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An Approach to Classifying Seral Vegetation within Habitat Types

Abstract

A concept for classifying seral vegetation within habitat types is presented. Conceptual illustrations and field data examples from the *Abies grandis/Vaccinium globulare* habitat type are used to demonstrate the classification. Prognostic capability of this technique is discussed.

Introduction

The dynamics of plant communities present a complex and often bewildering set of interacting variables. Conceptually, these variables can be grouped under two primary forces affecting vegetation: time and environment. Vegetation reflects time through successional development, which can be erased, altered, or accelerated by various disturbances. Vegetation reflects environment through climax communities (Daubenmire 1952), which are relatively stable barring disturbance or alteration of the environment. The complex environments of Northern Rocky Mountain forests have been recently subdivided by habitat type classification systems (Daubenmire and Daubenmire 1968, Pfister *et al.* 1977, Steele *et al.* 1981), which focus on potential climax vegetation. The habitat type approach has been tested in many areas of the West and proven useful to natural resource managers (Layser 1974), yet no classification with similar capabilities exists for successional (temporal) aspects of vegetation. This paper presents a classification system designed to meet that need and to interface with the habitat-type system.

Concepts

Although there is considerable information on plant succession, simulation modeling, and plot grouping techniques (Shimwell 1971, Mueller-Dombois and Ellenberg 1974, West *et al.* 1981) there are few concepts that deal systematically with classifying the temporal aspects of seral vegetation. Many vegetation classifications used today either are largely descriptive, emphasizing plant cover (Kuchler 1966, Eyre 1980), or focus on identifying site differences (Daubenmire 1952) Krajina 1965). The former group offers little ecologic prediction capability for land management and often treats only the dominant vegetal layer; the latter group, which has been expanded recently over the western U.S. (Pfister 1977), provides high prediction capability between classified environments but does not classify seral stages within environments. Classifications of the Braun-Blanquet (1932) approach are somewhat intermediate in utility and focus on species composition and structure that do not always subdivide environment. One

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land resource planning model (Henderson and West 1977) provides for temporal classification within habitat types but lacks the field data needed to develop site-specific output. Arno and Simmerman (1982) studied successional sequences in four habitat types and subdivided the time gradient by using classic structural stages such as shrub, sapling, pole, and mature forest. Their diagrammatic classification somewhat resembles the conceptual system presented here.

The lack of concepts addressing succession classification may stem from past philosophies coupled with a past lack of suitable environmental classification. Gleason (1927) stated that succession "is no more than the mass effect of the action or behavior of individual plants," and hence any stage of succession need not "follow an orderly sequence in its development." This assumption would seem to preclude a systematic classification of seral communities. However, the general environment of each sere can be classified by using the habitat-type approach, most easily done when some near-climax vegetation remains in the area. Each classified macroenvironment (habitat type) in turn determines which species can potentially occupy the site during various successions. This environment also determines which species have potential to become well represented, as opposed to gaining only a minor foothold on the site. ("Well represented," herein, is any canopy coverage >5 percent of the land area in question.) The potentially well-represented species within one habitat type can be arranged according to their succession-sequence characteristics, such as early seral vs. climax. This arrangement then provides the basis for developing successional classification within a given habitat type.

Focusing on potential seral species and their relative succession-sequence characteristics avoids the need for first predicting actual successional pathways, which, as Gleason (1927) suggests, may be random. If successional pathways become predictable, the predictions and classification structure should corroborate each other. Thus, a successional classification design to accommodate individual species behavior will handle equally well those successional studies that may follow less individualistic approaches. However, the converse may not be true.

Certain analogies with the habitat type classification help convey conceptual aspects of the following successional classification:

1. Habitat type classifications are based on climax plant communities, thus holding time relatively constant while the environmental gradient is being subdivided. Similarly, successional classification should hold environment relatively constant by means such as habitat types while the time gradient is being subdivided.
2. Habitat-type classification characterizes environment from the integrated expression of the potential climax plant community rather than from weather and soils data. Likewise, succession classification should characterize successional time from relative stages of community development rather than from number of years or growing seasons. Years do not measure successional advance because some years or growing seasons may only maintain the existing community. As suggested by many persistent seral communities, successional advance depends on less predictable occurrences such as seed production, seed predators or diseases, annual weather patterns, existing species composition, and combinations thereof. Although investigators often relate seral communities to years since disturbance, a severe disturbance can convert a near-climax community to an early seral stage, while a similar site disturbed less severely at the same time can result in a mid-

seral stage. Consequently, notations that characterize relative stage of development would more consistently place plant communities in their appropriate successional positions.

3. Classification of environment by habitat type employs indicator species according to their relative ecologic amplitudes (relative vulnerability to environmental change) and ability to dominate at climax (Steele *et al.* 1981). Similarly, classification of successional time by relative stage of development should employ indicator species according to their relative vulnerability to successional change and ability to dominate certain successional stages. In developing this concept, plant community coverage data from 375 m^2 plots (Pfister and Arno 1980) were taken in various seral stages within one habitat type. Some data for near climax stages were taken from a previous study (Steele *et al.* 1981). Known successional roles of the sampled species were subjectively compared with various attributes such as life form, reproductive strategies, natural longevity, relative tolerance to shade, possible allelopathic interactions, and resistance to disease and insects. Some of these attributes have predictive value in succession simulation models (Noble and Slatyer 1977, Cattelino *et al.* 1979). The results showed that relative vulnerability to successional replacement is the most useful indicator for subdividing the succession sequence. This characteristic reflects the integrated effects of the combined above attributes of individual species during succession and is interpreted through relative decline in canopy cover. Species dominance is also needed to characterize community structure. Neither characteristic alone nor any of the individual attributes consistently places a community in its logical successional position.

The Model

The secondary succession model by Huschle and Hironaka (1980) provides an initial framework for developing the successional classification concepts. Their cone-shaped model projects a convergence of many seral community types toward one climax community and suggests a structural framework for systematically classifying seral vegetation. Their model was developed for nonforest communities but applies equally well to forest communities and even to the tree, shrub, and herbaceous layers separately. The framework of their model suggests delineation of vegetation according to relative successional stage and emphasizes the potential complexity of seral vegetation within one habitat type.

Forest communities often have several vegetation layers at different successional stages, each likely proceeding at a different rate. Therefore, this classification first stratifies a plant community by layers—tree, shrub, herbaceous. In each layer, the well-represented species most vulnerable to successional decline is combined with the dominant species of that layer to delineate a temporal-structural unit of vegetation. Since the habitat type determines which species are potentially well represented and any well-represented species may be a potential dominant, temporal-structural units for all possible seres within a habitat type can be established once the major seral species and their relative vulnerabilities are known. These units, called layer types, can be arranged to form a classification model. In this model (Fig. 1), the bottom row of layer types represents possible combinations of the earliest seral indicator (most vulnerable species) with the potential dominants of that particular vegetation layer; relative vulnerability

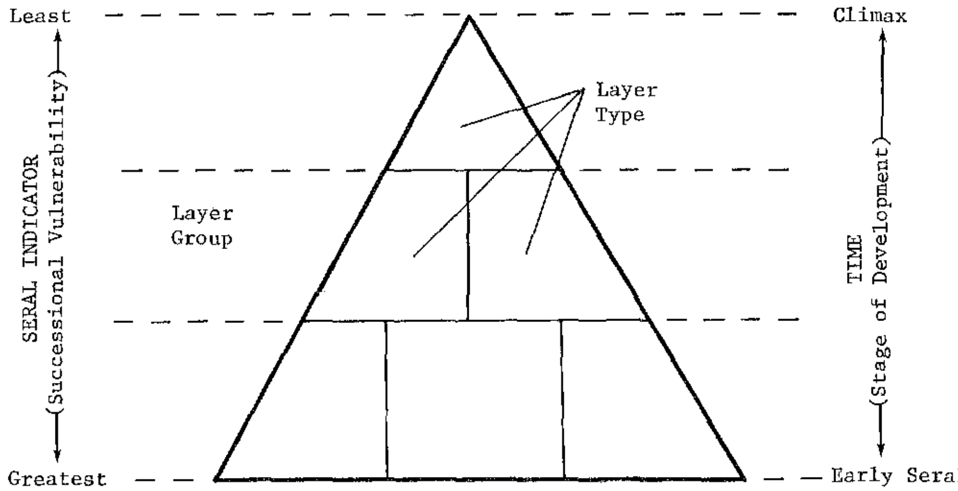

Figure 1. Basic structure of succession classification model.

of seral indicators progressively decreases upward toward climax. Since increasingly fewer species have potential to dominate toward climax, increasingly fewer units are possible and the triangular model results. In three dimensions, Figure 1 resembles the basic cone-shaped model of Huschle and Hironaka (1980). To maintain a systematic nomenclature, each taxonomic unit is called a layer type, and each group of layer types having the same seral indicator is called a layer group.

Examples

The Tree Layer

With forest habitat types, the clearest examples of this classification approach occur in the tree layer. In the *Abies grandis/Vaccinium globulare* (*ABGR/VAGL*) habitat type (Steele *et al.* 1981), *Abies grandis, Pseudotsuga menziesii*, and *Pinus contorta* are the major tree species. *Larix occidentalis, Picea engelmanii,* and *Pinus ponderosa* are also occasionally present, but are omitted to simplify this explanation. Consider these three major species on the same site, each one well represented. From general knowledge that *Pinus contorta* can be succeeded by *Pseudotsuga*, which in turn can be succeeded by *Abies grandis*, one can visualize *Pinus contorta* as an indicator of the earliest successional stage, *Pseudotsuga* the secondary successeional stage, and *Abies* as the climax dominant. Although unforeseen factors may preclude the entire replacement sequence, the relative vulnerability to replacement has been established. These three indicator species are then combined with the possible dominants to form the classification model found in Figure 2. The first species of each unit in this model is the seral indicator (most vulnerable); the second species is the dominant (greatest canopy coverage). As Figure 2 shows, a *Pico-Abgr* layer type would have *Pinus contorta* (and possibly *Pseudotsuga*) well represented in the stand, but *Abies grandis* would have the greatest canopy coverage regardless of relative heights. This nomenclature provides a simple general description of relative successional position and present structure for the tree layer. The same framework applies to the other vegetation layers. Names for each vegetation layer are then combined to characterize the entire plant community.

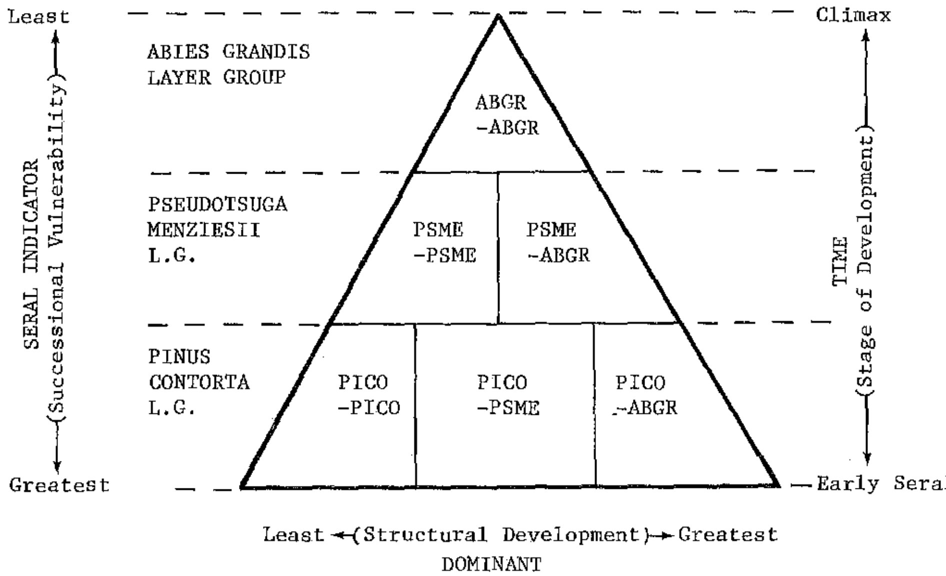

Figure 2. Example of succession classification model using the tree layer.

A key to layer types (Table 1) is easily derived from the classification model (Fig. 2). Seral indicators are delineated at the point where their canopy coverage ceases to be well represented (>5 percent coverage). The key should start with the most vulnerable indicator species and progress along the time gradient to climax (Table 1). Where appropriate, seral indicators with similar relative vulnerabilities can be combined to simplify the classification. Such groupings are most apt to occur in the shrub and herb layer classifications for which similar keys can be written. The arbitrary use of 5 percent canopy coverage may also be adjusted to better accommodate actual situations. Usually, relative shade tolerance is the main species attribute acting in the tree layer, but other attributes previously mentioned may also be involved. The integrated effects of these individual attributes during succession is reflected in the relative vulnerability of each species as outlined in the key.

This exercise illustrates the actual approach used for the shrub and forb layers. But because the tree layer goes through recognizable size classes of development such as sap-

TABLE 1. Example of key to tree layer groups and layer types as derived from Figure 2.

1. All tree species (>4.5 ft tall) poorly represented[1]	depauperate tree layer
1. At least one species (>4.5 ft tall) well represented[1]	2
2. Pinus contorta well represented	PICO Layer Group
2a. Pinus contorta dominant	Pico-Pico Layer Type
2b. Pseudotsuga menziesii dominant	Pico-Psme Layer Type
2c. Abies grandis dominant	Pico-Abgr Layer Type
2. P. contorta poorly represented	3
3. Pseudotsuga menziesii well represented	PSME Layer Group
3a. Pseudotsuga menziesii dominant	Psme-Psme Layer Type
3b. Abies grandis dominant	Psme-Abgr Layer Type
3. P. menziesii poorly represented	4
4. Abies grandis well represented	ABGR Layer Group
4a. Abies grandis dominant	Abgr-Abgr Layer Type

[1]Well represented is arbitrarily defined as having a canopy coverage greater than 5% of the land area; poorly represented is less than 5%.

ling (.24-10.2 cm; .1-4 in, d.b.h.[1]), pole (10.2-30.5 cm; 4-12 in), mature (30.5-45.7 cm; 12-18 in) and old growth (>45.7 cm; >18 in), these additional subdivisions should be noted. These notations are best added to each tree species after the tree layer type (l.t.) is identified, such as Mature *Pico*-Sapling *Abgr* l.t. For consistency within the classification, the smallest size class present that applies to the key (Table 1) should be selected as the notation. This procedure is followed because the larger size classes usually decline first during succession, and the layer group indicator species is not actually replaced until it is represented by less than 5 percent canopy cover, regardless of size class. Also, the youngest size class best depicts the appropriate seral stage because it represents the reproductive status of the most vulnerable tree species in the sere. Figure 3 illustrates the subdivisions within layer types that can result from combinations of seral indicators and dominant when size class notations are used.

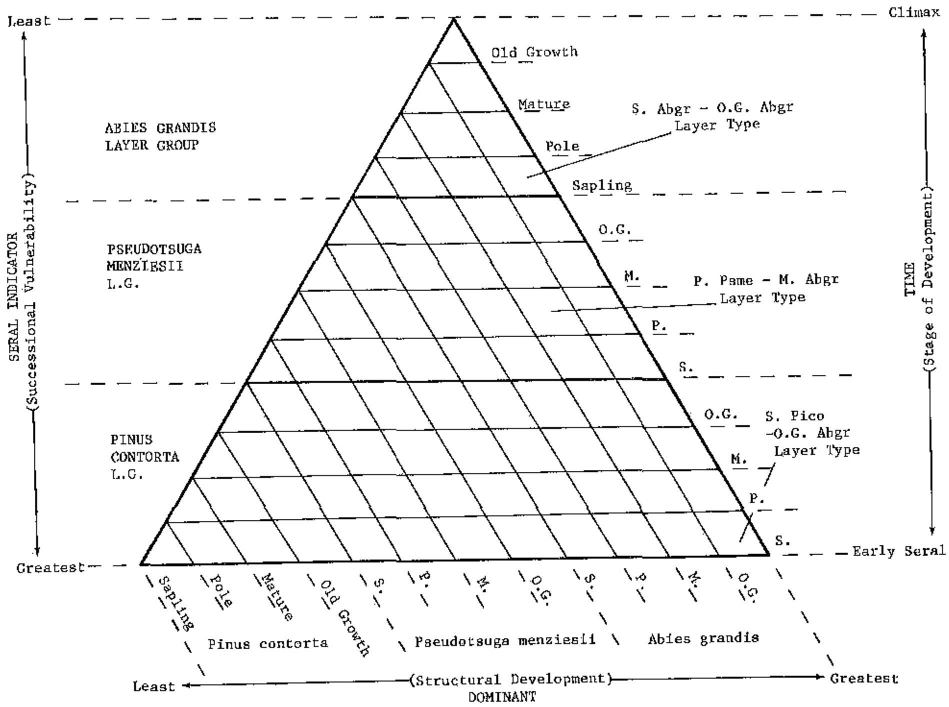

Figure 3. Tree layer subdivisions (using size class notations) as indicated by combinations of successional indicator and dominant.

At first, visualizing some tree layer types in their appropriate successional position may be difficult. For instance, a Sapling *Abgr.* l.t. woult not seem to be more successionally advanced than an Old Growth *Pico*-Pole *Abgr* l.t., because we think of these seres in terms of years of development. But in terms of their relative position along the successional gradient, a pure stand of Sapling *Abgr* is closer to potential climax than a mixed older stand of *Pico* and *Abgr* because, lacking disturbance, it will not go through the earlier successional stages of the *PICO* and *PSME* layer groups. In fact, a Sapling *Abgr* l.t. may even reach climax in fewer years than an Old Growth *Pico*-Sapling *Abgr*

[1]d.b.h. diameter at breast height (4½ ft.).

l.t. if the latter has *Pseudotsuga* well represented and must pass through a long lived *Psme-Abgr* l.t.

The Shrub Layer

Shrub layers in the *ABGR/VAGL* habitat type contain more seral species than the tree layer and thus generate more possible units within the classification model. For example, various seral stages were sampled in 58 plots scattered throughout the range of *ABGR/* VAGL in central Idaho; 54 of these plots had at least one shrub species well represented. Six shrub species were well represented among the 54 plots. The possible combinations of seral indicator and dominant using these six species result in 21 layer types (Fig. 4).

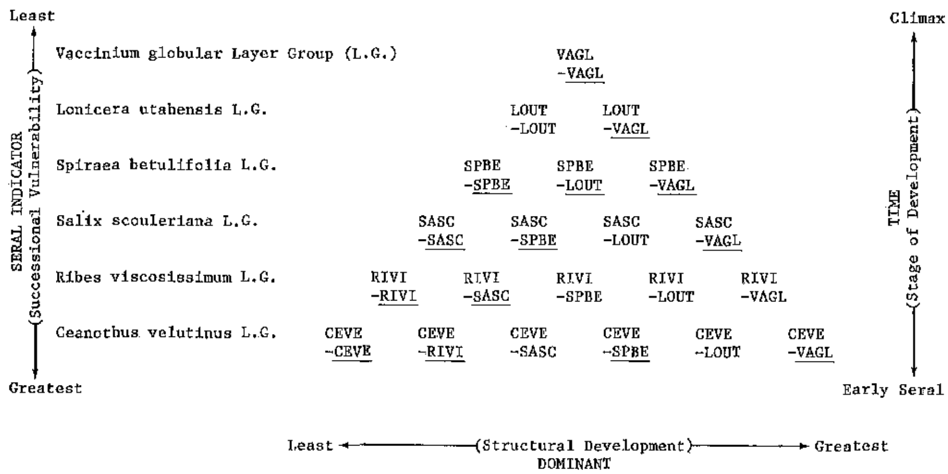

Figure 4. Classification model of possible shrub layer types in *Abgr/Vagl* habitat type; underlined layer types are represented by field data.

The formula for the triangular matrix of N layer types is $N = \frac{n^2 + n}{2}$, where $n =$ the number of species involved; in this case, $n = 6$. Of these 21 types, 14 appear in the data set. The remaining seven may either appear following disturbance patterns and intensities that differ from those of the past or may be rare, regardless of site history.

When sufficient data are available, analysis of synthesis tables (Mueller-Dombois and Ellenberg 1974) provides insight to the relative vulnerabilities of the species involved and a basis for adjusting the classification model. Individual plot data and groupings by layer type can be subjectively arranged from early seral to climax on the horizontal axis. A similar arrangement on the vertical axis should list the well-represented species according to relative vulnerability. Arrangements along both axes can be adjusted so that points where species cease to be well represented reflect a logical progression of decreasing vulnerability that coincides with a logical progression of the stands toward climax. The species that first ceases to be well represented is considered the most vulnerable and is placed at the bottom of the classification model (Fig. 4). Other species are placed in their appropriate relative positions. Table 2 lists pertinent data extracted from the final analysis of a synthesis table. These data reflect a logical relative decline in average coverage of seral species that parallels the general successional sequence of stands sampled in the *ABGR/VAGL* habitat type. Shrub layer groups show groupings

TABLE 2. Constancy[1] and average coverage percent[2] (the latter in parentheses) of major seral shrubs[3] in ABGR/VAGL habitat type.

LAYER GROUP	Ceanothus velutinus						Ribes viscosissimum					Salix scouleriana				Spiraea betulifolia			Lonicera utahensis		Vaccinium globulare
SHRUB LAYER TYPE	Ceve -Ceve	Ceve -Rivi	Ceve -Sasc	Ceve -Spbe	Ceve -Lout	Ceve -Vagl	Rivi -Rivi	Rivi -Sasc	Rivi -Spbe	Rivi -Lout	Rivi -Vagl	Sasc -Sasc	Sasc -Spbe	Sasc -Lout	Sasc -Vagl	Spbe -Spbe	Spbe -Lout	Spbe -Vagl	Lout -Lout	Lout -Vagl	Vagl -Vagl
Number of Stands	n=4	n=1	.	n=1	.	n=2	n=3	n=1	.	.	.	n=1	n=3	.	n=7	n=3	n=1	n=4	.	n=13	n=10
SHRUB SPECIES																					
Vaccinium globulare	8(2)	10(2)	.	10(2)	.	10(26)	7(T)	10(15)	.	.	.	10(1)	10(22)	.	10(68)	7(T)	10(2)	10(62)	.	10(69)	10(52)
Lonicera utahensis	5(9)	10(2)	.	—	.	10(8)	10(10)	10(2)	.	.	.	10(T)	7(T)	.	10(15)	7(T)	10(15)	10(14)	.	10(15)	10(2)
Spiraea betulifolia	10(5)	10(2)	.	10(20)	.	10(8)	3(T)	—	.	.	.	10(2)	10(31)	.	9(6)	10(22)	10(15)	10(15)	.	8(2)	7(2)
Salix scouleriana	5(20)	10(2)	.	10(T)	.	10(1)	10(2)	10(15)	.	.	.	10(62)	10(20)	.	10(16)	7(2)	10(T)	5(1)	.	4(2)	6(1)
Ribes viscosissimum	5(8)	10(15)	.	—	.	10(1)	10(18)	10(15)	.	.	.	—	7(T)	.	7(T)	10(1)	10(T)	2(T)	.	5(1)	6(1)
Ceanothus velutinus	10(38)	10(15)	.	10(15)	.	10(15)	7(T)	10(2)	.	.	.	10(2)	7(2)	.	—	2(T)	10(T)	—	.	—	1(2)

[1]Code to constancy values. + = 0-5% 1 = 5-15% 2 = 15-25% 3 = 25-35% 4 = 35-45% 5 = 45-55% 6 = 55-65% 7 = 65-75% 8 = 75-85% 9 = 85-95% 10 = 95-100%

[2]T = Trace.

[3]Underlined values show where a species serves as a seral indicator.

of stands beyond which a particular seral indicator ceases to be well represented. For instance, *Ceanothus velutinus* (most vulnerable) is well represented only in the earliest seral stages of the shrub layer, whereas *Vaccinium globulare* (least vulnerable) can be well represented throughout the data from early seral to climax. Occasionally, two species will display similar vulnerabilities and can be grouped when constructing the key to layer types.

Discussion

Although the Huschle and Hironaka (1980) succession model and the classification model (Fig. 1) have similar patterns, the classification model should not be construed as predicting successional pathways, even though it illustrates the many possibilities. As shown in Figure 1, succession on a given site only progresses upward in the form of species replacement between layer groups. Progression to the right within a layer group is treated as structural development to distinguish it from the upward advance between layer groups. In reality, a shift in either direction is a form of succession. Retrogressive changes from disturbance cause a shift downward or to the left. Changes in any direction seldom occur in stepwise progression and generally skip many layer types and even layer groups. Predicting change requires comparison of existing and potential composition of individual stands with the relative position of that stand in the classification model. Predictions of retrogressive changes must also consider the type and intensity of disturbance. Even though some layer types are relatively common and others quite rare, generalized pathway predictions must be made from fiel; observations.

The classification models (Figs. 2, 4) may seem too complex for practical use. A simplistic classification is always the most desirable, but oversimplification can reduce accuracy. An adequate classification of any system must have enough taxonomic units to accomodate its components. The classification herein delineates vegetation according to the possible successional units occurring through time. Because not all units may exist on the landscape at one time, this classification may appear more complex than necessary. But if all possible vegetation within one habitat type could be surveyed, the classification design would appear adequate rather than overly complex.

This classification provides ecologic prediction capability and implications for land management. For example, each shrub layer potentially occurring in the *ABGR/VAGL* habitat type can be located within the model (Fig. 4). The relative position of a given shrub layer in the model indicates whether succession or disturbance is needed to convert that shrub layer to some other shrub layer. The model also suggests the intensity of disturbance (in terms of species to be removed) that may be needed to achieve the desired layer type. For instance, if a *Spbe-Vagl* l.t. is disturbed lightly enough to remove *Vagl* but not enough to introduce *Ceanothus*, *Ribes*, or *Salix*, it will only shift to the left in the *SPBE* layer group. But if it were severely burned, it may shift downward to the *SASC* or *CEVE* layer group or, if severely scarified, the *RIVI* layer group or possibly no shrub layer at all. However, composition of each stand must be examined to determine if that particular community has potential to produce the desired layer type from a given treament. Considerable study is needed on reaction of many species to types and intensities of disturbance.

Large disturbed areas often contain more than one habitat type. As the Huschle and Hironaka (1980) model suggests, one seral community may overlap different habitat types, especially in early seral stages. Vegetative potential, total species composition, and management implications may vary even though classification models for different habitat types result in the same name for the overlapping community. Trained personnel can extrapolate habitat types from adjacent, less disturbed areas by considering terrain features and often subtle differences in species composition. In some cases, comparison of succession classification models with existing seral vegetation may also indicate which habitat type exists. When habitat types cannot be delineated, the more severe of the two habitat types in question should be used for management purposes. Management plans can be revised as successional advance makes the habitat types more discernible.

With this classification approach, seral vegetation can be tentatively classified without the entire classification structure being formalized. The field investigator need only determine which well-represented species in a given layer has the greatest vulnerability to successional replacement and which species is dominant. After these determinations and supporting coverage values are collected for a number of stands, they can be synthesized (Table 2) and applied to classification models (Figs. 2, 4) to develop layer types. Accuracy of the field worker can be improved by first developing a tentative list of species according to their suspected relative vulnerability to succession. Partial listings may be derived from sample data previously collected for habitat-type classification studies.

The main use of this classification is to relate one plant community to all others in the same habitat type in terms of relative successional stage. Understanding such relationships provides ecologic prediction capability and a communication base. Even though the models outline possible successional directions and possible layer types within a habitat type, they do not diagram successional pathways. Actual pathways must be developed from examination of species composition within individual stands and known successional trends. Stages of a particular pathway, however, can be expressed in terms of the layer types presented and linked as outlined in the classification models.

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