped, obviously it has the potentiality of fostering another stand of the same species after the current stand is logged or has otherwise been destroyed. But there is no hint as to whether the stand will be superseded naturally by *Pseudotsuga*, *Tsuga*

or *Abies*, or whether or not the site is suitable to manage for the production of *Pinus monticola*, or whether or not fire will stimulate the development of good browse for winter game use. Thus cover types have extremely limited value for indicating the biotic potentialities, and it becomes mostly obsolete as the vegetation it portrays is destroyed or overwhelmed by a community of superior competitive ability. Neither is there any suggestion as to whether the stands mapped are growing under marginal or optimal conditions.

As a concrete illustration of discrepancies between cover types and HTs, what was mapped as the *Tsuga heterophylla-Pachistima* HT (Fig. 1c) is apportioned among cover types (Fig. 1b) listed as: *Pseudotsuga*, *Larix-Pseudotsuga*, *Thuja-Abies grandis*, *Thuja*, *Pinus monticola* and *Tsuga-Abies grandis* cover types.

The cover type map also bears no relationship to the soil map, except insofar as north and south slopes are distinguished in both maps.

A soil type map contains information highly useful in planning roads and in anticipating erosional or drainage problems associated with managing the land for timber, water, wildlife or recreation. To the extent that soil types can be correlated with vegetational potentialities, they may have more direct value in timber and wildlife management. For all these potential uses the soil map is of as permanent value as is the soil itself, which is not likely to change significantly in the absence of accelerated erosion.

In an earlier study Secor (1956) concluded that the *Abies lasiocarpa-Menziesia*, *Abies lasiocarpa-Pachistima* and *Tsuga-Pachistima* HTs all have Brown Podzolic soils that are indistinguishable in the field, but as a group they differ consistently from *Abies lasiocarpa-Xerphyllum* soils in that only the latter possesses a dark A3 horizon with weak crumb structure. Despite the lack of field differences in the profiles of the first three above, laboratory analyses showed significant differentiation in that the *Abies-Pachistima* soils have higher Ca and higher pH than the *Abies-Menziesia* soils. Thus there are demonstrable soil differences correlated with vegetation differences, even though standard soil classification procedures do not reveal them. Daubenmire and Daubenmire (1968) have provided additional information to show that there is very little correlation between soils types and HTs of a large area which included the Priest River Experimental Forest. It was pointed out that soil types are distinguished according to texture, structure and color, and the sequence and thickness of horizons as these are visually appraised in the field. On the other hand, fertility status, the annual cycle of soil moisture use and recharge, and the annual march of temperature cannot be ascertained by field inspection, and the aeration status can be inferred only broadly. Yet these and effective soil depth are the attributes most directly critical in determining community structure, growth rates and disease susceptibility.

Although HTs had not yet been mapped on the

Experimental Forest when McConnell made his survey, he commented that HTs tend to cross soil type boundaries "on westerly slopes", but in general there is "relatively close correspondence". Much of the broad correlation between the soil map and the HT map is a consequence of recognizing three phases of the Jughandle silt loam that are distinguished only by their vegetation. Thus the soil of the *Tsuga-Pachistima* HT is distinguished from that of the *Pseudotsuga-Physocarpus* HT on the one hand, and from that of the *Abies lasiocarpa-Menziesia* HT on the other by only the striking differences in their vegetation. On the basis of soil profiles alone, all Jughandle silt loam must be considered a single unit; except for a very small outcrop only two soil types have been recognized in the 2.7 square miles of mountainous terrain.

Apparently unknown to McConnell was the unpublished report of an earlier soil survey (Lapham & Youngs 1925) in this Forest which included the western 2/3 of the area shown in Fig. 1. Like McConnell, who grouped most of the variation in the area common to the two maps into one taxonomic unit but for vegetation differences, the earlier workers also considered the soils too little differentiated to warrant separation in about 95% of the area. The "Huckleberry fine sandy loam" of the earlier survey correlates rather well with the "Jughandle silt loam" of the later survey. Thus, although they differed as to textural designations, the two independent evaluations are in good agreement regarding the impracticability of subdividing these mountain slope soils.

Habitat type maps provide a considerable array of information. In the northern Rockies it has been demonstrated that HTs indicate significant differences in the rates of growth of tree species as they extend from one HT to another (Daubenmire 1961, Roe 1967, Boyd 1969), susceptibility to insect attack (Shepherd 1959, Roe and Amman 1970), susceptibility to mistletoe infestation (Daubenmire 1961, Roe and Amman 1970), potential for producing desirable browse following fire or logging (Daubenmire and Daubenmire 1968, Boyd 1969), the rate of development of a new forest cover following logging (Boyd 1969), and the depth of drying of the soil profiles in summer (Daubenmire 1968). Although it was not done while preparing the HT map for the Priest River Experimental Forest, one could easily vary the mapping symbol used for each HT and thereby indicate the character of the current vegetation as this differs from place to place over the HT. This would add to the HT map all the information given in a cover type map.

The major disadvantage of a HT map is that it must rest on a rather thorough synecologic study of a large area, so that successional trends become predictable for each site and the few species most critical in recognizing HTs have been ascertained. The cost of obtaining the necessary synecologic foundation for interpretive mapping is far greater than the cost of preliminary investigations needed for making the cover type map. But once the synecology has been worked out it is possible to con-

struct a simple key (Daubenmire and Daubenmire 1969) permitting anyone with little botanical training to classify stands with ease (Roe 1967).

Comments on experiences in habitat type mapping

Detailed maps showing the distribution of narrowly defined vegetation types have often been made, but so far as is known the HT map prepared for the Priest River Experimental Forest is the first interpretive mapping of its kind in western North America. Some of the procedures and problems encountered are worth comment for their possible use by others who may wish to make such a map.

Work on the Forest was greatly facilitated by the intricate system of logging roads in approximately the southern half, and which have been entered on the detailed topographic map referred to earlier. Still, considerable area remained that had to be traversed on foot to locate the positions of ecotones, with only compass and altimeter readings to judge their location. Accuracy depends on frequent calibration of the altimeter, correct setting of the declination of the compass, and on the accuracy of the topographic map. Considerable difficulty was experienced with the last. Often ecotones were associated with minor changes in direction of slope that either were undetectable on the aerial photos from which the map was made, or that the cartographer felt must be ignored because of time and money limitations. It is frustrating to stand beneath a cover of trees and find no match for slope direction on the map for that elevation, but this is probably an inherent limitation of the method of constructing a map from aerial photographs where slopes are covered densely with tall trees. Cartographers should be encouraged to show every detail they can detect, and never resort to "rounding off" what might seem inconsequential minor features. A number of other types of discrepancies were also found between the map and ground features that should have been apparent from the air, and all these must certainly be reflected in some inaccuracies in the vegetation map, in turn.

The value of reference points to check locations and altitudes is difficult to overemphasize. In addition to contour details, the base map should be as complete as possible, showing roads, trails, bare rock outcrops, etc. At times the altimeter deviated as much as 50 ft from correct values in the course of a long period of following ecotones where there were no map features to permit checking.

Ecotones varied from those which were so sharp as to be only a very few meters wide, to those which were very broad. For narrow ecotones the line on the map was drawn down the middle, but for broad ones their aerial extent was mapped. The potentialities of such units are intermediate between the two contiguous types, and small differences in treatment should enable the manager to take advantage of the most desirable features of the habitat types on either side. These broad ecotones were not areas of progressive change from one type to the other, but rather a belt in which variable combinations of overstory and understory plants occurred in erratically distributed patches.

Despite the sources of inaccuracy discussed above, it is judged that accuracy well exceeds the 85% reliability which is considered acceptable for soil types maps.

Work at the forest was started in the very rugged southwest corner, which is not included in Fig. 1. Here HTs exist as closely spaced narrow strips, and as only fragments of the *Thuja-Pachistima* HT were encountered, it was decided to lump these and fragments of the *Abies grandis-Pachistima* HT with the less-dry phase of the *Pseudotsuga-Physocarpus* HT. But as the work progressed into more gentle topography this decision proved to be an unfortunate one, since considerable area of the *Thuja-Pachistima* HT was eventually encountered. In retrospect it would have been better procedure either to have spent several days in reconnaissance to discover which HTs were present in sufficient amounts to warrant mapping separately, or to have started mapping in the most gentle topography and proceed toward the rugged areas. The latter would have been more economical of time.

It was discovered that the ideal time for mapping in the Experimental Forest occurred on clearcut areas just after having been logged, but prior to cutting down the unmerchantable, residual trees and prescribed burning of the debris in preparation for regeneration. At this time young trees and seedlings that would have become the climax tree stratum are still standing and identifiable at a distance, and these are far more useful in habitat identification than the old seral trees that commonly form the overstory just removed. Also the forest undergrowth has not yet been obscured by the overlay of tall weeds that invade all but the driest and coldest habitats after deforestation.

The most difficult vegetation to classify was on burns of a few years age, for this often involved traversing a field of densely tangled seral shrubs and weeds, searching beneath for the tell-tale root sprouts of those shade-tolerant shrubs and herbs which survived the fire and are the most valuable indicators. The position of such a burn in the mosaic of less-disturbed stands is also of great help in ascertaining its synecologic status.

Two types of aerial photos in color would have been highly useful in this particular vegetation mosaic. In the August the foliage of *Physocarpus* alone of all the shrubs assumes a distinct purplish color, and since this shrub forms a dense ground cover in *Pseudotsuga-Physocarpus* stands and persists there after burning, a vertical photograph made at this season would have been of material help in locating accurately the boundaries of the HT which this plant characterizes.

Also, in late autumn the foliage of *Larix occidentalis* turns brilliant yellow, and a photograph at this season showing the distribution of this seral tree would have provided helpful information during mapping.

It was observed that species with higher water requirements than a given HT affords can often invade the disturbed margins of roadways through that HT. Thus small trees of *Abies grandis* can sometimes be found in such microsites in the

Pseudotsuga-Physocarpus HT, and young *Tsuga* in turn may line roadways through *Thuja* stands where conditions are elsewhere too dry for *Tsuga* survival. Apparently freedom from competition for water, combined with less interception wastage of rainfall, and perhaps benefits of drainage from the adjacent roadway all conspire to provide the additional increment of water necessary for such invasions. This evidence of higher moisture status of roadsides is in accord with the superior growth of trees in the immediate vicinity of roads, which has been demonstrated (Pfister 1969). The significance of this phenomenon for mapping is that one must look beyond the road margin to evaluate the reproductive status of trees, which is so critical in HT mapping.

Working 40-hour weeks in the month available, the writer mapped at the rate of approximately 1 square mile per 24 hours (11 ha/hr). Since this work was done, Pfister (1970) has mapped HTs on a smaller area, more thoroughly covered with roads, at the rate of approximately 1.8 square miles per 24 hours. It would be hazardous to extrapolate from these figures to estimate the cost of mapping other areas, since factors highly variable from place to place facilitate or retard the rate of progress: abundance of roads and trails, degree of variation in topography and soils, amount of recently logged and burned area, adequacy of maps, weather conditions, degree of accuracy deemed acceptable, etc. The high cost of the basic synecologic work needed to determine the HTs and their indicator species must also enter the cost appraisal, if such information has not already been worked out for the area mapped.

Although the principles and problems discussed here have been based on work in a forest area in a mountainous setting, the same probably apply to other types of vegetation and topography.

Conclusions

Forest land management is becoming increasingly complex owing to growing competition among alternative uses, and to concerns over environmental

quality. Planning efficient use of a complex area must be based on the widest possible array of information regarding each of its components. In this endeavor maps portraying habitat types (with cover type designations), soil types and topography, each have special values and limitations that must be taken into account.

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