Habitat types: Their development and practical application

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HABITAT TYPES: THEIR DEVELOPMENT
AND PRACTICAL APPLICATION

by

Gretchen Ann Merrill
B. A., Swarthmore College, 1972

Presented in partial fulfillment of the requirements for the degree of
Master of Forestry

University of Montana
1975

Approved by:

[Signatures and dates]
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CHAPTER 1

INTRODUCTION

Since the appearance of *Forest Vegetation of Northern Idaho and Eastern Washington* (Daubenmire and Daubenmire 1968), the use of habitat typing as a method of vegetation classification has increased rapidly. The Forest Service adapted the habitat type system to Montana (Pfister et al. 1974, Mueggler 1974), and it is now being incorporated into data collection and decision making at several levels. The newness of the system and the long range nature of the decisions it is influencing make the formation of any final judgment on its efficacy impossible at this time. However, a preliminary evaluation of current use and of research pertaining to the system is needed. The usefulness of the system at all stages of development should be gauged in relation to previous work and future potential. Numerous studies are in progress or being initiated and planned which are stratifying results by habitat type and attempting to quantify the relationship between habitat types and various ecosystem variables. This is a propitious point in time to attempt to assess the objectives and preliminary results of these studies.

Missoula offers a unique opportunity for the synthesis of habitat type related activities. The U. S. Forest Service Research Laboratory where the Montana habitat types were developed is located in Missoula, in addition to a Forest Service Ranger District, Super-
visor's Office, Regional Office, and the Northern Forest Fire Laboratory. Other facilities such as the Forest Service Research Laboratory in Bozeman and Moscow, Idaho are easily accessible.

An exhaustive survey of every agency activity and research project related to the habitat type system would be an undertaking requiring one or more years. For this paper, selected forest management personnel believed to have an overview of the system and frequent contact with it were interviewed as were several scientists conducting research related to habitat types. An analysis of the management implications of the habitat type system is more meaningful if a conceptual background is provided. Any excursion into the literature on vegetation classification is somewhat discouraging. As Daubenmire (1966) himself wrote: "There has accumulated... a spectrum of concepts, terms, and methods so broad as to discourage the novice and confuse even the specialist at times." Whittaker (1962) summed up the situation well: "Probably in no other field of natural science has there been such proliferation of local schools with distinctive viewpoints and techniques." I will attempt to extract only what is pertinent, and yet at the same time provide enough information to form a clear picture of the schools of phytosociology¹ that preceded and contributed to habitat typing.

Research related to habitat types and the use of habitat type information by federal and state agencies will be discussed. Included

¹ Phytosociology may be defined as "The discipline which concerns itself with the study of vegetation as such, with its floristic composition, structure, development, and distribution" (Poore 1955a).
in this analysis is a consideration of the collection, compilation, and integration of habitat type data into management programs. Through this discussion and a critique of the system, my goals in undertaking this paper will hopefully be attained. Explicitly, the goals of this paper are to provide: (1) an analysis of the conceptual foundations of the habitat type system, (2) an overview of current research and management practices relating to the habitat type system, and (3) an evaluation, though necessarily tentative, and based upon interviews with management personnel, of the present success and future potential of the habitat type system as a tool in land management.
CHAPTER 2

THE VALIDITY OF AND THE NEED FOR CLASSIFICATION

The early approaches to vegetation as an entity were all classificatory (McIntosh 1967). Exceedingly diverse criteria were used to define the various vegetation units, but all theories assumed that plant communities could be lumped into units. The first dissent to this almost universal assumption is usually attributed to H. A. Gleason (Whittaker 1962). Gleason (1926, 1939) proposed the individualistic hypothesis, which stated that species were distributed independently of each other. Following this line of reasoning, if communities were groups of plants growing together mainly as the result of chance, a basis for the classification of vegetation did not exist. Other investigators (Curtis 1959) incorporated and developed the individualistic hypothesis and the data in support of the theory grew until Whittaker (1962) could assert that the dichotomy between the association-unit theory (classification) and individualistic dissent represented the first major choice in the interpretation of natural communities. The extreme of the spectrum might be simplistically represented at one end by those who view plant communities as complex organisms or quasi-organisms and, on the other, by those who believe

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2 A community may be defined as "a system of organisms living together and linked together by their effects on one another and their responses to the environment they share" (Whittaker 1975).
no two communities are exactly alike (Anderson 1965). All intermediate views are represented as well. The argument centers around two main points: (1) whether vegetation is a continuous or discontinuous variable and (2) whether or not species are organized into distinct groups corresponding with associations\(^3\) (Whittaker 1962).

Those who regard vegetation as a continuous variable have never rigorously defined the vegetation continuum (McIntosh 1967). It is described as "... a gradient of communities in which species are distributed in a continuously shifting series of combinations and proportions in a definite sequence or pattern" (McIntosh 1967). No discrete divisions, entities, or other natural discontinuities are present, except when there is an abrupt discontinuity on the ground due to a change in soil, habitat, historical treatment, or chance (Curtis 1959, McIntosh 1967).

A basic technique of the continuum school is ordination or the arrangement of communities along axes created by environmental gradients. Greig-Smith (1960) commented on the nature and value of ordination:

> Ordination is not to be equated with any one technique, e.g. continuum analysis. There is as much room for discussion on criteria of ordination as on criteria of

\(^3\) The association is perhaps one of the most variously defined terms in phytosociology. The most widely accepted definition is the one emerging from the Sixth Botanical Congress in 1935: an association is a vegetation unit characterized mainly by characteristic and differential species in the sense of Zurich-Montpellier, or at least a unit of the same order of sociological value (Whittaker 1962). The terms in the definition will be clarified in the discussion of the Zurich-Montpellier School.
classification. The advantages of an ordinational approach is that it will expose the units of a classification based on the same criteria whereas a classification approach may obscure the presence of continuous variation.

Many classifiers would disagree with this statement, as will be shown shortly.

According to McIntosh (1967), discontinuity in vegetation infers a local steepening of environment gradients, as indicated by an "abrupt and coincident change in the quantity or kinds of species."

Daubenmire is basically a proponent of this local-steepening of gradients viewpoint. He may occasionally make statements against the continuum concept which are quite strong: "We are faced with a choice of either a continuum or a classification; the two viewpoints are strictly incompatible. Without classification there can be no science of vegetation" (Daubenmire 1960). However, his stand in favor of classification is usually not notably dogmatic. He argues that the forest vegetation of the northern Rocky Mountains is not a continuum, but states that neither is it composed of sharply defined units (Daubenmire 1952).

There is no denying that vegetation presents a continuous variable by virtue of ecotones; the argument hinges on the existence or absence of plateau-like areas exhibiting minor gradients separated by areas of steeper gradients, with the plateau-like areas being of sufficient similarity to warrant being designated as a class (Daubenmire 1966).

There are numerous specific points of controversy between the subscribers to the two philosophies. These include the claims that (1) ordination treats vegetation as a flora, that is, simply as a list of species; (2) the continuum concept pays insufficient atten-
tion to population dynamics; and (3) sampling procedures on both sides bias the results.

Daubenmire (1960) commented on the treatment of the vegetation as a flora with no concern for natural processes:

Flora are generally recognized as continua, and any method of subdividing the landscape on an essentially floristic basis, ignoring succession and environmental variation, will seem to substantiate the continuum hypothesis.

Anderson (1965) emphasized the role the selective processes play in vegetation development. He believed that if overall selection is long lasting and of considerable intensity, vegetation will tend toward uniformity within one area and recognizable classes will result. If selection is weak and intermittent, chance plays a larger role and more variety in species composition and more structural diversity may appear.

Lieth (1960) emphasized the role of environment and plant history in shaping the nature of vegetation. For example, he believed gradient analysis may be better suited to Central Asia and the Great Plains, while classification techniques may be superior in the Alps or other areas of marked tectonic relief. Daubenmire (1968) cited the ecologic amplitude of various taxa and the heterogeneity of the environment as reasons for the formation of classifiable communities. He also stressed the effect of disturbance upon discontinuities (1966). For example, the boundaries of the drier zones in the Washington steppe (Artemisia-Agropyron, Artemisia-Festuca, and Agropyron-Festuca) are obscured when heavy grazing favors conversion to Bromus tectorum.
There have been many vocal assertions that the demonstration of continuity or discontinuity is an artifact of the method used. Gimmingham (1968) was of the opinion that

...up to the present they [ordination and classification] have not yielded clearcut guidelines towards a theory of community organization... The main difficulty attached to the use of these techniques in the search for such a theory is that the form of the results is a property of the method employed.

McIntosh (1967) believed that a preference for classification "...is built into any methodology which starts with subjectively recognized communities as parts of an abstract entity or uses a methodology which can produce only a classification." This statement appears to be true to some extent. In eastern Washington, Northern Idaho, and Montana, the stands which provided the data for Daubenmire and Pfister were carefully chosen with the forthcoming classifications very much in mind (Daubenmire and Daubenmire 1968, Pfister et al. 1974). Those on the classification side of the dispute include Egler (1968) and Daubenmire (1966) who wrote, "It appears to me that if one selects any of the several appropriate methods one can demonstrate a continuum anywhere."

The divergence may not be as severe as it seems from these extreme statements. There are many who advocate a more moderate course. Robbins (1968) saw four possible resolutions to the apparent controversy: (1) acknowledgment of a right and a wrong, (2)...

4 See Appendix 1 for a listing of all scientific and common names of species referred to in this paper.
a fusing, (3) compromise in a side by side use of both methods, or
(4) a search for an entirely new method. Alternatives (1) and (4)
seem unproductive, since there is clearly no right or wrong for all
situations. Also, both broad groups of techniques are becoming more
refined and contain many unexplored potentialities. Either alternative
(2) or (3) or both are the most probable outcomes in the long term.

Many authors (Lieth 1968, Shimwell 1971, McIntosh 1967, Whittaker
1962, Krajina 1960b, Selleck 1960b, Kalela 1960, Egler 1968) have
noted that many studies partake of both ordination and classification
or that the two methods should serve to complement each other. As an-
derson (1965) concluded,

To uphold one or the other approach as a sacrosanct med­
ium for a preliminary understandIng of vegetat­Ional com­plexity is to admit to a lack of understandIng of the
basic processes involved in the development of vegetation
structure.

Shimwell (1971) believed it is time to "... bury the horse long­since dead."

Thus it is apparent that most authors consider classification
a valid approach to the study of vegetation, although many have res­
ervations about its applicability in all situations. Various class­
ification systems may have specific purposes which are quite diver­
gen­t, but in general these may be divided into two groups: (1) class­
fication for its own sake; vegetation studies based on philosophical
convictions concerning the nature of vegetation; and (2) classifica­
The pragmatic purpose is by far the most common. It is more conven-
ient to have units with boundaries to talk about than a constantly changing whole (Gleason 1939, Daubenmire 1970). Rowe (1960a), who believed the forest may be more accurately thought of in terms of gradient patterns, conceded that types are useful and thus justified. Many authors emphasize the value of ecologically valid types in land management (Ovington 1960, Mueller-Dombois 1964, Driscoll, 1964). This train of thought is developed to a high degree by Daubenmire and Pfister. Daubenmire saw classification as much more than a convenience; the types delineated in the classification process should be ecologically sound. That is to say, they should have predictive value and act as integrators of numerous site factors. Pfister et al. (1975) wrote that natural resource managers and field biologists "... need a logical, ecologically-based environmental classification with which to work."
CHAPTER 3

SCHOOLS OF VEGETATION CLASSIFICATION CONTRIBUTING CONCEPTS TO THE HABITAT TYPE SYSTEM

In the following sections several of the most important contributions to phytosociological thought will be discussed. Each school or individual worker originated or successfully applied concepts later integrated by Daubenmire into the habitat type system.

Whittaker (1962) described the early attempts at vegetation classification as being more comparable to the social sciences than to physics. "Premature insistence on vigor, objectivity, and exactitude may lead to a methodology based on illusion" (Whittaker 1962). Many factors are operating when an investigator takes the initial steps toward the classification of vegetation. These may include personal choice and judgment, intuition, cultural influences, and values and aesthetics (Whittaker 1962, Shimwell 1971). Given the unrigorous nature of much vegetation classification and the numerous extraneous influences noted above, it is impossible to define absolute criteria for the correctness of a classification (Whittaker 1962). Each classification has to be analyzed separately within its own context with due consideration given to the appropriateness of the system in relation to its objectives.

Every classification system, by the definition of classification, seeks to divide the vegetation of an area into classes. In order to accomplish this, certain criteria must be chosen from among

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the many properties of ecosystems. Whittaker (1962) believed that the criteria used to define the classes should be easily observed and of maximum significance in relation to the ecosystem as a whole. This last characteristic is especially important, for it seems that the vegetation classes must reflect important aspects of the relationship between the plants and their environment in order for the system to be truly meaningful.

The Zurich-Montpellier School of Phytosociology

The Zurich-Montpellier School of phytosociology originated in southern Europe just before 1910 and continued to grow and flourish for many years after. By 1935, the year of the Sixth Botanical Congress, the Zurich-Montpellier School could be described as the most positive current phytosociological school (Shimwell 1971). Many workers were involved and their activity centered around those cities which gave the School its name. One of its most prominent adherents, indeed, the man most commonly associated with the School, is Braun-Blanquet, who did much of his work in the plant communities of the Alps.

The Zurich-Montpellier School is an example of classification for its own sake. The methodology was based strictly on the floristic composition of communities (Whittaker 1962, Shimwell 1971, Braun-Blanquet 1932, Poore 1955a). The species was considered to be the fundamental unit of the plant community. "In the species are embodied certain definite adjustments to and demands upon the environment. Hence the species have come to be regarded as conspicuous in-
dicators of certain conditions of life" (Braun-Blanquet 1932).

The idea of plants as indicators of environment was certainly not original to Braun-Blanquet, but it is one of the most important concepts in all of vegetation classification and is still heavily depended upon today. Braun-Blanquet believed that it was impossible to define and delimit habitat\(^5\) without going directly to the vegetation.

The sampling procedure of the Zurich-Montpellier School was not at all randomized. Maximum uniformity and homogeneity of the vegetation was sought. The choice of sample site was influenced by various subjective factors: (1) the phytosociologist's preliminary interpretation of the vegetation, (2) his conceptions of units, (3) his judgment on representative versus atypical stands, and (4) his judgment on stable versus unstable stands (Whittaker 1962). After a suitable area was chosen, a rather thorough and complex stand description was carried out which included a list of all species present. Care was taken not to go outside the previously defined uniform area (Poore 1955a). The next step was the compilation of the association table. This included the species lists from all stands in the association. "The grouping of the lists from the sample plots into association tables is one of the most important, if not the most important, part of the technique of Braun-Blanquet's plant sociology"\(^5\)

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\(^5\) Habitat may be defined as the dwelling place of a community, including all the operative factors, except composition, that influence the plants (Braun-Blanquet 1932).
(Poore 1955a). From these species lists the abstract association was extracted.

As Braun-Blanquet and other Zurich-Montpellier workers examined the association tables, they sought out character species, species which were largely confined to one grouping of stands and clearly less important to the rest of the sample material (Whittaker 1962). These character species had different degrees of fidelity; that is, they were more or less restricted to one particular plant association. Species were described according to their degree of fidelity. Exclusive species were those strictly confined to only one association. The exclusive species plus the next two classes, the selective and preferential species, made up the larger group known as character species.

Braun-Blanquet considered fidelity to be the most important of all floristic characters (Poore 1955a). Species of high fidelity (the top three fidelity classes or the character species) were considered to have fine ecological adjustment and to be of very high value as ecological indicators (Braun-Blanquet 1932). The use of character species has some obvious restrictions. As Shimwell (1971) noted: "The importance of each character species is always relative and all degrees of fidelity exist, most character species being of reliable diagnostic value only within certain geographical limits."

Braun-Blanquet did consider other measures of the importance of species, but none were given as much weight as fidelity. Stand descriptions included an index of cover-abundance and a sociability...
rating for each species on each plot. Braun-Blanquet defined dominance as the degree of cover of a species, but believed it was not an important phytosociological characteristic (Poore 1956). The dominants in one community, according to Braun-Blanquet, may have an effect on the distribution and nature of the other species, but this influence is unspecific; the subordinate flora may be found under another dominant as well.

The association which results from an examination of the association tables is regarded as an abstract unit or type (Whittaker 1962). Braun-Blanquet wrote (1932) that the association might be thought of as "pieces of vegetation with similar combinations of species" which "are united into abstract types." However, the association was not an imaginary construct. "The concept of the association includes a true reality, namely, the characteristics common to the individuals [stands] of the association" (Braun-Blanquet 1932). It is interesting to note that the association is recognized previous to any kind of formal study, which recognition requires "... skill, sociological training, and wide experience" (Braun-Blanquet 1932). Although the association is believed to represent an ecological reality, it is concerned more with a description of the habitat than with causality (Poore 1956).

The Braun-Blanquet method is known for its disregard of suc-

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6 Sociability is the way a plant grows in relation to other plants, i.e., singly, in small colonies, in great crowds, etc.
cession. Communities are treated as apparently static and associations occur at all levels of succession (Poore 1955a). Braun-Blanquet subscribed to the climatic climax^ theory. "In a climatically uniform region there is only one climatically limited terminal stage, only one climax" (Braun-Blanquet 1932). However, he apparently did not consider vegetation dynamics pertinent to his classification system.

Numerous criticisms of the methods of the Zurich-Montpellier School have been made. If no uniformity can be found in the vegetation of an area, the system breaks down (Poore 1955a). The initial recognition of a community is a matter of practice and depends greatly on the talent of the worker (Poore 1955a). The Daubenmires (1968) felt that it is unsound to emphasize the total floristic list in classification, since not all species are of equal importance in the community. Poore (1955a) described the whole Zurich-Montpellier process of constructing and analyzing association tables as "muddled and haphazard."

By far the most attacked technique is the use of character species and the heavy dependence on fidelity. Whittaker (1962) noted that character species cannot always be found. Scandinavia is often cited as an area where this is the case. Species with high fidelity

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7 Succession may be defined as "the changes in the structure and composition of vegetation with time" (Shimmell 1971).

8 There are numerous definitions of the climax, none of which is completely rigorous. Selleck (1960a) offers a good definition: climax communities are those which ". . . represent time phases of great stability in which successional causes cannot be observed and the future cannot be predicted."
are often rare species, and it is questionable whether rare species should play such an important role in the characterization of plant communities (Curtis 1959). If the character species of a certain association are suspected before sampling starts, there exists the chance that sample plots may be chosen because of the presence of faithful species or ignored because of their absence (Poore 1956). Or conversely, if the character species are truly not known, some other criteria must be used to select the sample stands. The primary criterion is homogeneity which is partially a reflection of dominance and physiognomy. Thus, the basis for unit selection is not the basis for later designation.

In spite of various shortcomings, the Zurich-Montpellier School of plant sociology has been extremely influential. It was the first truly developed vegetation classification system and its techniques are widely used even today. Concepts and methods used by the Zurich-Montpellier School which appear, sometimes in modified form, in the work of Daubenmire and Pfister include: (1) the use of floristic criteria to delineate associations, (2) associations which are regarded as ecological realities, (3) the use of the vegetation as an integrator and expression of site factors, (4) emphasis on homogeneity of study sites, (5) subjective selection of study sites, and (6) recognition that the undergrowth is distributed independently of overstory dominants.

The Northern Tradition

The Northern Tradition, sometimes called the Scandinavian
Tradition, originated in the late 1800's. It included many workers and several distinct trends; the Uppsala School is the most well known. The work of the northern phytosociologists tended to be more quantitative than that of the Zurich-Montpellier School. Quadrat studies and quantitative research into the nature of the association were emphasized. Vegetation units had sharper boundaries that those in southern Europe. The composition of the various strata or layers was an important consideration in defining the vegetation units (Whittaker 1962).

Some authors believe the emphasis on strata or synusias was a function of the nature of the northern and mountain vegetation (Whittaker 1962). The overstory was in most cases very simple and usually contained only *Picea abies* and *Pinus sylvestris* (Daubenmire 1956). The physiognomy of the vegetation, namely an overstory which was usually very distinct from the understory, also encouraged stratification. Lippraa (1939) was a strong proponent of the synusial approach. He believed that single layers were independent of each other and combined in a variable fashion. Whittaker (1962) concurred that "Plant species which characterize units of different strata, and hence these units themselves, are differentially distributed; and the stratal units are in this sense partially independent." The synusial approach to classification is generally recognized as sound. Oosting (1956) wrote that the strata "... cannot be neglected in any study of communities. Often an understanding of the community as a whole is possible only after information is complete on the
individual strata."

Several layers were defined by Arnborg (1960); field layer (dwarf shrubs, herbs, grasses, ferns), bottom layer (lichens, mosses), tree layer, shrub layer, and seedling layer. The undergrowth, which includes the field and bottom layers, was emphasized in classification. This approach is defended by many authors (Daubenmire 1956, Kalela 1960, Arnborg 1960, Kujala 1969) on the grounds that the area is very poor in species, that the understory vegetation reaches equilibrium much faster after disturbance than do the trees (in 40 to 70 years as opposed to 100 to 200 years, according to Kalela), and that the undergrowth serves as a more accurate site indicator than do the trees. Kujala (1960) wrote:

Some schools of thought seek to use the trees as the main basis for forest typing. The immediate result of this is that in the same major type there will be included many different plant associations whose closest correspondents clearly belong to different major type groups.

In order to define the vegetation units, the Northern phytosociologists used the criteria of dominance and constancy rather than fidelity (Poore 1956, Whittaker 1962, Shimwell 1971). This was at least partly the result of the paucity of species and the wide amplitude of those species which were present (Whittaker 1962).

Using the concepts of stratification, emphasis on the understory, constancy, and dominance, the Northern investigators defined

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9 The constancy of a species in a certain geographical area equals the percentage of plots of equal size taken in that area in which that species occurs. For example, if a species occurred in eight out of ten plots, its constancy would be 80%.
the association. However, the concept was slightly different than that of the Zurich-Montpellier School. The association in the north was more concrete; it could be thought of as

- a complex of species-combinations which recur with especial frequency in nature and possess a common nucleus of species (constants) almost never lacking and present in more or less definite quantitative relations; this complex is as a rule sharply bounded in relation to the similar species combinations (Whittaker 1962).

One of the early and influential figures in the Northern Tradition is Cajander (1949), who developed the concept of forest types. It incorporated the Northern idea of the association and emphasized the correlation between vegetation and the environment. Sukachev (1960) described a forest type as

- all forest plots which are homogeneous in composition of tree species, other layers of vegetation, fauna, in the complex of environmental factors affecting growth (climate, soil, hydrologic conditions), in the interactions among components of the biogeocoenose ecosystem.

As a result of the above characteristics, the stands in a forest type are also homogeneous in the processes of restoration, succession, and the growth of tree species. Arnborg (1960) wrote that "the forest types in Scandinavia are plant community types but are also based on more or less known correlating environmental features." And further, that "it is postulated that forest type classification is not a matter of classifying the forest plant community but of classifying the site types with the aid of the vegetation." This emphasis on the forest site is closely associated with the importance of classical forestry in Finland and other Scandinavian countries (Whittaker 1962). Cajander (1949) postulated: "In all probability it is

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justifiable to assume that, when forest types are identical, identical treatments of the forest will lead to the same results."

The initial recognition of the forest type appears to be as subjective as that of the Braun-Blanquet association.

Before description of forest types is begun, it has to be ascertained by excursions into natural forests or forests verging on the natural, which forest vegetation units are the most dominant or frequent ones in the area in question (Cajander 1949).

Several concepts used in the habitat type system appeared in the discussion of the Northern Tradition. These include (1) the division of the plant association into strata or synusia, each of which is analyzed separately, (2) the use of dominance in the definition of vegetation units, (3) emphasis on the indicator value of the understory, and (4) a strong management orientation which stresses the relationship between vegetation and site factors.

Clements: Vegetation as a Dynamic System

F. E. Clements will be the last theorist considered in relation to Daubenmire's habitat type system. Working in the first quarter of the twentieth century, Clements formulated hypotheses concerning the vegetation development which had extremely far reaching influence. Many of his ideas have been discredited today (the organismic formation, monoclimax), but others (emphasis on succession) are now a standard inclusion in ecology texts.

Clements is well known for the confusing array of terms he employed. He devised a hierarchy of climax vegetation units in which the formation played the key role (Clements 1928). The formation
may be described as

... the climax community of a natural area in which the essential climatic relations are similar or identical. It is delimited by development, but this can be traced and analyzed only by means of physiognomy, floristic, and habitat (Clements 1928).

Thus, a formation is a climax community whose development is controlled by climate and which occurs on a uniform habitat. Associations were considered climax communities also, but the term is restricted to "... those climax communities which are associated regionally to constitute the formation... they are recognized chiefly by floristic differences" (Clements 1928). Clements regarded the formation as an organic entity. He carried to an extreme the analogy between the plant community and an individual organism: "As an organism the formation arises, grows, matures, and dies" (Clements 1928).

The growth processes of the formation, or succession, were analyzed in great detail. "The honor of grasping the full meaning of the dynamics of vegetation belongs to the North American scholars, Cowles and Clements" (Braun-Blanquet 1932). Although Clements was the first to exhaustively develop successional concepts, he was definitely not the first to distinguish between climax and seral communities.10

As described by Clements, the process of succession included four essential stages: initiation, selection, continuation, and term-

10 Clements (1928) himself discussed the work of several other authors who recognized vegetation development. These included Hult, Klinge, Drude, Warming, Schimper, Moss, Cowles, and Tansley.
These stages were under the influence of five interacting processes: denudation of the habitat, immigration, ecesis (adjustment to environment), competition, and stabilization (Shimwell 1971). The succession proceeded by orderly steps through a number of seral stages and finally terminated in the formation. Developmental units all had special names which were different from, but related to, the names of the climax units.

As was noted above, the end product of succession, the formation, was a climax community. Clements believed that all the vegetation in one climatic zone would eventually converge into the same climax formation, even though it might arrive there by numerous successional pathways. This conception of the nature of the climax is referred to as the monoclimax theory (Clements 1928). Clements described several types of communities which were closely related to the formation, but, not being determined by climate, were only "... apparent climaxes of greater or less duration" (Clements 1928). These "apparent climaxes" included the subclimax, preclimax, and postclimax. The subclimax included all those communities held in a position short of the true climatic climax by forces such as grazing, fire, edaphic factors, migration barriers, etc. (Clements 1928). Pre- and post-climaxes are analogous to what is commonly referred to today as topographic climaxes. For example, in a given elevation zone on the side of a mountain, Clements would consider the south slope community (drier than the climatic climax) as preclimax, while north facing slopes (wetter than the climatic climax) would be considered
Shimwell (1971) contended that the monoclimax theory is untenable. The first major assumption of the theory -- that all the vegetation in a region converges to the same climax structure -- is obviously belied by the many descriptions of edaphic, microclimatic, and many other types of climaxes. The Daubenmires (1968) wrote that evidence from the northern Rocky Mountains does not support "Clements' hypothesis of convergence in that one type of community represents this [climax] equilibrium throughout a macroclimatic belt." The second objection to the monoclimax theory is that it is "... based upon differences within identity" (Shimwell 1971). That is to say, there are so many exceptions to the rule that a truer picture of reality is obtained if the rule is discarded.

Tansley (1935) proposed that the monoclimax theory be rejected as an exercise in semantics and that the polyclimax theory be substituted. According to the polyclimax theory, environmental factors in addition to climate can act to maintain stability. Tansley (1935) argued that several types of climax in addition to the climatic climax could occur in one region; these might include the edaphic climax, physiographic climax, biotic climax, and fire climax. Selleck (1960a) wrote that the rift between the polyclimax and monoclimax theories rests not on the question of the existence of stable communities, but rather on the assumption that, given sufficient time, climate is the overall controlling factor and on the length of time considered adequate for stabilization to occur.
Daubenmire is an adherent of the polyclimax position. When considering the various climax associations which are indicative of the habitat types, he makes no distinction between the various controlling factors except occasionally to call attention to them (Daubenmire and Daubenmire 1968, Daubenmire 1970).

A final noteworthy aspect of Clements' vegetation classification scheme is his emphasis on the value of the habitat as a basis for the recognition and delimitation of vegetation units. "As effect and cause, it is inevitable that the unit of the vegetative covering, the formation, should correspond to the units of the earth's surface, the habitat" (Clements 1928). Since Clements recognized that knowledge of the habitat was in a rudimentary state, he advocated using a multifactor approach to defining communities.

The actual recognition of formations by means of physiognomy, of floristic, and of habitat has been tried repeatedly by the use of detailed and exact methods of quadrat and instruments. This has afforded exclusive proof that no one of the three viewpoints is adequate alone or primary (Clements 1928).

As has already been suggested, a number of points in Clementsian ecology have been questioned. Whittaker (1962) listed several weaknesses: (1) use of the organismal analogy to characterize the formation, (2) the monoclimax theory, and (3) development of a formal system of classification based on dynamic relations which are sometimes hypothetical. However, these shortcomings do not decrease the value of Clements' contribution to vegetation science. Although they do not recognize the monoclimax, Daubenmire and Pfister are similar to Clements in their consideration of dynamics in classification and
in their use of the climax as a sort of integrator for all the seral stages.
CHAPTER 4

THE BASES FOR DAUBENMIRE'S HABITAT TYPE SYSTEM

Although Daubenmire applied the concepts of the habitat type system in many studies, the formal exposition of the system appeared in 1968 in *Forest Vegetation of Eastern Washington and Northern Idaho* (Daubenmire and Daubenmire 1968). The goals of this study were fourfold: (1) to record the structure and composition of remnants of virgin forest that are rapidly disappearing, (2) to provide a classification of this vegetation on an ecosystem basis, (3) to draw together available information on climate, soils and animal life that can be correlated with the vegetation, and (4) to include enough area to provide an accurate evaluation of geographic gradients in vegetation and problems of local differentiation (Daubenmire and Daubenmire 1968).

The basic vegetation unit of the system is the association. The association may be defined as

... all climax stands in which the dominants of the corresponding layers are essentially the same, to the extent that any differences in composition are due to chance dissemination or to a transitory historic factor rather than to a fundamental dissimilarity in habitat potentialities (Daubenmire 1968).

It is a "... subjective concept based on those characters at least potentially common to all the separate stands which represent it, and which serve to separate the group from all other stands" (Dauben-
A union is a major subdivision of an association which re-appears in other associations. The most prominent example is the *Pachistima myrsinites* union, "... a floristically rich and morphologically diverse mixture of perennial herbs no one of which dominates" (Daubenmire and Daubenmire 1968). It is especially important in the *Tsuga heterophylla* series.

The habitat type itself is considered to be the basic ecological subdivision of the landscape (Daubenmire and Daubenmire 1968). As the association is a unit of vegetation, the habitat type is a unit of land. "The collective area which an association occupies or will come to occupy as succession advances is called a habitat type" (Daubenmire 1952). Thus, to say a piece of land is a ponderosa pine/*Symphoricarpos albus* habitat type is to say that that land has the potential to support a climax association of ponderosa pine and snowberry.

A series is all those habitat types characterized by the same climax tree species. A phase is a further subdivision of a habitat type based upon understory species. Daubenmire recognized 22 habitat types and only one phase (Douglas fir/*Calamagrostis rubescens* *Arctostaphylos uva-ursi* phase).

Vegetation as a Discrete Variable

The first postulate upon which the habitat type system rests is the discontinuous distribution of vegetation. The following quote from Daubenmire (1966) illustrates his belief in the existence of rela-
tively discrete vegetation communities:

The recurrence of closely similar plant assemblages wherever the net influence of climate, soil, animal and time factors have provided closely equivalent environments was early recognized, and these concrete units were combined to form abstract classes and types, each of which had consistent distinguishing characters.

The Role of the Climax

The climax is a cornerstone of the habitat type system. "The philosophy has been accepted that any basic study of a vegetation mosaic must begin with emphasis on the relatively stable (i.e. climax) community" (Daubenmire 1970). Daubenmire (1968) defined climax as "... any apparently self-perpetuating phytocoenosis, or for non-reproducing populations where there is no evidence of a possible successor." As stated earlier, both Daubenmire and Pfister are proponents of the polyclimax theory.

Factual evidence supporting monoclimax is nonexistent, whereas some have shown by population analysis data that more than one community type in a restricted area can show concrete evidence of self-perpetuation. On this basis polyclimax is easily definable and demonstrable (Daubenmire 1960).

In distinguishing the various types of climaxes, Daubenmire followed Tansley (Daubenmire and Daubenmire 1968).

Daubenmire regarded the climatic climax as the ideal requiring moderate conditions for development, conditions which are not often observed. The stable communities of deep, nonstony loams that have gentle slope, are moderately well drained, and have somewhat

\[11\] For a more complete discussion of this topic see Chapter 2.
average chemical characteristics are referred to as climatic climax (Daubenmire 1956). A climax association which is a climatic climax in one area may exist as a topographic climax in another (Daubenmire 1968). Pfister et al. (1974) noted the difficulty in relating to the climatic climax in the northern Rocky Mountains: "It is conceptually difficult to speak strictly in terms of climatic climaxes for habitat types in much of this mountain forest because steep topography and rocky soils are so prevalent."

The climax serves several functions in the habitat type system. First, it aids in the interpretation of disturbed vegetation (Daubenmire 1956, Daubenmire and Daubenmire 1968). As soon as an area is disturbed, it begins to evolve toward the climax (Daubenmire 1956).

A basic aim of synecology is to predict the potentialities of disturbed areas from inspection of their current, usually disturbed plant cover. To do this, any units of classification or ordination must emphasize trends rather than take a static view that emphasizes only current vegetation composition (Daubenmire and Daubenmire 1968).

A second function of climax is to clarify the vegetation-environment relationship and thus more sharply define the habitat type boundaries. "The chief value of the [climax] system resides in directing interest toward understanding the role which environmental elements play in determining vegetation mosaics" (Daubenmire 1968). After competitive elimination has had time to work, the vegetation-environment relationship is most clear (Daubenmire and Daubenmire 1968). The trend toward climax includes (1) replacement of species with similar and broad ecological amplitudes by groups having narrower and complementary requirements, (2) increased numbers of inter-
specific dependencies, and (3) increased regularity of floristic composition and structure among stands representing one association (Daubenmire 1968). It is clear that stands near climax would be easier to delineate than those in the early portion of the sere.

A third function of the climax is to create simplicity and order out of the chaos of a myriad successional stages (Kalela 1960, Mueller-Dombois 1960, Daubenmire 1968, Daubenmire 1956). Daubenmire (1968) expanded on the integrative function of the climax:

Since each piece of demonstrably seral vegetation, as well as each disclimax, can be related dynamically to some one primary climax, a system based on habitat types is infinitely simpler than one giving equal weight to all describable types of plant cover.

Finally, the climax is regarded as the best reflection of the biotic potential of the site (Daubenmire 1960). Pfister et al. (1974) wrote: "Since it is the end result of plant succession, the climax plant community reflects the most meaningful integration of the environmental factors affecting vegetation."

Several authors have decried the excessive emphasis on climax in vegetation classification. Selleck (1960a) discussed several possible reasons for the invalidity of climax and concluded: "For practical purposes in field ecology a climax appears to be rarely if ever attained and is influenced by such a host of nebulous factors that it is even questionable theoretically." Whittaker (1962) saw danger in studying vegetation "... in terms of what it ought to be or might conceivably become, rather than what it is." McIntosh (1968) criticized the use of climax on the following grounds: (1) it
is difficult to determine what is stable, (2) it is difficult to find examples of this stable community in a given area, and (3) a classification based on the climax leaves out most of the vegetation. According to Rowe (1960b), "the climax concept may have a valid use regionally, if given a precise meaning in terms of structure, composition, and of stability within the specific time framework." The role the climax plays in a classification system should definitely depend upon the geographic area in question. If enough remnants of climax vegetation remain to provide a representative sample of all the climax types and if disturbance is not so recent and severe as to make identification of the potential climax impossible, then the climax concept may function prominently and successfully in classification.

**Homogeneity and Other Sampling Considerations**

Gleason (1939) recognized how indispensable homogeneity was to the recognition of plant communities:

> Homogeneity of structure, over a considerable extent, terminated by definite limits, are the three fundamental features on which the community is based. ... Uniformity, area, boundary, and duration are the essentials of a plant community (Gleason 1939).

The belief in the need for homogeneous stands to serve as a basis for phytosociological studies is widespread. Daubenmire (1966) stated that homogeneity is absolutely essential in order to get a true picture of vegetation. "If two methods of analysis support different conclusions, one must ask if they are equally valid. As I see it, no sample is valid unless it is drawn from an area of maximum homogeneity" (Daubenmire 1966). According to Poore (1955b), "Homo-
geneity of the stand is unquestionably the basis of plant sociology." Curtis (1959) considered homogeneity to be the most important criterion for stand selection.

The central problem with homogeneity is its determination. Curtis (1959) described it as a difficult concept to understand and employ in the field. He interpreted homogeneity as having to do with the uniformity of distribution of the species throughout the area sampled and used a Chi-square homogeneity statistic to quantify it. Daubenmire (1970) admitted that homogeneity is always relative, yet he gave this definition: "We may define a homogeneous piece of vegetation as one in which variations are attributable to chance rather than to intrinsic habitat factors." A somewhat more realistic approach is provided by Poore (1955b):

It would appear that no satisfactory definition of homogeneity has yet been given and that statistical techniques can only give us measures of the degrees of over- or under-dispersion of the various species of a community relative to a particular quadrat size or quadrat sizes, and with the same quadrat size relative to each other.

If there is no generally accepted criterion for assessing homogeneity, then the selection of homogeneous stands must be to some extent subjective. "It has been said that the most important decision made by an ecologist is that made when he stops his car" (Ashley as quoted in Curtis 1959). Subjectivity pervades the initial phases of many classifications (Poulton 1961, Driscoll 1964, Illingworth 1960, Daubenmire 1962). "The synecologist must always decide just what constitutes separate units before he can start to classify them" (Daubenmire 1968). This statement may not be as blatantly arbitrary

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as it appears. Poore (1956) maintains that all plant sociological systems must be highly subjective, but as they proceed by trial and error they approximate a true description of the actual state of affairs. Daubenmire (1968) argued that, when the initial subjective recognition of associations is followed by objective analysis, "... the latter tend to correct impressions and bring out subtle facts which are of great value in distinguishing related communities."

As might be expected, systematic or random sampling procedures are avoided by most classifiers. Daubenmire (1968) wrote that most species in a community are markedly aggregated; therefore, random sampling could grossly overestimate some species if a cluster of plots coincided with a family group. Some authors advise rigid stratification when locating sample plots (Poulton 1961).

Since means based on parts of two populations having different parameters in consequence of environment or history constitutes a misrepresentation of fact, it behooves an investigator to strive for the most rigorous stratification of vegetation that the material and his observational activity permit (Daubenmire 1968).

When collecting the data for the formulation of the habitat type system, the Daubenmires followed the principles of stratification and maximum homogeneity. Six stands of each association were analyzed; in each stand a 15 by 25 meter rectangle was laid out in a carefully selected site parallel to the contour to minimize any diversity due to elevational change (Daubenmire and Daubenmire 1968). Pfister et al. (1974) attempted to introduce a degree of objectivity into his sampling procedure. Although the entire stand to be sampled had to be "representative, homogeneous, and relatively mature," the
exact location of the plot was chosen by pacing a preset distance into the stand from the road.

McIntosh (1967) criticized the subjective selection of stands:

Selection of stands to fit an a priori notion of community type does not constitute evidence that vegetation consists of such types. Assertion that such choices are justified by the fact that they represent homogeneous, stable, climax, or more frequent communities as against the rest of the area in which the communities are presumably heterogeneous, mixed, unstable, seral, fragmentary, and less frequent are not satisfactory in the absence of evidence that the selected areas do in fact fulfill the criteria.

This is a criticism which is very difficult to counter. The only way in which the classifiers can justify their use of subjective and undefinable concepts such as homogeneity is by proving that the classifications they generate are indeed ecologically sound and reflective of environmental factors.

The Synusial Approach

Daubenmire (1969) believed that in order to achieve an ecologically oriented classification, "... one in which the effects of climate and soil are reflected critically in the outcome of competition," it is necessary to emphasize the character of both trees and ground vegetation at climax. A synusia may be defined as "... a population of one species or of several species that are closely similar in ecology as indicated by similarity of local environmental amplitude, phenology, and frequently by similarity of life form as well" (Daubenmire 1952).

Daubenmire's approach to synusiae is to analyze the trees and undergrowth separately and, by combining certain characteristics of
each, to thus arrive at the association. In order for this method to be valid, the trees and the undergrowth must be distributed independently of each other. The Daubenmires (1968) asserted that this is indeed true: "In the northern Rockies, forest overstory and undergrowth occupy the land independently." Support for this viewpoint is widespread in the literature. Whittaker (1962) listed five categories of dynamic relations which may occur between species: (1) full dynamic association, (2) partial dynamic association, (3) indifference, (4) partial dynamic dissociation (competition) and (5) full dynamic dissociation. According to Whittaker, the herbs on the forest floor and the trees fall into the indifference category.

Lippmaa (1939) traced one layer community of forbs and grasses all across Eurasia and noted that "the protecting tree layer may be very different in different countries." Inferior layers may depend on superior ones for moderation and amelioration of the environment, but they are not dependent upon any tree species in particular (Cain 1936, Daubenmire 1968). In other cases, synusiae which occur as inferior layers in one community may occur in others as the superior layer or may occur completely alone (Cain 1936). Poore (1955b) concluded after investigating a Scottish woodland:

The ground flora varies independently of any variation in the composition of the tree layer, although of course it is dependent on the presence of some sort of cover for the maintenance of a moist, shaded microclimate, for protection from excessive erosion, and for the particular condition of at least the deeper soils.

In the habitat type system neither layer is disregarded, although the trees receive more weight.
Although synusiae or layers merit separate consideration because of their sharp differences in life-form, phenology, microenvironmental requirements and influence, there are so many interrelationships among subdivisions of the phytocoenosis that they can scarcely be considered other than as components of a larger entity (Daubenmire 1968).

When developing the ecological ramifications of the habitat type system, Daubenmire assumed that the various layers reflect different characteristics of their environment.

Superficially these groups inhabit the same general environment but actually they live in well-defined sectors of it, the demarcation being temporal or spatial, or both. To mix all these groups, as in a single alphabetic list, is to obscure a great amount of fundamental ecologic diversity within the community as a whole (Daubenmire 1968).

The tree stratum is more closely related to macroclimate (Daubenmire and Daubenmire 1968), while the undergrowth is more responsive to the soil and microclimate (Kalela 1960, Daubenmire and Daubenmire 1968). Because of their reflection of macroclimate, more emphasis is given to the trees. This is the "... only alternative that leads to a comprehensive climate-vegetation-soils classification" (Daubenmire and Daubenmire 1968). The trees are more affected by intrinsic climatic factors than is the undergrowth since the undergrowth lives in a microenvironment (Daubenmire 1952). However, the arguments that the undergrowth is insignificant because the trees have deeper roots or access to more soil nutrients are not true (Daubenmire 1952, Krujala 1960).

The use of more than one layer has definite advantages in classification. One frequently cited advantage is the rapid rate of recovery of the undergrowth after disturbance (Daubenmire and Daubenmire 1968, Krujala 1960, Pfister et al. 1974, Illingworth 1960). Ac-
According to Pfister et al. (1974), "Undergrowth successional trends toward climax usually appear to progress more rapidly than those in the tree layer, i.e., the undergrowth species composition appears to reach a relatively stable condition soon after the coniferous canopy closes."

Illingworth (1960) pointed out the practical aspects: "The practical value of an ecological classification is greatly enhanced if the site type can be identified after a major disturbance such as logging or fire." An additional advantage in including undergrowth in a classification is that the ecological amplitude of some undergrowth species may be narrower than that of the trees, so that a classification resulting from the combination of the two will result in a more exact definition of the types (Mueller-Dombois 1964).

There seems to be very little evidence to repudiate the synusial approach. Systems which ignore certain layers completely (certain Scandinavian classifications) or which take no cognizance of layers at all (Zurich-Montpellier) have been criticized for these practices. Only one author among those surveyed claimed a dependent relationship between the undergrowth and specific dominant trees:

The interactions of this tiny group of plants [the 12 to 15 dominant tree species found in Wisconsin] with the general climate and the regional soil groups produces a series of microenvironments which differ according to the biological character of the dominants. Most of the remaining species of the flora must grow in these modified conditions and they tend to be sorted out in groups aligned with the particular dominant concerned (Curtis 1959).

Poore's (1956) cautionary note on the use of synusia is an appropriate summary:
Although the main argument in favor of the synusia is that it grows in a more uniform habitat than the phyto-coenose, this uniformity is only relative; and the search for a perfect basic unit for plant sociology is illusory.

**Indicator Species**

Through the use of indicator species, Daubenmire sought to characterize the biotic potential of a piece of land, the habitat type. Thus an indicator species in the context of the habitat type system may be thought of as a species indicative of habitat potential. An obvious alternative procedure is the possibility of measuring the habitat factors directly. Our ability to accurately measure site factors has increased greatly, but the following statement made in 1877 is still applicable:

The most reliable natural indications of the agricultural capabilities of a district are to be found in its native vegetation. . . The natural vegetation may be regarded as the natural correlation of soil, climate, topography, drainage, and underlying formations and their effect upon it. To determine the exact character of each of these agencies independently is a work of no little difficulty, and then to compare and combine their respective influences upon vegetation presents very great additional difficulty (Chamberlin as quoted in Curtis 1959).

Attempts to account for genetic variation are a modern example of the difficulty in correlating abiotic parameters and plant community characteristics. The assumption is commonly made that genetic variation is the result of environmental differences (Howe, personal communication). However, after measuring soil, elevation, and climatic parameters, the geneticists were unable to identify which influences accounted for the differential responses of the plants. The conclusion is that, at least in this case, geneticists are poor quan-
tifiers of integrated environmental factors. The basic difficulty in using direct measures of site factors to estimate site potential is that it is impossible to compare instrumental readings to the vegetal response to the site factor (Cajander 1949).

Interaction between factors, or factor compensation, must also be considered. Daubenmire (1968) remarked that a single habitat type may be demonstrably variable throughout its geographic range as to both climate and soil, but, since factor compensation is occurring, the ecological sum of all variation in climate and soil remains essentially the same throughout.

While the case seems good for giving environment more emphasis, there is also solid evidence that it cannot be given first place in classification; for man lacks an ability to predict the nature of vegetation from a given set of environmental data, except in such a broad manner as to be of little use (Daubenmire 1960).

Many investigators avoid the difficulties inherent in direct monitoring of site factors by using the vegetation to indicate the site potential (Pfister et al. 1974, Poore 1956, Braun-Blanquet 1932, Driscoll 1964, U.S.F.S. 1933). McIntosh (1967) summed up:

Vegetation responds to changes in the environment by changes in the qualitative and quantitative characteristics of species populations and in species composition. These, of course, are the premises for the use of species as indicators.

After the decision has been made to define the vegetation units by means of indicator species, it is necessary to determine which species make good indicators. "Each species of the landscape biota may have indicator significance in relation to a given habitat by virtue of its presence and importance there or of its absence" (Whit-
Some authors urge that every species in the stand be given equal weight in defining the vegetation unit (Braun-Blanquet 1932, Kalela 1960). The Daubenmires (1968) do not agree with this view. They maintain that not all species are equally useful in ecosystem classification and that small floristic differences between stands are important if they are regularly associated with the same characteristics of the environment.

McIntosh (1967) is in favor of groups of species:

In general, multiple species combinations are preferable as a basis of indication because the ecological optima and amplitude of a species are commonly influenced by other species and the combination makes a better indicator of the habitat complex than a single individual species. Species with narrow amplitudes of tolerance are commonly preferred.

According to Daubenmire (1968), when two or more species exhibit similar patterns, "... one may expect intrinsic differences in environment even where none is apparent."

In addition to the question of how many indicator species to use, the nature of the indicator species must be considered. The indicator plants might be constants, faithful species, or dominants. It may be that none of the above is best and that local conditions will dictate suitable criteria for selecting indicator species. As will be seen in the next section, the Daubenmires (1968) chose dominance to be the essential characteristic for their indicator species.

Indicator species are not the final solution to typifying the habitat. Rowe (1960a) offered several criticisms of the indicator spec-
ies concept. (1) It is not sound "... to base the identification of biologically equivalent sites on phytocoenoses whose synecological relations are poorly understood and whose similarities are of a highly subjective nature." (2) A specific phytocoenose may not be occupying all its potential range. (3) If the ecological amplitudes of the indicator plants are large, then a wide range of environment may be lumped together as biologically equivalent. (4) It is impossible to say that a plant indicates some environmental phenomenon unless you specify competition. Whittaker (1962) pointed out that two species may live in the same habitat and have environmental requirements which differ in some respects if they are not direct competitors. There is also a circular argument involved; the vegetation unit is caused by the habitat unit, but the habitat unit is recognized by the vegetation unit (Whittaker 1962).

It is possible to overemphasize the role vegetation plays as an indicator of site factors (Beaufait, personal communication). If the plants are not enough, other parameters may have to be integrated into the system. This problem will be explored further in the section on correlations between habitat types and site factors.

The Choice of Indicator Species

Daubenmire (1968) has criticized attempts to define the association using only one plant characteristic.

Several attempts have been made to establish rigorous diagnoses for associations using some type of analytic data such as frequency, dominance, or constancy. These attempts have always been abandoned later because of their inflexibility in the face of biologic variability. One cannot hope to
find consistent differences among a series of ecosystem types using only a single character of one phase of the complex (Daubenmire 1968).

However, in other publications (Daubenmire and Daubenmire 1968, Daubenmire 1966), Daubenmire argued that dominance, even dominance of only one species if it is correlated with environmental differences, may be sufficient to recognize community types.

Dominants may be thought of as "... those species whose removal would bring about the greatest readjustments in the edaphic, aerial, and biotic character of their ecosystem" (Daubenmire 1968). There are several reasons why Daubenmire considers dominants to be the key to the character of ecosystems. First, the dominants exert the greatest influence on microclimate, on soil profile, and on animal associations. Also, the dominants are the chief means of capturing solar energy for the ecosystem. But the most compelling reason for emphasizing the dominants is that, as a result of competition, they are the most ecologically significant species.

A strong argument can be made that a similarity of dominants in the different layers arising anew at different places through competitive elimination is the most perfect evidence of a high degree of ecological equivalence through a series of stands (Daubenmire 1968).

Competitive exclusion is more critical for trees than for shrubs and herbs (Daubenmire and Daubenmire 1968). In northern Idaho, "Population analyses of many old, undisturbed forests... show that in more than 95% of the stands population structure points clearly to one [tree] species as capable of displacing all others" (Daubenmire 1966).
A major criticism of the use of dominants to define associations is that they are often species of wide ecological amplitude, growing successfully in a variety of habitats. Daubenmire (1970) agreed with this view to some extent, but contended that the problem may be solved by considering the understory as "... indicators of smaller units of great ecologic homogeneity..." In defining the 22 habitat types, Daubenmire did indeed follow this procedure. First, he grouped stands according to the tree species that showed the strongest evidence of self-perpetuation, i.e., the species which through the process of competitive elimination would in time become the dominants. Eight subdivisions based on the climax tree species (the series) resulted which were in turn divided on the basis of difference in the shrubs and herbs dominating the undergrowth (Daubenmire and Daubenmire 1968).

There are many vegetation parameters which may be used to define dominance. Dominance analysis is "... any evaluation that expresses the size or bulk of the shoots of each species in relation to space" (Daubenmire 1968). Cover, basal area, line interception, volume, and productivity could all be used to indicate dominance. Daubenmire has chosen to use cover. Cover may be defined as "... the percentage of ground surface included in the vertical projection of a polygon drawn about the undisturbed extremities of the plant. Discontinuities within the canopy of one plant are ignored" (Daubenmire 1970). Cover is believed to be an important estimator of the relative role which a species plays in the economy of the community (Poore 1956).
It [cover] serves as a criterion for relative dominance, of potential productivity, of the influence of plants on precipitation interception and soil temperature, and of the value of vegetation to animals. It is applicable to almost all phytocoenoses (Daubenmire 1968).

One readily apparent problem with cover as a measure of dominance is its interpretation. It is necessary to decide what percentage of cover is significant. In the key to the northern Idaho and eastern Washington habitat types (Daubenmire and Daubenmire 1968), relative terms such as well represented, abundantly represented, and inconspicuous are used without clarification. Pfister et al. (1974) improved the situation greatly by defining common, scarce, poorly represented, well represented, and abundant in terms of exact percentages of cover. However, the question of what cutoff point is ecologically significant remains. In the first step of the Pinus flexilis series key (Pfister et al. 1974), the choice hinges upon whether Festuca idahoensis is well represented (greater than 5% canopy coverage) or poorly represented (less than 5% canopy coverage). If the criteria common (greater than 1%) and scarce (less than 1%) had been chosen instead, many areas would key out differently.

The controlling role of the dominants and the validity of dominance types is not universally accepted; Poore (1956) advocated a middle course. In some communities the dominants may be all important, in others less so. Curtis (1959) believed there is no "prior information" which could justify blindly following "... a standardized or fixed system based on dominants, character species, constant species, or other single criteria." Whittaker (1962) recognized advantages in the use of dominance types: (1) they can be applied with-
out thorough floristic knowledge, (2) they do not require excessive time and energy for application, and (3) they emphasize "important" species which may concern those in forestry and range management. However, he concluded that it is a superficial approach since it focuses attention on a few of the most conspicuous species and since dominant species may be ineffective as indicators of the environment.

Habitat Types as an Expression of Site Potential

The final concept upon which the habitat type system is based is a synthesis of all the qualities and concepts enumerated up to this point. If the assumptions on the value of synusiae, the importance of dominant species as indicators, etc., are valid, then the result should be a classification of ecosystems, a "natural" classification which can predict the potential of the land. This is indeed the claim that its originators make for the habitat type system.

The "landscape approach" to classification has long been the ideal. "The ecosystem concept implies a degree of interdependence among climate, soil, plant life and animal life such that any alteration of one component of the system sooner or later requires adjustments in the others" (Daubenmire 1970). In a publication devoted to seeking a common ground for the classification of forest communities (Silva Fennica 105), the conclusion was that defining the ecosystem through the use of as many floristic and ecological parameters as possible should be the goal (Krajina 1960b, Rowe 1960b). Although Daubenmire subscribes to this philosophy, his habitat types are, in the final analysis, defined according to floristic characteristics.
Many environmental factors were measured during the sampling process (Daubenmire and Daubenmire 1968), but this information was not incorporated into the classification in a formal way. Daubenmire (1968) offered this elaboration of the role the environment plays in classification. (1) It is helpful in deciding what is a homogeneous stand. (2) It is helpful in limiting the amount of variation allowable in grouping stands into associations. (3) It acts as a check against viewing floristic accidents as phenomena of high significance. (4) It allows inclusion of occasional stands into the association which happen, through chance, to lack one or more of the usual dominants. It may be assumed that environmental measurements were incorporated into the formation of the habitat type system according to these guidelines.

Beginning with the assumption of the discontinuous distribution of vegetation, the Daubenmires proceeded to group homogeneous climax stands, using indicator species (dominants) in the overstory and undergrowth, into associations. These associations represented the biotic potential of land units designated as habitat types. The whole system is thought to approach a natural classification. "That system may be considered closest to a natural one that allows the most predictions about a unit from the mere knowledge of its position in the system" (Daubenmire and Daubenmire 1968). The only way to judge how closely the habitat type system approximates the ideal of a natural classification is to analyze attempts at correlating the types with such factors as the growth rates of trees, disease sus-
ceptibility, soil moisture regimes, and the responses of the vegetation to fire and grazing. The success or failure of these attempts is the real test of the system.
CHAPTER 5

THE ADAPTATION OF DAUBENMIRE'S SYSTEM TO MONTANA

The concept of regionality implies that a vegetation classification system, devised for one area and using the species of that area as indicators, has a limited geographic validity. "Since component species drop out one by one with increasing distance from a given point of observation, associations as definable combinations of species are local phenomena" (Whittaker 1962). The Daubenmires recognized this in their 1968 study: "For lack of comparable data for adjacent areas, the characters listed for recognizing each habitat type are intended for use mainly in the core area."

Some authors see the fact that community types are of a definitely provincial nature as a weak point of classification (Gleason 1939, Lieth 1968). Others accept regionality as an inherent condition of classification, which, as long as it is recognized, is no cause for alarm. Rowe (1960b) noted that awareness of regionalization prevents incorrect extrapolation.

Regionality affects not only the indicator species used in classification, but the methods as well (Cain 1960, Beaufait, personal communication). As was suggested previously a stratal approach stressing the undergrowth is appropriate to the vegetation of Scandinavia. The Forest Service acknowledges that the habitat type method of classification is only one of many, but it appears to be applicable
to the vegetation and topography of Region I (Beaufait, personal communication).

**Pfister's Montana Habitat Types**

There are a number of reasons, both circumstantial and analytic-al, that the Forest Service chose to adapt the habitat type system for Regional use. Although it is almost impossible to judge based upon only seven years' experience, the Daubenmire system was apparently working well in northern Idaho and eastern Washington, and a number of practicing foresters had been exposed to habitat types and found them to be useful and applicable. Also, it is believed that, for a long period of time, Daubenmire was the primary force in plant ecology in the northern Rocky Mountains and many people were exposed to his ideas (Beaufait, personal communication). According to Pfister et al. (1974), Daubenmire's habitat type system had been used successfully as a mode of communication, as a basis for organizing management implications, and as a foundation for conducting and evaluating research. It was in the hope of expanding these benefits that the Daubenmire system was adapted to a larger geographic area.

Pfister's system is based on concepts essentially identical to those of Daubenmire. He defines a habitat type as "the aggregation of units of land capable of producing similar plant communities at climax" (Pfister et al. 1974). Each habitat type is believed to "... represent a relatively narrow segment of environmental variation and thus delineate a certain potential for vegetative development" (Pfister et al. 1974). Pfister interprets ecotones as being
narrow. As a result, the types include more diversity but more of the land is definable to habitat type. This is very similar to Daubenmire’s idea of plateau-like areas of little variation, the types, surrounded by areas of steeper environmental gradients, the ecotones (Daubenmire 1966). Pfister also calls attention to the importance of succession and the indicator significance of undergrowth:

It (the habitat type) can be identified during most intermediate stages of succession by comparing the relative reproductive success of the tree species present with known successional trends and by existing undergrowth species.

The objectives of Pfister’s study were very similar to those of Daubenmire: "...to develop an ecological classification of forest land in which not only vegetation but also climate, geography, and disturbance factors are taken into account" (Pfister et al. 1974). The specific goals were fivefold: (1) to develop a habitat type classification for the forested lands of Montana based on the potential vegetation, (2) to describe the general geographic, physiographic, climatic, and edaphic features of each type, (3) to describe the association (climax plant community) occupying or potentially occupying each type, (4) to produce a first approximation of general management implications for each type including successional development, timber productivity potential, and other biological observations of importance to the forest land manager, and (5) to develop and test the reconnaissance-plot method of data gathering for habitat type classification in a minimum period of time (Pfister et al. 1974).

As was specified above, Pfister’s habitat types dealt only
with forest lands, i.e., stands with a potential of 25% canopy cover. The sampling system was similar to Daubenmire's: a subjective search for uniform, mature communities. Random or systematic sampling was rejected for several reasons, the most familiar being that plots chosen by such methods would not represent the desired homogeneous, relatively undisturbed, and mature forest communities. In addition, systematic or random sampling was considered to be more time consuming and was thought to "... hamper the ecological interpretation of the pattern of forest vegetation emphasized in the transect approach" (Pfister et al. 1974).

The field investigation was begun by running elevational road transects at selected locations. Several features were noted en-route: apparently homogeneous communities of trees and undergrowth; well developed, undisturbed stands; transitions into other communities; young seral communities; and topography and edaphic factors. At the end of the transects these notes were inspected and representative communities were chosen to be sampled on the return trip. At each location, coverage estimates were made for forbs, shrubs, and trees in a 375 square meter plot. In order to test site potential a relatively free growing tree of each species, if available, was measured for height, age and dbh. In addition, at each plot the investigators collected samples of the upper 20 cm. of soil and parent material, recorded fire history, noted insect and disease occurrence and animal use, and estimated the environmental position of the stand in relation to adjoining habitat types.
In the office, the data were subjected to a series of approximations and tests. These included several ordinations which arrayed stands on the basis of their quantitative compositional data. Prior to ordination, the stands were grouped by climax tree species. Individual species distributions were plotted by ordination also. This "afforded insight regarding potential groupings of similar stands and the use of various species as indicators" (Pfister et al. 1974). Finally, "... a careful inspection of geographic location, elevation, topographic position, soils, etc., was made to insure that specific environmental patterns could be related to each habitat type and phase" (Pfister et al. 1974). These procedures resulted in 58 habitat types, four community types, and 54 phases. The community types are Pinus contorta stands where Pinus either is a persistent seral species or climax.

It is apparent from these figures that Pfister was more inclined to split his types than was Daubenmire, although a portion of the increased number is due to the larger area and greater environmental diversity included in the Montana types. Phases arose from different conditions; they could indicate a broad transition between two adjacent habitat types that occupied a major area, or they could represent a different dominant in a third layer whereas the habitat type is defined by dominants in two layers.

Meuggler's Mountain Grassland and Shrubland Habitat Types of Western Montana

Although this paper is concerned with the forest habitat types
of Daubenmire and Pfister, mention should be made of *Mountain Grassland and Shrubland Habitat Types of Western Montana* (Mueggler 1974). Mueggler subscribes to a somewhat different philosophy of vegetation distribution than do Pfister and Daubenmire; one of the concepts upon which he based his study was that "Natural vegetation does not occur in discrete units, but rather as a continuum along complex environmental gradients" (Mueggler 1974). However, he believed that land management based on the continuum concept is not feasible and that "relatively" similar plant communities should produce and respond similarly to management.

After an initial attempt at ordinating his data, Mueggler was forced to revert to the "less sophisticated association table approach" since the numerical techniques obscured the importance of the dominant species which Mueggler believed should be stressed in the development of classification. His indicator species were chosen with three criteria in mind: (1) dominance, (2) suspected affinity to specific environmental conditions, and (3) constancy of species within proposed groups. The separation of the habitat types was based on these indicator species, a reasonable consistency of secondary species, and the likelihood of similar anticipated responses to management. It is interesting to note that an investigator with an apparent leaning toward the continuum concept and numerical analysis was forced to use more traditional methods in order to reach his goal of a management-oriented classification. This situation suggests that the end may indeed determine the means.

Mueggler encountered more difficulty than did Daubenmire and
Pfister in locating pristine areas to sample and often had to resort to disturbed areas which, according to the field workers' judgment, had not been appreciably altered.

The grassland and shrubland habitat types are applicable to western Montana only; their relationship to the adjacent mountain areas of Wyoming, Idaho, and Canada is not yet determined. No information is available on forage potential or management implications.

**The Ecoclass Concept**

A truly comprehensive classification of the land must consider all the essential components, namely vegetation, soils, and time. The habitat type system covers the vegetation, successional stages may be described without excessive difficulty, and the Forest Service has proposed the land system to include the soils. Two heirarchies of classes would be delineated, one for vegetation and one for land (U.S.F.S. 1973).

The vegetation system would include community type, habitat type, series, region, and formation. The land system would include the landunit, landtype, landtype association, subsection, section, and province. A class from one system could be combined with one of several classes from the other system to form an Ecological Land Unit (ELU). The whole process would be known as the Ecoclass method of ecosystem classification.

The habitat type would play a varied role in this system, depending on the class from the land system with which it was combined.
For example, if a habitat type were combined with a landunit,¹² the result would be the habitat type-landunit, the lowest common level of the ELU that is homogeneous in (potential) climax vegetation and form and structure of the land (U.S.F.S. 1973).

It is beyond the scope of this paper to delve deeply into the Ecoclass concept. However, it is an important system to be aware of, since some studies are already using it to stratify results and since it has potential for improving the correlation between environment variables and habitat type.

¹² A landunit is the lowest unit in the land system. It identifies an area in terms of soil characteristics, slope shape, aspect, and steepness. It may have one or more than one specific kinds of soils. If it has more than one, the soils are closely related genetically and morphologically. (Ecoclass Taskforce Report, U.S.F.S. 1971.)
CHAPTER 6

CORRELATIONS BETWEEN THE HABITAT TYPE SYSTEM AND ENVIRONMENTAL VARIABLES

The utility of the habitat type system in forest management resides in its reputed ability to provide a permanent and ecologically based system of land stratification (Pfister et al. 1974). Habitat types should act as a foundation upon which to base predictions of responses to land and vegetation management. For the types to be truly useful management tools, quantitative correlations between the types and conditions critical for management must be made. "The usefulness of forest typology will depend not only on the correct isolation for forest (site) types but also on the fullness of knowledge of their silvicultural properties" (Sukachev in Illingworth 1960).

However, many of the correlations appearing in the original publications (Daubenmire and Daubenmire 1968, Pfister et al. 1974) are of a rather general nature. In Management Implications by Habitat Type (Pfister 1971) prepared for the 1971 Habitat Type Training Session in Coeur d'Alene, Idaho, it is emphasized that the management implications are compiled from "... existing fragmentary data where available, observations, and general ecological relationships..." and that they are "... not the final word, but rather hypotheses which need testing and modification." Forest Habitat Types of Montana (Pfister et al. 1974) contains appendices of mean basal area, site index, mean maximum heights, and estimated yield capability of
Montana habitat types based on site index data and stockability factors. However, these tables contain many estimated figures and cannot be considered quantitatively definitive.

The need for more studies defining the relationship between habitat types and ecosystem variables is clear. Forest Service scientists conducting studies dealing with vegetation relationships are urged to report their results in terms of habitat types (Pfister 1971). In the following sections, some of these studies and their conclusions, if available, will be discussed. Included will be an assessment of some of the problems encountered in attempting to correlate various environmental measurements with habitat types. No attempt will be made to cover every possible area where correlations could be developed; only areas of active research will be considered.

Soils and Habitat Types

The relationship between vegetation and soils is not clear. Several authors believe that there is a definite correlation and urge that interpretation of soils and vegetation take place simultaneously (Poulton and Tisdale 1961, Robinson 1970, Mueller-Dombois 1964). Other workers maintain that the connection is not so obvious: "...grouping by soils materials tends to unite some closely related commu" (Whittaker 1962). Driscoll (1964) hypothesized that plants and soil should be closely related since they are the products of the same environmental factors (climate, organisms, relief, parent
material, and time). However, he found that on azonal soils factors genetically unrelated to soils, such as subsoil characteristics, were creating the difference in vegetation. Even on zonal soils, "... environmental factor interactions and compensations strongly influence the occurrence and dispersion of plant communities" (Driscoll 1964).

Daubenmire (1970) also noted the important factor compensation:

- Each plant association has a rather broad ecological amplitude regarding many soil properties (including most of the visible ones emphasized in soil classification), with a narrower amplitude of tolerance for others (e.g., fertility and the soil moisture regime). We must conclude that either the structure of vegetation is insensitive to many soil properties or that different combinations of soil properties add up to the same ecological sum.

In general, Daubenmire felt that there was no significant correlation between soils and vegetation. This was the case in eastern Washington and northern Idaho and also in a study of the steppe vegetation of Washington (Daubenmire 1970). Although the chemical character of soil material may not be important to vegetation in the northern Rocky Mountains (Daubenmire 1969), there "... is no universally applicable conclusion, except that the situation must be worked out independently in each area" (Daubenmire 1968).

As far as the Montana habitat types are concerned, there is as yet no basis for judgment (Arno, personal communication). There was no soils scientist in the Montana survey and correlations so far are on a very general level. Some land managers who have used the habitat type system in Montana feel that the relationship between the
types and soils is vague (Kellie, personal communication; Salmonson, personal communication). Certain critical soils may be tied to certain habitat types on a local scale and in these cases the habitat type will be particularly informative. Beaufait (personal communication) believes that soil will prove to be independent of habitat type. Several studies by the Soil Conservation Service in eastern Montana and by the Forest Service on the Custer National Forest (U.S.D.A. 1971) describe the soils in these areas and describe the vegetation associated with certain soils.

A study is being initiated in the Little Belt Mountains of Montana which may produce some concrete answers (Bryson 1975). The objectives of the study are to identify the habitat types in the Little Belt Mountains, to measure a predetermined set of soil characteristics, and to determine which soil factors demonstrate a significant influence in developing vegetation community complexes. The proposed study will last for two years and will include 60 sites.

It is apparent that at present there is no guide for land managers which relates soils to habitat type. However, this does not mean that important local correlations, which may become apparent by combining a thorough knowledge of local soils and habitat types, do not exist.

Fire Fuels and Habitat Types

The relationship between habitat types and fuels is just beginning to be defined. Habitat types may be applied to fire management
at two levels. The first is on a broad scale where generalizations are sufficient; the second is on a smaller scale of perhaps 100 acres. At this level an extrapolation of broad scale correlations could be quite inaccurate.

Fuels are a function of timber type and time, where time refers to both the stage of succession and to the age of the stand presently occupying the site. Since habitat type is not directly connected with any of these variables, direct correlation between fire behavior and habitat type may be crude and applications of the habitat type system to fuel management will be correspondingly broad. For example, an alpine fir/Xerophyllum tenax habitat type could include some stands consisting predominantly of lodgepole pine and others of mostly alpine fir. The various stands would have very different histories and mortality factors. A lodgepole pine stand in an AF/Xete habitat type could be quite dense and have high suppression mortality. The forces which generate these diverse situations seem to be random and independent of habitat type.

This does not imply that no correlations between fire factors and habitat type will be found. It is possible that in habitat types where grass and brush are the most important fuel certain correlations with fire may exist, since habitat type reflects moisture regimes which in turn affect the amounts of grass and brush produced. However,

13 The information in the first part of the section is taken from an interview with Dr. James Brown of the Northern Fire Laboratory.
grass and brush do not build up excessively; down woody material is the critical fuel.

Some very general statements may be made about the relationship between fuels and productivity in broad groups of types. In dry sites which are typically PP/Agsp, PP/Feid, DF/Agsp, etc., small amounts of fuels will be produced because of expected general low productivity. For a very large group of types in the middle range of productivity, a poor correlation with fuels will probably exist. In these types, what is on the ground depends on too many factors in addition to productivity. Upon reaching the high elevation types, productivity and fuel loads will decrease together.

A study devised by Dr. Brown is in progress which will change the conjectural nature of fire-habitat type relationships. For the past three years, Region I has been conducting a State I inventory which will ultimately include all forests in the Region. Certain fuel measurements which will provide the data bank for Brown's study are taken at each plot in this inventory. Information collected includes duff measurements, tallies of all twigs and branches less than three inches in diameter along a 6.8 foot transect, and tallies of all branches and logs greater than three inches in diameter along a 27.2 foot transect (Brown 1974). It will be possible to correlate fuels with all other plot information including slope, aspect, elevation, stand, age, timber type, and habitat type. The program which will process the data has not yet been written, so the minimum number of stands necessary in each habitat type has not been determined. The
initial breakdown will probably be on a national forest basis, although the scarcity of some habitat types will require the pooling of those types from several forests. In these cases, the relationship between fuels and habitat type may be obscured by the forest to forest variation within one type. Firm results should be available in about two years. Dr. Brown sees some danger in summarizing and distributing preliminary information; it may not be possible to correctly interpret it at the present time, and managers may base unwarranted conclusions upon it. Data from some forests are now being summarized by habitat type in terms of tons per acre of the various sized fuels.

Apparently the only other studies relating fuel loading and the role of fire to habitat types are investigations concerning the function of fire in wilderness conducted by Robert Mutch and associates of the Northern Fire Laboratory. The Whitecap Fire Study in the Selway-Bitterroot Wilderness in the Bitterroot National Forest included three years of sampling (1971-1973). The data were stratified by habitat type; Pfister's checklist was used and areas were keyed out to phase. The data, which have not yet been completely treated and summarized, go into the wilderness fire program developed by James Brown and others at the Fire Laboratory. One printout will give brush fuels for a certain habitat type by species in pounds per acre. Using another program, the fire model, developed by Frank Albini, habitat type can be correlated with rate of spread, flame height per

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14 Information on the Whitecap study was provided by Rick Oberheu of the Northern Fire Laboratory who participated in the study and is involved in analyzing the data.
minute at various wind speeds, Byram's intensity, and Van Wagner's crown scorch height (Oberheu, personal communication).

Mapping of the Whitecap area will not be by habitat type, but by Ecological Land Units (ELUs). The area contains five ELUs and 16 habitat types. The ELUs are less specific than habitat types and include, in the Whitecap area, shrubfields, Ponderosa pine savanna, Ponderosa pine-Douglas fir south slope communities, north slope communities, and subalpine communities. Management decisions will probably be based on ELUs.

Habitat types were abandoned as the basis for another wilderness fire study in the Teton Wilderness in Wyoming because they were unrepresentative of the cover types of the area (Oberheu 1975). A student of Daubenmire delineated two habitat types, spruce-fir/Vasc and SF/Cage, but the stratification finally chosen was four "stand classes": even-aged lodgepole pine, transition area, spruce-fir area, and burn. Each unit of land was felt to be very uniform. Differences in fuel loading and rate of spread were found between the stand classes, indicating that cover type rather than habitat type is more important in determining fire characteristics.

General opinion and the preliminary conclusions of these studies appear to suggest that correlations between fuels and habitat types will probably be of a general nature. Specific knowledge of cover type and mortality factors on the areas in question will be necessary.

Timber Productivity and Habitat Types

Prediction of the yield capacity of a site is one of the key
management implications of the habitat type system. At the time of the 1971 Training Session, evaluation of the productivity of various types was integrated into an estimated maximum potential productivity rating given in cubic feet per acre per year. Each type was rated on a scale of 1 (0 to 20 cu. ft./A/yr.) to 10 (200+ cu. ft./A/yr.) (Pfister 1971). In Forest Habitat Types of Montana, Pfister provided tables of the estimated yield capability of Montana habitat types based on site index data and stockability factors. Yield capability, given in cu. ft./A/yr., is divided into five classes: 0-20 (very low), 20-50 (low), 50-85 (moderate), 85-120 (high), and 120+ (very high). The types are indicated as broad bands, often spanning two complete yield capability classes and entering a third. The productivity rating is "... intended to serve as a foundation for development of future 'site-specific' management implications by users of the system and future research studies" (Pfister et al. 1974).

The shortcomings of the yield table method of estimating productivity are notorious; Pfister used it, as does everyone else, for lack of a better alternative. Yield tables were devised for fully stocked natural stands. However, very few natural stands achieve what is considered "full stocking," a term which is difficult to interpret. Moreover, yield capacity based on managed stand potential would be more meaningful than that based on natural stands. Regional site index curves, from which the yield tables are derived, are not avail-

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15 Yield capability equals the mean annual increment of growing stock attainable in fully stocked natural stands at the age of culmination of mean annual increment (Pfister et al. 1974).
able for many species. For example, site index-yield capability curves were hypothesized for Douglas fir and spruce (Pfister et al. 1974).

The potential productivity ratings of habitat types now available are applicable only on a large scale. When a more accurate estimate is needed, Pfister, et al. (1974) urged additional local sampling. On the district or even forest level, edaphic factors as well as habitat type must be taken into consideration when estimating site capability (Beaufait, personal communication).

More specific studies are obviously needed, especially in terms of potential plant biomass productivity, potential fiber productivity (cu. ft./A/yr.), and potential lumber productivity (bd. ft./A/yr.) (Pfister 1971). Potential tree biomass productivity is currently being examined in relation to the grand fir, western redcedar, and western hemlock habitat types of northern Idaho (Hanley 1975).

The objectives of this study are to

estimate the potential tree biomass productivity of the three Pachistima union habitat types from the gathering and evaluating of available literature and local measurement records . . . productivity differences related to site index, habitat type, and tree components will be determined insofar as the data permit (Hanley 1975).

The tree species which will be involved include western white pine, western larch, Douglas fir, grand fir, western hemlock, western redcedar, lodgepole pine, Englemann spruce, and alpine fir. No field work will be undertaken; productivity of selected stands will be estimated by calculating the difference between current tree biomass and projected future tree biomass. The initial results will be available in the summer of 1975.

The current guidelines for habitat type productivity are large
scale estimations. Managers can use them to rank the types in relation to each other and as rough indications of what a particular site might yield. However, local measurements are essential.

The Genetic Implications of Habitat Types

If vegetation is the expression of all integrated site factors, and if the sum of all site factors is relatively constant within one habitat type, then the plants which thrive in one geographic section of a habitat type should also do well in another area of that same type. Region I is applying this theory in the development of seed transfer zones. Habitat types are the basic unit for seed zones in the northern Rockies (Howe, personal communication). In northern Idaho there are five major seed zones; in Montana, seven.

There are no biological restrictions on exchanges between the same habitat type within 1000 foot higher or 2000 foot lower elevations within a seed transfer zone. Certain transfers must be approved by a certified silviculturist: (1) exchanges between different habitat types within a seed transfer zone, (2) exchanges in elevation exceeding 1000 feet up or 2000 feet down, and (3) exchanges of seed between border districts of two seed zones (Howe 1974).

The seed transfer zone program is needed because the present system, under which each ranger district collects its own seed, is cumbersome and inefficient. It is impossible for an individual district to maintain an inventory of all the habitat type-species-elevation combinations it may require (Howe 1974). The system is not yet implemented, but it is hoped that eventually all users of forest tree
seed will participate in the program.

At present, habitat types are only speculatively used to establish the boundaries of genetic populations (Howe, personal communication). Progeny and provenance tests are needed to determine the strength of the relationship between habitat types and genetic variation. One test of this nature was conducted on 24 populations of Rocky Mountain Douglas fir in order to assess the genetic variation in height at two years of age (Rehfeldt 1974). Four populations of seedlings represented each of six habitat types from western Montana, northern Idaho, and eastern Washington (DF/Pham and DF/Syal, DF/Caru, GF/Pamy, WRC/Pamy, WH/Pamy, and AF/Pamy). The study showed that the mean heights of seedlings from DF/Caru and AF/Pamy were significantly lower than those of seedlings from all the other habitat types. In general, the populations representing these habitat types were from the highest elevations. However, populations from two lower elevation AF/Pamy sites which grew in frost pockets had heights similar to those of the seedlings from the higher elevations. This suggests that the differentiation of the populations from the DF/Caru and AF/Pamy habitat types is a function of the cool environments found in those types.

Genetic variation could not be interpreted totally in terms of habitat types, however. Populations from northern Idaho and eastern Washington had significantly greater mean heights than those from western Montana, even if the DF/Caru and AF/Pamy populations were excluded. Apparently, the crests of the Bitterroot and Cabinet Moun-
tains divide the region into two areas of contrasting selective pressures.

According to Rehfeldt (1974), the "... definitions of large proportions of genetic variance for Rocky Mountain Douglas fir serve as a guide to forest management." The seed transfer zones are an example of this idea in action. Now that a significant amount of genetic variation has been shown to be attributable to habitat types, many possible uses of the connection between types and genetic variation suggest themselves. For example, habitat types may define the boundaries of populations which could be used in tree improvement programs. If increased tree height were the desired characteristic, geneticists will now realize that they should avoid breeding stock from DF/Caru and AF/Pamy habitat types but should instead concentrate on trees from other habitat types in northern Idaho and eastern Washington.

Wildlife and Habitat Types

The connection between wildlife and habitat type is in an observation stage (Beaufait, personal communication). There are a number of reasons why a rigorous relationship between animals and habitat may be difficult or impossible to define. Animals seem to slip among the interstices of the types: the ecotones, forest glades, streamsides, and alpine meadows. All these areas are ignored by the habitat type system, even though they may be most important to many animals. With wildlife perhaps even more so than with fire, the vegetation which is actually on the site is more important than the vege-
vation which that site may ultimately support. Often the scale which an animal relates to may not be comparable to the scale of habitat typing, especially if one considers animals other than deer and elk.

Many wildlife studies which purport to relate animal distribution, behavior, etc., to "habitat types" are in reality relating the animal variable to a loosely defined cover type. For example, a study in Maryland which correlated shrew distribution with habitat type actually used four cover types: Japanese larch, mature hardwood, scotch pine, and open area (Harman 1972). Hein (1970), in a study of grouse distribution, gave a thorough analysis of the vegetation including successional trends, and concluded that broods are restricted to late seral stages of xeric communities and are commonly found near the forest edge.

These wildlife studies appear to create a small scale, local set of "habitat types" expressly for use in the particular studies. An extensive investigation of the lonestar tick defined habitat types such as hay meadow, native prairie, ecotone (woods-prairie interface), opening in woods, and various tree types defined by the dominant species (Semtner 1971, 1973, 1974). These types did reflect tick density; in the prairie type there was a direct correlation between proximity of the sample to the ecotone and numbers of adult ticks.

The "habitat types" described above bear no relation to Daubenmire's habitat type system, but these studies serve as examples of possible approaches to the problem of relating wildlife to vegetation and of the sorts of vegetation wildlife associates with.
Investigations which have stratified data by Daubem\-mire's or Pfister's habitat types have enjoyed mixed success. Schmautz rated the 22 Idaho and Washington habitat types according to an estimation of their relative value as winter and summer big game range (Pfister et al. 1971). The value of a habitat type for big game winter range depends on (1) its potential to produce palatable forage during some part of the successional cycle and (2) the availability of that forage during the critical winter months. Therefore, the summer range rating is based primarily on estimated potential to produce palatable forage, while the winter rating is based on production adjusted for availability. A list of types whose forage production is improved by fire is included. The greatest value of Schmautz's analysis is indicating potentially valuable summer and winter range areas (Halvors-
son, personal communication). For example, the DF/Phma habitat type has the highest capacity for winter forage production, but the manager must know the location and characteristics of the particular winter range in question in order to accurately assess availability.

The only current, large scale investigation relating wildlife to habitat type is the Cooperative Elk-Logging Study which is being conducted by Region I, the Intermountain Forest and Range Experiment Station, the Montana Fish and Game Department, the Bureau of Land Management, and the School of Forestry at the University of Montana. The purpose of the study is "... to determine the influence of logging and road construction, together and individually, on the behavior, movement, harvesting, and survival of the Rocky Mountain Elk in
Montana (Lyon 1975). According to the 1974 Progress Report, moist sites are a very important component of elk summer range. Habitat types which are likely to include such areas are AF/Caca and AF(WBP)/Vasc in eastern Montana, and AF/Luhi-Mefe, AF/Clun, and AF/Mefe in western Montana. The report emphasizes that moist sites must be interspersed with other necessary habitat components including certain timber types, dry, broken, and open parks, and various other physical characteristics. Lyon (1975) recommended that the five critical types "... should be managed to maintain the overall integrity of the elk habitat..." in areas where they are "... appropriately interspersed with other requirements of Elk."

As with the forage productivity potential ratings of Daubenmire's habitat types, the recommendations and conclusions of the Elk-Logging Study are intended only as guidelines. The manager is warned that extrapolation may be hazardous, that the tentative conclusions may not apply to certain local situations, and that literal application must not be substituted for on-the-ground inspection (U.S.D.A. Forest Service 1974a). The study may continue indefinitely (Lyon, personal communication), so more results and conclusions can be expected.

The correlation between habitat types and wildlife is in an infant stage with an uncertain future. Some of the difficulties may be overcome by defining the successional stages which lead into each climax association. Or, with regard to wildlife, the types may continue to act merely as pointers to potentially valuable areas.
CHAPTER 7

THE USE OF HABITAT TYPE INFORMATION BY FEDERAL AND STATE AGENCIES

The preceding portion of the paper dealt with correlations between habitat types and environmental variables, especially in those areas which are the subject of current research. In the following sections, the applications of these correlations will be discussed.

The implications connected with certain habitat types are the essential part of the system for the land manager. To say an area is a PP/Agsp habitat type is meaningless unless it is also known that this habitat type is one of the driest types in the ponderosa pine series, that it is subject to relatively long periods of summer drought, that it is prone to steep slopes and erosion problems, that adequate regeneration after heavy cutting may take 20 to 30 years, and that potential for livestock forage is moderately high (Pfister et al. 1974). In order to put this and other habitat type-related knowledge to work, the land manager must first determine what habitat types he is working with. This necessitates some sort of systematic collection and compilation of habitat type information. Once habitat type information is available, the implications of the particular types must be integrated into management decisions. Hopefully, the results will be decisions of increased ecological validity.

The following information on the collection, compilation, and
integration of habitat type data is taken from interviews with personnel from the Forestry Division of the State Department of Natural Resources and Conservation, the Missoula Ranger District, the Lolo National Forest Supervisor's Office, and the Region I Regional Office of the Forest Service. 16

The Collection of Habitat Type Information

The initial step of determining the habitat type of an area is one of the most crucial in the process of utilizing habitat type data. The originators of the key to the Montana habitat types recommend using the field form specifically devised for taking habitat type plots (Arno, personal communication). The field form lists all the indicator species by scientific name and common name and gives the species abbreviation used in designating the types. Blanks for recording coverage classes, plot location, elevation, aspect, slope, topography, and configuration are provided. A completed field form includes the minimum amount of information necessary to determine the type (Arno, personal communication).

Once coverage classes for all indicator species in a plot have been determined, the habitat type can be keyed out using the key for the appropriate series. Pfister et al. (1974) listed several requirements for successful use of the habitat type key. Accurate identification and canopy coverage estimates for all indicator species are essential. To initiate use of the key, the user must identify

16 A list of people interviewed in this study is contained in Appendix 3.
the correct potential climax tree species. A tree species is considered to be reproducing successfully if data and observations indicate that at least 10 seedlings less than four inches d. b. h. per acre occupy or "will occupy" the site (Pfister et al. 1974). Once the correct series has been selected, the key should be followed literally. The key is only valid in stands with mature tree canopies which have not been severely disturbed. If a stand is severely disturbed, the habitat type should be extrapolated from the nearest mature stand with similar abiotic factors.

On the district level, habitat typing is integrated into routine inventories which provide the information necessary for stand prescriptions. On the Missoula District, the Stage II inventory crews have been habitat typing since 1968 when Daubenmire's types were published. As updated types for Montana were developed, these were adopted (Lund, personal communication). Stage II inventories are based upon stands which were identified from air photos. The crews take the habitat type for each stand. If there is a major break in type, the stand may be split into two parts. The Stage II crews on the Missoula District use a somewhat simplified version of Pfister's field form. It has space for 10 plots, which is about the number required for one stand.

This is a rather small scale, intense habitat typing of the sort

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17 The Forest Service definition of a stand is a homogeneous unit five acres or more in size.

18 The form was developed by Lyonal Hall of the Missoula District. The site factors such as elevation, etc., are not included.
which is necessary for project work. On the forest level a much larger scale and different methods are employed. The timber planning division of the Lolo National Forest, which was in charge of the Stage I inventory, hired a special habitat typer\(^\text{19}\) who worked both in conjunction with the crews and independently. The Stage I inventory is a special inventory instituted by Region I several years ago and habitat typing is an integral part of the inventory. Three to four forests are inventoried each summer; the field work on the Lolo was completed in 1974. The actual area inventoried on the Lolo consisted of 60 randomly selected units of approximately 250 acres each. As the units were sampled, one of Pfister's field forms was completed at each recognized type change, and a detailed habitat type map of the unit was prepared.

The forest habitat typer used habitat type information from the sample units, but depended most heavily on a series of road transects made of each Forest District (Bosworth, personal communication). The road transects included some off-road reconnaissance and several days were spent on horseback in the unroaded sections of Fish Creek. In the summer of 1975, poorly sampled areas will be surveyed more intensively and the habitat type map of the forest will be finalized.

The information on the forest habitat type map will be suitable for large scale, multiple use planning (Bosworth, personal communication; Kellie, personal communication). For specific projects,

\(^{19}\) The habitat typer for the Lolo Forest was Rick Ringleb.
such as thinnings and cuttings, the forester involved will have to collect more detailed habitat type data for the forest silviculturist (Kellie, personal communication). At least one other division in the Supervisor's Office, that in charge of wildlife, occasionally collect their own habitat type information using the standard field form and key (Halvorson, personal communication).

The Forestry Division of the State Department of Natural Resources and Conservation is also utilizing habitat type data. Their collection methods are less formalized than those of the Forest Service (Salmonson, personal communication). If Forest Service information is available, it is used; if not, habitat types are determined wherever silvicultural treatments are planned. Field forms are not used except in a habitat type survey. Any comprehensive program of habitat typing state lands would be difficult because they are widely scattered. The Swan State Forest has been typed using a combination of air photos, road transects, and off-road hiking.

To successfully collect habitat type data requires a certain amount of training and knowledge. First, it is necessary to understand some of the concepts of the system, especially the idea that habitat types represent the biological potential of the land. If an inexperienced worker is typing a lodgepole pine stand and finds an alpine fir seedling every two chains, he will find it easy to ignore the seedlings completely unless he has a basic understanding of succession and the importance of the climax association. The habitat typer must also be able to identify the 63 indicator species and make ac-
curate coverage estimates.

The largest pool of trained users of the system has been created by a series of annual training sessions which began in 1971. They are run by Pfister and his associates and have a minimum annual attendance of 60 (Arno, personal communication). The majority of those attending are Forest Service employees, but there are also representatives of the BIA, BLM, State Forestry Division, and private industry. In 1975 the Forestry School of the University of Montana is handling the enrollment, which is becoming more diverse. In 1974 about eight employees from the State Forestry Division and six from the Missoula Ranger District attended the training session (Salmonson, personal communication; Lund personal communication). There is also a three-credit course in habitat typing at the University of Montana which has been offered for three years and which is attended by both agency personnel and students.

Those who have completed the training session or are familiar with habitat typing through previous experience train the temporary summer employees who do most of the actual habitat typing on federal land. Difficulties are encountered while attempting to effectively train a number of people with widely diverse backgrounds as habitat typers in a short period of time. Salmonson (personal communication) believes that a certain amount of previous study and one week of field work are necessary to learn the system. On the Missoula District, temporary workers are exposed to one day of theory and plant identification in the office and four to five days in the field (Lund,}

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personal communication). During the two-week training session for the Stage I inventory crew on the Lolo National Forest, crew members were exposed to approximately a day of background, theory, and an indicator species slide show. Dried indicator specimens were available the entire time. One intensive field day was spent learning the species and practicing coverage estimation; numerous plant quizzes and exercises were given on subsequent days. Depending on the background of the individual, acquiring habitat typing skills may require the assimilation of a large amount of information in a short length of time.

The Compilation of Habitat Type Data

At this rather early stage in the use of habitat types as management tools, some managers habitat type an area only for a specific and temporary purpose such as laying out a timber sale. However, since habitat types are, in the absence of catastrophic events and in a human time scale, immutable, it would be desirable to keep a permanent record of habitat types.

The most efficient way to do this is through mapping. Daubenmire (1968) is a strong defender of using habitat types as a basis for mapping nonarable land: "The oft-repeated comment that different bases for mapping are needed for different purposes would have little truth if mapping were done on a fundamental basis protraying habitat types plus successional stages." Habitat type maps have enduring value and, when combined with an understanding of successional stages, indicate past history, present condition, and expected trends.
Cover type maps are not interpretive, only descriptive, and soon become outdated (Daubenmire 1968).

When mapping habitat types, various degrees of scale and accuracy are acceptable depending on the uses to which the information will be put. At a detailed level for research and project planning, an appropriate scale might be 4 inches to 8 inches to the mile. Habitat type or phase would be used and only small inclusions of other types would be accepted (Pfister et al. 1974). On a broader level, such as for multiple use planning units on national forests, the scale might range from \( \frac{1}{2} \) to 2 inches to the mile, and more inclusions would be permissible. The management implications of the various types should also be considered during mapping:

Where implications for management are similar, it may be desirable to consider an entire series (PP, DF) as one group. If management considerations contrast, even at phase level (DF/Caru), it may be desirable to split the habitat type in the grouping process (Pfister et al. 1974).

Approaches to mapping are quite variable among agencies and levels of agencies. The State Forestry Division regards mapping as an ideal future goal for which there is neither personnel nor funding at the present time. The map of the Swan State Forest which is being compiled is not yet finished (Salmonson, personal communication). The minimum area of habitat types now recognized on state lands is variable, but five acres is considered desirable. The Missoula Ranger District of the Lolo National Forest has no separate mapping program for habitat types, nor has a minimum area formally been established. Stand boundaries used in the Stage II inventories may be
altered due to obvious radical discontinuities in habitat type.
Since five acres is the minimum stand size recognized, this can be
considered the minimum area for habitat typing. However, it is not
likely that a ten acre stand will be broken in two parts (Lund, per-
sonal communication).

The map being finalized in conjunction with the Stage I inven-
tory will be the master habitat type map for the Lolo National Forest
The minimum area recognized was approximately 25 acres, although no
precise number was predetermined. More field work and comparisons
with air photos will be needed to complete the map. This timber in-
ventory is generating two other kinds of maps as well with which the
habitat type map will ultimately be combined. One set is based on
photo interpretation (PI) types. The PI types were taken from one
inch to the mile air photos and are based on texture, stocking, height,
and number of stories in the stand. The minimum size of these div-
isions is ten acres. The second set of maps is based upon land use
areas: water, nonforest land, productive forest land, and non-pro-
ductive forest land. Each of these broad classes is divided into
numerous components (U.S.D.A. Forest Service 1974b). The PI type
and land use classification maps will be combined to identify the
stands; there will be about 20,000 for the entire Lolo Forest. At
this point the habitat type map will be applied as an overlay or
through comparison of areas from the habitat type map (Bosworth, per-
sonal communication). If habitat type splits a stand determined by
PI type and land use classification the stand may be divided again
if the types are quite different.
Application of Habitat Type Information to Management Situations

The first problem confronting the land manager who attempts to consider habitat type information in making decisions is pulling together all the pertinent implications into a coherent and comprehensible form (Kellie, personal communication). The guide currently used in Region I, Management Implications by Habitat Type (Pfister 1971), is based on the 22 Daubenmire types, so that it is not always directly applicable in Montana. Pfister's 1974 types are more numerous and detailed. Implications are suggested in the descriptions of each type, but it is hard to draw all this information together. A series of interviews with land managers revealed that habitat type information is considered to be quite important in some areas, of potential but unknown value in others, and inapplicable in yet others.

Fuels and fire management fall into the category of possible potential value. Kellie (personal communication) feels it will be necessary to wait for the results of Brown's study before applying habitat type information to fuels management. Lund (personal communication) noted that fire frequency was lower in certain moist types such as AF/Mefe. This fact can be used to allocate funds for slash disposal; in wetter types, slash removal need not be as thorough as in drier types with a higher fire frequency. Thus, if the manager must take chances with slash disposal because of lack of funds, habitat types can be used to identify low hazard areas (Lund, personal communication).

It is in fields related to silviculture that managers feel the greatest possibilities for the use of habitat type information lie.
(Beaufait, personal communication; Kellie, personal communication). Growth and yield is an area of untapped potential. Using a few comparisons from stand examinations, site indexes similar to those documented by Pfister have been found on the Lolo, though this subject needs more investigation at a local level (Kellie, personal communication). On the Missoula District, Pfister's productivity figures tend to be somewhat lower than those the district usually uses. Habitat types have not yet been applied to thinning procedures (Lund, personal communication).

Habitat type correlations are currently used mostly in connection with harvest and regeneration techniques (Kellie, personal communication). For example, dry sites such as DF/Xete would require seedtree or shelterwood cuts instead of clearcuts. According to Salmonson (personal communication), even more severe sites, such as PP/Agsp, may be excluded from inventories or put on a longer rotation. Less money may be invested in reforestation on such sites and they will probably be separated when determining annual allowable cut. Higher elevation zones, which are now included in the timber base in some areas, will also be excluded. The point was made that the manager must consider the silvicultural needs of each species and recognize the critical environmental factors in each area (Kellie, personal communication).

During the analysis of the data from the 60 sample units of the Stage I timber inventory, habitat type data were used in several ways. When each plot sheet from the inventory was inspected to select crop trees, habitat type was one of the criteria. Preferred speci-
lies for management in each habitat type were emphasized (Bosworth, personal communication). A prescription for each stand in the 60 sample units will ultimately be written and habitat type will be a consideration. Pfister's recommendations will be used along with any others provided by the Lolo. And, as discussed in the mapping section, habitat type will be used to some extent to delimit stands on the final forest map. The prescriptions for the sample stands and the map information will be extrapolated to form the basis for the timber management plan for the whole forest.

Habitat types are also becoming an integral part of the paperwork which surrounds all silvicultural treatments. The Montana Environmental Protection Act requires an environmental impact statement for each timber sale on state land and a description of the habitat type is always included (Salmonson, personal communication). In the Silvicultural Description and Prescription Form, the habitat type of each project area must be included and "potential for low shrubs or grass to occupy the site following mechanical disturbance of fire (based on habitat type and observation). . . " must be estimated.

Wildlife managers are not making extensive use of habitat type information, but they feel a potential for certain correlations may exist (Lyon, personal communication; Halvorson, personal communication). In defining key big game winter range, Region I criteria, which do not include habitat type, are used, but the mapping results

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20 Formulated by Roger Lund, silviculturist for the Missoula Ranger District.
may be compared with habitat type boundaries. Halvorson (personal communication) feels that when relating habitat types to wildlife, a local scale, such as a single national forest, must be used. For example, DF/Phma habitat type happens to be key winter range and also of large extent on the Lolo.

Another example of how habitat type can point out areas as potential value for wildlife is the hypothetical case of a timber sale proposal. If the wildlife manager had no knowledge of the specific area but knew the habitat type, which suggested prime elk summer range, this would be an indication to investigate the situation further (Halvorson, personal communication). This is the type of correlation generated so far in the elk-logging study.

Apparently not much use is being made of implications for range management. Range personnel on the Missoula District are not using the habitat type system (Lund, personal communication). Salmonson feels that habitat type does not allow many predictions of range value at the present time.

These examples of integrating habitat type information into management procedures are certainly not exhaustive, but they are representative. Other forests may emphasize different correlations or make specific local connections between environmental variables and habitat type.
Chapter 8

Critique of the Habitat Type System

Daubenmire's and Pfister's vegetation classification systems were designed to be used in the field by land managers as an aid in making ecologically sound decisions, and it is on this basis that they should be judged. The basic problem in vegetation science "... remains in the interpretation of the results and particularly in relating results of vegetation analysis to the environment" (McIntosh 1967). Habitat types supposedly have a very direct, even predictive, relationship with many variables. The only way to substantiate or refute this alleged connection is by performing detailed correlation studies and by using the results of these studies as a basis for management decisions. If decisions so based produce "better" results than those made previously, then the habitat type system has fulfilled its objective.

At this early stage of habitat type use, various habitat type-related studies are just beginning to produce results, but it will be impossible to analyze the outcomes of management decisions based partly on habitat type information for some time to come. Some correlation studies have shown enough connection between habitat types and such key variables as genetic variability and timber productivity to suggest the worth of the system. However, even though it is

21 "Better" as used here implies anything that is less destructive to the flows and patterns of nature.

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too early to observe the results of any management decisions, the system has been in use long enough for several weak points and tendencies toward misuse to become apparent.

There are certain areas of management where actuality cannot be related to the potential to a sufficient degree to give habitat types much predictive value. Fire management is one example of this situation. The correlations which now exist between habitat types and fire management appear to be quite general. It seems likely that a large measure of specific knowledge of mortality factors, cover type, and stand history will have to be used in conjunction with habitat type.

A similar situation exists in relation to animals. It is possible that habitat type will never be able to stand alone in any correlation between wildlife and environment (Lyon, personal communication). There are too many variables operating in wildlife habitat that habitat types ignore. For example, high elevation meadows with high water tables are not described by any type (Halvorson, personal communication). Similarly, the habitats of such animals as the mountain goat and pika are not adequately covered by the habitat type system. Timberline was difficult to classify; under very severe conditions, "climax" relationships are frequently unclear (Pfister et al. 1974). The Montana habitat type investigators described what was at timberline in three rather broad types and essentially concluded that any species that could grow there was a potential climax species (Arno, personal communication). For most management questions re-
garding timberline habitat types, this information is sufficient, but as a basis for deducing concrete relations between habitat type and wildlife, it is not enough.

Another reason for the difficulty in correlating wildlife and vegetation is the possibility that certain animals, such as small birds, may be more affected by the structure of the vegetation than by the actual species (Lyon, personal communication). That is to say, several species could provide food and cover and, if any of these were present, the habitat would be acceptable to the animal.

Halvorson (personal communication) does not believe that the problem of relating seral species to the climax association is insurmountable. He feels we have some understanding of successional patterns for climax types and will come to know the potential of habitat types in relation to both seral and climax animals.

Recreation may be another realm where so many variables are operating that it is hard to make a durable connection with habitat type (Lund, personal communication). An exception to this would be spectacularly scenic alpine areas, but in general it is difficult to say what peoples' preferences will be. Also, modes of recreation are very diverse and can be carried out in many different habitat types. One possible relationship useful in determining carrying capacity would be durability of the soils, but this correlation would probably only be valid on a local scale (Lund, personal communication).

Some of the gaps in the habitat type system, areas not covered by any type, have already been discussed in relation to wildlife. Other vegetation not touched upon by the system includes Juniper wood-
lands, aspen groves, and bottom lands (Arno, personal communication). Juniper woodlands are rare, occurring only near Butte and Drummond. The aspen grove and bottom land communities, however, would be useful types to have. The aspen groves have aesthetic and wildlife value, but they do not occupy a large area and would require more analysis to define. Bottom lands are difficult to classify under the habitat type system since there is usually severe human disturbance and periodic flooding (Arno, personal communication).

A large set of problems associated with habitat typing is due not to any inherent deficiency in the system but rather to the methods of training habitat typers. When habitat types were first introduced, quality control was a serious problem; people were often sent out with little or no training (Arno, personal communication). Training is much better now, but many workers are sent into the field with inadequate skills. The Missoula District found that a large part of the summer would be over before an inexperienced typer became proficient (Lund, personal communication). After the field form and the indicator species have become familiar, habitat typing can be interesting and challenging; but until this facility is attained, it is a slow and frustrating process. It is very easy to miss sparse seedlings or inconspicuous indicator species such as Clintonia. Looking at the ground consistently is an alien action for most people who work in the woods. Without accurate initial typing, of course, the entire system falls apart. A partial solution might be to develop a habitat typing certification similar to cruising or scaling certifications.
This would allow credit to be given for habitat typing knowledge in the rehiring process (Lund, personal communication).

There are additional field problems unrelated to the expertise of the typer. There are always transition zones and microhabitats which do not fit the type (Salmonson, personal communication; Lund, personal communication). Daubenmire (1942) acknowledged this situation:

There was the inevitable problem of drawing a line where in the field a transition is encountered. In places the lines boundaries of the vegetation types, which are intended to pass through the middle of ecotones, may err as much as 10 km.

In a more recent publication (1974), Daubenmire recommended that map boundaries be drawn in the center of narrow ecotones only. In the case of broad ecotones, the entire extent should be mapped.

Seasonal changes in the indicator species are also sometimes confusing. In addition, State II inventories, which include habitat typing, may sometimes be done in fall and winter, making habitat typing impossible (Lund, personal communication).

In order to use the management implications of the habitat types correctly, correlations must be localized (Beaufait, personal communication). Crews on the national forests must find suitable stands, measure height and age for site index, and then identify soils and habitat type. This will establish a solid local correlation between habitat type and productivity. It is really not possible to make blanket statements about the productivity or other characteristics of a habitat type over its whole range. For example, Pfister
et al. (1974) provides two separate tables for the yield capability of the habitat types, one for the Kootenai, Flathead, Lolo, and Bitterroot National Forests, the other for the Deerlodge, Beaverhead, Helena, Lewis and Clark, Gallatin, and Custer National Forests. Only two or three of the types which appeared in both of the tables had identical yield capacity ratings in both cases. Productivity estimates related to Daubenmire’s types were applied to the same habitat types on the Lolo with implausible results (Lund, personal communication). Either the habitat typing or the productivity of a habitat type is different from one end of its range to the other.

In the descriptions of the types, Pfister et al. (1974) often made different recommendations for management for areas east and west of the Continental Divide. For example, west of the Divide the DF/Spbe habitat type should be managed as is DF/Syal, while east of the Divide it should be grouped with DF/Aruv, DF/Arco, and DF/Juco.

The above instances of variation within types point out the dangers of excessive extrapolation and overdependence on habitat types. Habitat types are not the answer to every management problem and will probably be the total answer to none. Especially at this time, because of the tentative nature of the correlations and recommendations related to habitat types, they must be used judiciously.
CHAPTER 9

CONCLUSIONS AND THOUGHTS ON THE FUTURE POTENTIAL OF HABITAT TYPES

The use of habitat types has brought with it several intangible benefits which will increase in the future. The habitat type system forces foresters and land managers in general to be more observant and more aware of what they are working with as an entity, not just the trees or forage. Another often repeated function of the habitat type system is to serve as a framework for current knowledge and future research. This role is in a primitive stage of development, as has been documented, but it has immense potential. Already there is a problem of compiling and organizing all the management implications for the various types, due to the rapidly accumulating volume of information (Kellie, personal communication). Habitat types also provide a common means of identifying a particular plant association, thus making communication easier.

Most managers feel they are merely scratching the surface of habitat type potential. Developing specific local correlations of "calibrating" the types for a particular forest or district is a common goal (Beaufait, personal communication; Lund, personal communication). The future may see such refinements as using phases and developing lists of species which are adaptable to each habitat type (Kellie, personal communication). On the Lolo there is a project attempting to relate habitat type to woodpeckers. Hopefully, it will be expanded to other animals (Halvorson, personal communication).
The State Forestry Division hopes to train more people and habitat type all state lands as funds become available. An inventory beginning in 1976 in the eastern part of the state will include habitat typing (Salmonson, personal communication).

In the future habitat type input into decision making will probably increase, either independently or as part of the Ecoclass System. The present vagueness of many habitat type-environment correlations is recognized. Until these relationships are clarified, habitat types must be used conservatively as a guide to areas of potential value or fragility. "This is a subjective classification and as such should always remain open to future refinement" (Pfister et al. 1974).
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### List of Species Mentioned in Text

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**Trees**

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</thead>
<tbody>
<tr>
<td>Agropyron spicatum</td>
<td>blue-bunch wheatgrass</td>
</tr>
<tr>
<td>Bromus tectorum</td>
<td>cheatgrass</td>
</tr>
<tr>
<td>Calamagrostis canadensis</td>
<td>bluejoint</td>
</tr>
<tr>
<td>Carex eyrei</td>
<td>elkseedge</td>
</tr>
<tr>
<td>Festuca idahoensis</td>
<td>Idaho fescue</td>
</tr>
<tr>
<td>Luzula hitchcockii</td>
<td>woodrush</td>
</tr>
</tbody>
</table>

**Herbs**

<table>
<thead>
<tr>
<th>Latin Name</th>
<th>Common Name</th>
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</thead>
<tbody>
<tr>
<td>Arnica cordifolia</td>
<td>heartleaf arnica</td>
</tr>
<tr>
<td>Clintonia uniflora</td>
<td>queencup beedlilly</td>
</tr>
<tr>
<td>Pachistima myrsinites</td>
<td>mountain lover</td>
</tr>
<tr>
<td>Xerophyllum tenax</td>
<td>beargrass</td>
</tr>
</tbody>
</table>

**Grasses and Grass-Like plants**

<table>
<thead>
<tr>
<th>Latin Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arctostaphylos uva-ursi</td>
<td>kinnikinnic</td>
</tr>
<tr>
<td>Artemisia tridentata</td>
<td>big sagebrush</td>
</tr>
<tr>
<td>Juniperus communis</td>
<td>common juniper</td>
</tr>
<tr>
<td>Menziesia ferruginea</td>
<td>menziesia</td>
</tr>
<tr>
<td>Physocarpus malvaceus</td>
<td>ninebark</td>
</tr>
<tr>
<td>Spiraea betulifolia</td>
<td>white spiraea</td>
</tr>
<tr>
<td>Symphoricarpus albus</td>
<td>snowberry</td>
</tr>
<tr>
<td>Vaccinium scoparium</td>
<td>grouse whortleberry</td>
</tr>
</tbody>
</table>

---

22 Nomenclature follows Hitchcock and Cronquist (1973).
# LIST OF MONTANA FOREST HABITAT TYPES

## Habitat types and phases

### SCREE

#### Pinus flexilis climax series

- **Pinus flexilis**/Agropyron spicatum h.t.
- **Pinus flexilis**/Festuca idahoensis h.t.
  - Festuca idahoensis phase
  - Festuca scabra phase
- **Pinus flexilis**/Juniperus communis h.t.

#### Pinus ponderosa climax series

- **Pinus ponderosa**/Agropyron spicatum h.t.
- **Pinus ponderosa**/Festuca idahoensis h.t.
  - Festuca idahoensis phase
  - Festuca scabra phase
- **Pinus ponderosa**/Purshia tridentata h.t.
  - Agropyron spicatum phase
  - Festuca idahoensis phase
- **Pinus ponderosa**/Symphoricarpos albus h.t.
  - Symphoricarpos albus phase
  - Berberis repens phase
- **Pinus ponderosa**/Prunus virginiana h.t.
  - Prunus virginiana phase
  - Shepherdia canadensis phase

#### Pseudotsuga menziesii climax series

- **Pseudotsuga menziesii**/Agropyron spicatum h.t.
- **Pseudotsuga menziesii**/Festuca idahoensis h.t.
- **Pseudotsuga menziesii**/Festuca scabra phase
- **Pseudotsuga menziesii**/Vaccinium caespitosum h.t.
- **Pseudotsuga menziesii**/Physocarpus malvaceus h.t.
  - Physocarpus malvaceus phase
  - Calamagrostis rubescens phase
- **Pseudotsuga menziesii**/Xerophyllum tenax h.t.
  - Vaccinium globulare phase
  - Arctostaphylos uva-ursi phase
- **Pseudotsuga menziesii**/Vaccinium globulare h.t.
  - Vaccinium globulare phase
  - Arctostaphylos uva-ursi phase

### Abbreviations

<table>
<thead>
<tr>
<th>SCREE</th>
<th>PP/Agsp h.t.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PF/Feid h.t.</td>
</tr>
<tr>
<td></td>
<td>Feld phase</td>
</tr>
<tr>
<td></td>
<td>Fesc phase</td>
</tr>
<tr>
<td></td>
<td>PF/Juco h.t.</td>
</tr>
<tr>
<td></td>
<td>Agsp phase</td>
</tr>
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<td>Feld phase</td>
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<tr>
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<td>PP/Prvi h.t.</td>
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<td></td>
<td>Prvi phase</td>
</tr>
<tr>
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<td>Shca phase</td>
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</table>

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23 From Forest Habitat Types of Montana, pp. 19 and 20.
<table>
<thead>
<tr>
<th>Sequence</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudotsuga menziesii/Linnaea borealis h.t.</td>
<td>DF/Libo h.t.</td>
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<tr>
<td>Symphoricarpos albus phase</td>
<td>Syal phase</td>
</tr>
<tr>
<td>Calamagrostis rubescens phase</td>
<td>Caru phase</td>
</tr>
<tr>
<td>Pseudotsuga menziesii/Symphoricarpos albus h.t.</td>
<td>DF/Syal h.t.</td>
</tr>
<tr>
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<td>Asp phase</td>
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<td>Calamagrostis rubescens phase</td>
<td>Caru phase</td>
</tr>
<tr>
<td>Symphoricarpos albus phase</td>
<td>Syal phase</td>
</tr>
<tr>
<td>Pseudotsuga menziesii/Calamagrostis rubescens h.t.</td>
<td>DF/Caru h.t.</td>
</tr>
<tr>
<td>Agropyron spicatum phase</td>
<td>Asp phase</td>
</tr>
<tr>
<td>Arctostaphylos uva-ursi phase</td>
<td>Aruv phase</td>
</tr>
<tr>
<td>Calamagrostis rubescens phase</td>
<td>Caru phase</td>
</tr>
<tr>
<td>Pseudotsuga menziesii/Carex geyeri h.t.</td>
<td>DF/Cage h.t.</td>
</tr>
<tr>
<td>Pseudotsuga menziesii/Spiraea betulifolia</td>
<td>DF/Spbe h.t.</td>
</tr>
<tr>
<td>Pseudotsuga menziesii/Arctostaphylos uva-ursi h.t.</td>
<td>DF/Aruv h.t.</td>
</tr>
<tr>
<td>Pseudotsuga menziesii/Juniperus communis h.t.</td>
<td>DF/Juco h.t.</td>
</tr>
<tr>
<td>Pseudotsuga menziesii/Arctostaphylos uva-ursi h.t.</td>
<td>DF/Arco h.t.</td>
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<tr>
<td>Picea climax series</td>
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</tr>
<tr>
<td>Picea/Equisetum arvense h.t.</td>
<td>S/Eqar h.t.</td>
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<tr>
<td>Picea/Clintonia uniflora h.t.</td>
<td>S/Clun h.t.</td>
</tr>
<tr>
<td>Vaccinium caespitosum phase</td>
<td>Vaca phase</td>
</tr>
<tr>
<td>Clintonia uniflora phase</td>
<td>Clun phase</td>
</tr>
<tr>
<td>Picea/Physocarpus malvaceus h.t.</td>
<td>S/Phna h.t.</td>
</tr>
<tr>
<td>Picea/Galium triflorum h.t.</td>
<td>S/Gatr h.t.</td>
</tr>
<tr>
<td>Picea/Vaccinium caespitosum h.t.</td>
<td>S/Vaca h.t.</td>
</tr>
<tr>
<td>Picea/Senecio streptanthifolius h.t.</td>
<td>S/Sest h.t.</td>
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<td>Pseudotsuga phase</td>
<td>DF phase</td>
</tr>
<tr>
<td>Picea phase</td>
<td>S phase</td>
</tr>
<tr>
<td>Picea/Linnaea borealis h.t.</td>
<td>S/Libo h.t.</td>
</tr>
<tr>
<td>Picea/Smilacina stellata h.t.</td>
<td>S/Smst h.t.</td>
</tr>
<tr>
<td>Abies grandis climax series</td>
<td></td>
</tr>
<tr>
<td>Abies grandis/Xerophyllum tenax h.t.</td>
<td>GF/Xete h.t.</td>
</tr>
<tr>
<td>Abies grandis/Clintonia uniflora h.t.</td>
<td>GF/Clun h.t.</td>
</tr>
<tr>
<td>Clintonia uniflora phase</td>
<td>Clun phase</td>
</tr>
<tr>
<td>Aralia nudicaulis phase</td>
<td>Arnu phase</td>
</tr>
<tr>
<td>Thuja plicata climax series</td>
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</tr>
<tr>
<td>Thuja plicata/Clintonia uniflora h.t.</td>
<td>WRC/Clun h.t.</td>
</tr>
<tr>
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<td>Clun phase</td>
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<tr>
<td>Aralia nudicaulis phase</td>
<td>Arnu phase</td>
</tr>
<tr>
<td>Menziesia ferruginea phase</td>
<td>Mefe phase</td>
</tr>
<tr>
<td>Thuja plicata/Oplopanax horridum h.t.</td>
<td>WRC/Opho h.t.</td>
</tr>
<tr>
<td>Tsuga heterophylla climax series</td>
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</tr>
<tr>
<td>Tsuga heterophylla/Clintonia uniflora h.t.</td>
<td>WH/Clun h.t.</td>
</tr>
<tr>
<td>Clintonia uniflora phase</td>
<td>Clun phase</td>
</tr>
<tr>
<td>Aralia nudicaulis phase</td>
<td>Arnu phase</td>
</tr>
</tbody>
</table>
Abies lasiocarpa climax series

Abies lasiocarpa/Oplepanax horridum h.t.  AF/Opho h.t.
Abies lasiocarpa/Clinotia uniflora h.t.  AF/Clun h.t.
Clinotia uniflora phase  Clun phase
Aralia nudicaulis phase  Arnu phase
Vaccinium caespitosum phase  Vaca phase
Xerophyllum tenax phase  Xete phase
Menziesia ferruginea phase  Mefe phase
Abies lasiocarpa/Galium triflorum h.t.  AF/Gatr h.t.
Galium triflorum phase  Gatr phase
Calamagrostis canadensis phase  Caça phase
Abies lasiocarpa/Vaccinium caespitosum h.t.  AF/Vaca h.t.
Vaccinium caespitosum phase  Vaca phase
Calamagrostis canadensis phase  Caça phase
Abies lasiocarpa/Calamagrostis canadensis h.t.  AF/Caca h.t.
Abies lasiocarpa/Linnaea borealis h.t.  AF/Libo h.t.
Linnaea borealis phase  Libo phase
Xerophyllum tenax phase  Xete phase
Vaccinium scoparium phase  Vasc phase
Abies lasiocarpa/Tsuga mertensiana phase  Mefe phase
Tsuga mertensiana/helenia ferruginea h.t.  AF/Mefe h.t.
Abies lasiocarpa/Xerophyllum tenax h.t.  AF/Xete h.t.
Vaccinium globulare phase  Vagl phase
Vaccinium scoparium phase  Vasc phase
Tsuga mertensiana/Xerophyllum tenax h.t.  MHI/Xete h.t.
Abies lasiocarpa/Vaccinium globulare h.t.  AF/Vagl h.t.
Abies lasiocarpa/Vaccinium scoparium h.t.  AF/Vasc h.t.
Calamagrostis rubescens phase  Caru phase
Vaccinium scoparium phase  Vasc phase
Thalictrum occidentale phase  Thoc phase
Abies lasiocarpa/Calamagrostis rubescens h.t.  AF/Caru h.t.
Abies lasiocarpa/Clematis pseudoalpina h.t.  AF/Clps h.t.
Abies lasiocarpa/Arnica cordifolia h.t.  AF/Arco h.t.

SUBALPINE H.T.s

Abies lasiocarpa (Pinus albicaulis)/Vaccinium scoparium h.t.  AF(WBP)/Vasc h.t.
Abies lasiocarpa/Luzula hitchcockii h.t.  AF/Luhi h.t.
Vaccinium scoparium phase  Vasc phase
Menziesia ferruginea phase  Mefe phase
Pinus albicaulis-Abies lasiocarpa h.t.  WBP-AF h.t.
Larix lyallii-Abies lasiocarpa h.t.  AL-AF h.t.
Pinus albicaulis h.t.  WBF h.t.

Pinus contorta climax series

Pinus contorta/Pushia tridentata h.t.  LPP/Futr h.t.
Pinus contorta/Vaccinium caespitosum c.t.  LPP/Vaca c.t.
Pinus contorta/Linnaea borealis c.t.  LPP/Libo c.t.
Pinus contorta/Vaccinium scoparium c.t.  LPP/Vasc c.t.
Pinus contorta/Calamagrostis rubescens c.t.  LPP/Caru c.t.
PERSONAL COMMUNICATORS


L. Jack Lyon. Intermountain Forest and Range Experiment Station, Forestry Sciences Laboratory, U.S.F.S., Missoula, Montana.


Earl Salmonson. Chief, Forest Management Bureau, State Department of Natural Resources and Conservation, Forestry Division, Missoula, Montana.