Toward the development of a vegetation classification system designed to aid in the maintenance of native biodiversity in Montana and Idaho

Jennifer Lynn Ferenstein

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TOWARD THE DEVELOPMENT OF A VEGETATION CLASSIFICATION
SYSTEM DESIGNED TO AID IN THE MAINTENANCE OF NATIVE
BIODIVERSITY IN MONTANA AND IDAHO

by
Jennifer Lynn Ferenstein
B.A., Reed College, 1988

presented in partial fulfillment of the requirements
for the degree of
Master of Science
University of Montana
1994

Approved by:

Mary H. O'Brien
Chairperson

Dean, Graduate School

Date
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I want to sincerely thank all of the people who took the time to talk with me. Without the valuable information they provided, this professional paper would not have been completed. Thanks to my committee members: Paul Alaback, Mary O'Brien, and Dan Pletscher for all of their patience and input. Thanks also to Derek Craighead of the Craighead Wildlife-Wildlands Institute for his support and advice.
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CHAPTER 1
INTRODUCTION

Biodiversity is no frill - it is life and all that sustains life.
-Noss (1991)

The Struggle to Maintain Native Biodiversity

The variety and variability of living organisms that inhabit the earth and the processes necessary to sustain these life forms are collectively referred to as biological diversity (biodiversity) (U.S. Congress, 1987). Many within the scientific and conservation community believe we are in the midst of a biodiversity crisis. Habitat destruction (physical reduction and chemical contamination of suitable habitat), over-exploitation (e.g., hunting, fishing, pet trade, trapping), and introduction of non-native species have all contributed to the simplification of ecosystems and the extinction of species at an unprecedented rate. A 1987 federal report stated the sobering reality that, "Natural ecosystem diversity has declined in the United States historically, and no evidence suggests that this long-term trend has been arrested." The report continues, "Twenty-three ecosystem types that once covered about half the conterminous United States now cover only about 7 percent." (U.S. Congress, 1987, p.66).

No one knows the magnitude of the crisis, but as E.O. Wilson (1992) a noted biologist explains:

Biologists cannot tell in absolute terms because we do not know to the nearest order of magnitude how many species exist on earth in the first place. Probably fewer than 10 percent have even been given a scientific name.
We cannot estimate the percentage of species going extinct each year around the world in most habitats, including coral reefs, deserts, and alpine meadows because the requisite studies have not been made. (p.255).

Although the loss of biodiversity has been acknowledged as an important issue for many years, it is only recently that we have come to recognize the inherent difficulties associated with trying to preserve native biodiversity.

Our incomplete understanding of the severity of the crisis coupled with the variety of viewpoints regarding the necessity of maintaining native biodiversity have hampered efforts to develop and implement effective conservation strategies that maintain native biodiversity over the long-term. Nevertheless, the biodiversity crisis is the rallying point around which most biological conservation efforts are now focused (Scott et al., 1993). Economic, political, and social impetus to protect native biodiversity appears to be growing and the importance of collecting sound ecological information is now recognized as a crucial component in the struggle to safeguard biodiversity (The Keystone Center, 1989).

Bruce Babbitt, Secretary of the Interior, for instance, recently called for the formation of the National Biological Survey (NBS) to help avoid, "the economic and environmental 'train wrecks' we see scattered across the country...the National Biological Survey will
unlock information about how we protect ecosystems and plan for the future." (National Research Council, 1993, p.vii). One of the primary purposes of the NBS as stated by the National Research Council is to "find ways to preserve the nation's biological heritage. Achieving this goal requires extensive information on the current status and trends in distribution and abundance of species and on relationships among species, and an understanding of the ecological processes on which they depend." (National Research Council, 1993, p.3).

The maintenance of native biodiversity requires a combined approach that addresses many challenges simultaneously. The goal of conservation efforts is not to maintain an environment that sustains maximum numbers of species, but rather native species in naturally occurring patterns of abundance (Noss, 1983). Noss (1987a) identifies four basic stages in the conservation process: (1) classification; (2) inventory; (3) evaluation (including reserve selection); and (4) protection and management (stewardship). At every step in this process, a complex array of social, political, and economic forces interact to influence the ultimate outcome of our conservation efforts.

The objective of my professional paper is to explore the classification stage of the conservation process, specifically, the classification of vegetation as a tool for improving our ability to maintain native biodiversity on a landscape level. The audience for
my professional paper is land managers and members of conservation organizations.

My efforts are primarily focused on federally owned lands. There are several reasons for this: (1) federal lands comprise one-third of the nation's land area and contain more than one-half of all wildlands, deserts, alpine areas, and shrublands in the country; (2) federal land contains more than one-third of all federally listed endangered and threatened species; and (3) many important laws and policies that offer protection to species are primarily applicable on public lands (The Keystone Center, 1989). This does not imply that the way privately owned land is managed is unimportant. On the contrary, it is essential that conservation strategies be developed and applied to these lands as well. However, it is beyond the scope of this paper to explore the implications of incorporating private land owners into the conservation process.

I have further narrowed the scope of my paper by focusing on the federal lands of Montana and Idaho for the following reasons: (1) these lands contain some of the largest remaining tracts of unroaded and relatively pristine wildlands in the lower 48 states; (2) efforts are currently underway to develop vegetation classification schemes for the two states; and (3) vegetation classification should serve as a tool to help maintain native biological diversity in Montana and Idaho.
Technological advances i.e., geographic information systems (GIS), remote sensing, computer models, and multiresource databases are rapidly changing the way that vegetation classification systems are developed and used. My professional paper will explore how these technologies are being integrated into classification efforts and identify some of the advantages and disadvantages of these emerging technologies.

The questions that I will explore include: what are the various conceptual and practical reasons for developing a vegetation classification system and what elements should a vegetation classification system contain to meet the objective of helping to maintain native biodiversity? Through interviews with land managers, ecologists, conservationists, and botanists I hope to shed some light on these and other questions and elucidate the role that vegetation classification should play in helping to maintain native biodiversity.

In the following sections of Chapter One, I present a literature review of some of the key concepts and issues surrounding biodiversity and vegetation classification. In Chapter Two, I describe the methodology and interview process used to collect my data. Chapter Three consists of my results and in Chapter Four I discuss the results. Chapter Five includes my conclusions and Chapter Six contains my key findings and recommendations on how a vegetation classification system that maintains native biodiversity
could be structured, how it might function, and how we can begin to move towards its implementation.
Why Preserve Native Biodiversity?

There are four broad reasons most commonly cited to justify the importance of preserving biological diversity. One of the most compelling (and for some people the only reason of real importance) is the intrinsic value of living creatures and the natural world. Aldo Leopold (1949) eloquently encapsulates this ethical imperative in *A Sand County Almanac*, "A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise." Often, the scientific and popular literature gloss over the validity of this argument and regard it as too ethereal to merit serious consideration (see for example, The Keystone Center, 1989; Salwasser, 1990).

Three additional reasons given for preserving biodiversity include: (1) economic considerations, e.g., a source for pharmaceuticals, building materials, and recreational opportunities; (2) assurance of a genetic source for improving plant and animal species that are useful to humans and as a source of genetic variation necessary for the continued evolution of life capable of adapting to changing environmental conditions; and (3) maintenance of biological processes which provide humans with essential services such as cleansing of air and water and cycling of nutrients.
In addition to the ethical, economic, and ecological reasons summarized above, there are also a variety of specific statutory authorities, policies, and regulations that federal land management agencies are required to follow to promote biodiversity within their respective jurisdiction. The agencies are also subject to a number of general laws, for example, the National Environmental Policy Act (U.S. Congress, 1969) and the Endangered Species Act (U.S. Congress, 1973).

The legal message is that federal agencies are responsible to varying degrees to inventory, monitor, restore, and maintain native biodiversity. However, as indicated by the ever increasing number of endangered and threatened species, these legal mandates have not been entirely effective. The reasons for the failure are complex and based upon political, economic, and social factors intertwined with basic gaps in our understanding of species and ecological processes. Several examples of important federal legislation are briefly described below.

The Forest Service and the National Forest Management Act
The National Forest Management Act (NFMA) was adopted to address forestry and land management issues within the National Forest System. The NFMA set standards for plans to be developed for each national forest and specifically charged the Forest Service that the plans provide for, “diversity of plant and animal communities...in order to meet overall multiple use objectives.” (U.S. Congress, 1976). The Code of Federal Regulations, at 36 CFR 219, provides
rules for developing integrated ecosystem plans, including the goal
to manage habitats to maintain viable populations of native and
desired non-native species, well distributed throughout their
geographic ranges in the National Forests and National Grasslands,
and to protect and restore natural biological communities (The
Keystone Center, 1989).

The National Environmental Policy Act
The National Environmental Policy Act (NEPA) requires that all
federal administrators consider the environmental consequences of
their actions before acting (U.S. Congress, 1969). The main
mechanism for achieving this is the Environmental Impact
Statement (EIS) which must be completed for all federal actions
"significantly affecting the quality of the human environment" (43
U.S.C.A. section 4332). However, NEPA is procedural, not
substantive; it requires only that the agency consider environmental
values during procedures, not necessarily that the agency choose to
follow the most environmentally sensitive alternative.
Nevertheless, NEPA does require the agencies to take a "hard look"
at their actions, as well as forcing every federal agency "to put its
reasons, reasoning, and conclusions into writing; and the citizens
who disagree with the conclusions can seek judicial review of the
action." (Coggins et al., 1993, p.333).

The Endangered Species Act
In contrast to NEPA, the Endangered Species Act (ESA) requires
substantive measures to protect plant and animal species that are
listed as either endangered or threatened as defined by the Act (U.S. Congress, 1973). The criteria for endangerment must be based solely on the best scientific and/or commercial data (Kohm, 1991). The Endangered Species Act of 1973 represents the most comprehensive legislation for the preservation of endangered species ever enacted by any nation (Coggins et al., 1993).

**The Endangered Species Act - Is It Working?**

Despite the strength of the language, the ESA has been criticized as inadequate (see for example, Grumbine, 1990; Orians, 1993; Scott et al., 1993). Critics point to the fact that nationally 775 species of plants and animals have been listed as threatened or endangered, and large numbers of candidate species have been nominated for listing. Recovery plans have been developed for only about half of the listed species (National Research Council, 1993). Among the many reasons for this backlog is the lack of adequate funding to achieve the stated goals of the ESA. However, many believe that the fundamental approach of the ESA precludes its success. Scott et al., (1993) stated that "the reactive, species-by-species approach to conservation has proved to be difficult, expensive, biased, and inefficient."(p.6)

One of the major difficulties with the ESA is that protection is not activated until the population of a given species is dangerously low. This has exacerbated the funding issue, for as Scott et al., (1987) state:
As a framework for conservation actions, the battles for species preservation are fought at six levels - landscape, ecosystem, community, species, population, and individual. Management costs per species increase, and the probability of successful recovery decreases, as conservation actions are focused on lower levels of this hierarchy. (p.783).

With entire ecosystems now threatened by widespread habitat destruction some suggest that it makes more sense to enlarge the Act to include protection for threatened and endangered ecosystems, communities, or habitats. Orians (1993) argued that in order to expand legislative protection for habitats, communities, or ecosystems, an ecological classification for these units must be developed. At present no established, generally accepted taxonomic system for levels of the hierarchy above the species level exists. The following section presents some of the major ecological concepts that support the idea that we need to expand our definition of biodiversity.

Spatial and Temporal Considerations of Biodiversity
The organizational levels of biological diversity most commonly recognized by scientists are arrayed as follows (Noss, 1990; Wilson, 1992):

Biome
  Landscape
    Ecosystem
      Community
        Species
          Organism
            Cell
              Gene
The levels most commonly studied are organism, species, and community (Noss, 1987b). Within each layer of the hierarchy are sublayers that merit consideration. For example, ecosystems should not be seen as separate entities. Almost all ecosystems are "open" and exchange energy, minerals, nutrients, and species. Kimmins (1987) defines the ecosystem level as "entire natural systems composed of communities and their physical environment." (p.25). He continues, "The term ecosystem is more of a concept than a real physical entity - a concept with six major attributes." (p. 26). These attributes are: (1) structure; (2) function; (3) complexity; (4.) interaction and interdependence; (5) no inherent definition of spatial dimension; and (6) temporal change.

Three different levels at which biodiversity can be considered include: Alpha diversity, defined as the number of species within a single habitat (uniform vegetation structure); Beta diversity which indicates the change in species composition along an environmental gradient or series of habitats; and Gamma diversity which represents the total species diversity of a larger geographic region (landscape or larger) (Noss, 1983).

The terms landscape and landform will be used throughout this paper. Swanson et al., (1988) define landscape and landform as follows:

*landscape* commonly refers to the form of the land surface and associated ecosystems at scales of hectares to many square kilometers. *Landform* is usually used at
a finer scale and more specifically, such as a landform carved out by a landslide or created by sediment deposition forming a gravel bar. Landscapes are composed of landforms and ecological units, such as patches. (p.93).

Traditional approaches to wildlife management have emphasized maintenance of biodiversity at the beta diversity level. It has long been observed that in areas where two or more distinct habitat types converge, species richness is usually high. This phenomenon is referred to as an edge effect. Maximizing beta diversity was often perceived to be as simple as creating as much edge as possible. For many land managers this is an appealing approach to stewardship, as it allows them latitude to pursue such activities as cutting, burning, and building.

However, as Noss (1983) and others have pointed out, it has had detrimental effects on native biodiversity at the gamma diversity level. Some species do not thrive in edge habitat, in fact, they often find themselves at a disadvantage when trying to compete against edge adapted species. Human activities that create edge habitat often fragment the landscape and create large areas of artificially induced edge. This type of landscape can inhibit the movement of certain species, increase the presence of generalist species (including exotics), and negatively affect habitat specialists such as late successional species. For these and other reasons beta diversity is not always the appropriate level on which to focus management efforts.
Noss (1987a) and others advocate that the landscape level is more appropriate, especially if the goal is to develop long-term conservation strategies designed to maintain native biodiversity. This strategy requires an integrative approach that recognizes the dynamic nature of the landscape. As Noss (1987a) writes, “In natural landscapes unmodified by man [sic], disturbances are patchy in time and space...” When human activities destroy habitat and restrict the range of flora and fauna, the natural shifting and patchiness of the landscape are reduced and diversity of structure and composition are lost.

Grumbine (1990) identified some of the problems associated with the species-level approach that fail to address landscape-level concerns:

1. An approach focusing on the individual needs of particular species does not address ecosystem structure and function.
2. The regional landscape context/matrix (habitat size, shape, configuration, juxtaposition, connectivity, etc.) is overlooked.
3. Critical elements of multi-community diversity (gradients and mosaics) are not included.
4. Disturbance regimes are neglected.
5. Large scale stresses (global climate change, acid deposition, air pollution, etc.) are not often considered.

The relationship between the basic hierarchical components of biodiversity is dynamic and incredibly complex; interactions within
and between these levels occur over a broad spectrum of space and time. Although humans have constructed the hierarchical approach to get a "handle" on the concept of biodiversity, such an arrangement does not mean that we understand how to translate the interactions that take place at multiple scales.

**Developing Conservation Strategies that Help Maintain Native Biodiversity**

Salwasser (1990) maintains, "We must manage ecological systems in ways that sustain the full richness of life without having to develop species programs for each of the thousands of species that may inhabit an area." (p. 83). This sentiment has prompted the call for innovative conservation strategies that will maintain native biodiversity over the long-term. While this is a laudable goal and many land management agencies are exploring their management options, it is not an easy task to accomplish. Social, political, and economic forces often oppose broad-reaching conservation strategies and the work of Kellert (1986) and others indicate that public perception of the systems view of nature is not well-developed.

Grumbine (1990) suggests three key issues for developing conservation strategies: (1) an integrated system of large nature reserves is required to preserve biological diversity at genetic, population, and landscape scales; (2) the current reserve network is inadequate to protect many species much beyond the short term (50 years); and (3) current species-level approaches must be augmented
by landscape-level strategies that recognize ecosystem patterns and processes. In order to maintain native biodiversity we must identify the primary habitat necessary to the key native species in the region. Classifying vegetation to delimit critical habitat is one important aspect of the conservation process. Concepts of vegetation classification are detailed in the following section.
VEGETATION CLASSIFICATION CONCEPTS

Community classification is justified not by theory, but by usefulness.
-Whittaker (1975)

The gap between conservation at the species and community level, and planning at the landscape level, has not been bridged.
-Noss (1987a)

The Nature of Classification

In the most general sense, the aim of classification is to group together a set of individuals on the basis of their attributes. Just as biodiversity and the processes affecting it can be examined at various spatial and temporal scales, so too, the classification of vegetation is greatly influenced by the scale under consideration. Allen and Starr (1982) write, “The level of ecological organization detected by community analysis depends upon two characteristics of the data set...these are (a) the area or time period over which the individual observations are made; and (b) the heterogeneity of the universe wherein the observations were made.” (p.156).

Classification is a human construct and the form of the classification scheme is not inherent in the vegetation, but is determined by the researchers’ choice of assumptions and goals (Whittaker, 1975). Based on our current understanding of biodiversity, one task at hand is to devise a classification system that contributes to the goal of characterizing native biodiversity. The challenge is to pick through traditional and innovative vegetation classification schemes and combine the best characteristics of each to develop a suitable system.
Defining Vegetation Ecology

Mueller-Dombois and Ellenberg (1974) define vegetation ecology as the study of plant communities including both the structure and composition of vegetation as well as vegetation systematics (classification of plant communities). This includes defining plant communities at all spatial scales as well as recognizing the relationships that exist between plant communities and environmental factors. As mentioned above, vegetation ecology is concerned with the description and classification of vegetation. Mueller-Dombois and Ellenberg (1974) write:

A vegetation class or community type is the result only of abstracting certain similarities of a number of concrete communities. As in the classification of species, rocks, land forms, or other study objects, the classification of plant communities depends on the questions asked and on general agreement. Classification is necessary for scientific communication, but it can never become absolutely objective or accomplished without the element of personal judgment. (p.153).

The purpose of the following sections is to (1) define the concept of plant community; (2) emphasize the importance of the identification and classification of vegetation as tools for maintaining native biodiversity; and (3) provide an overview of the major types of vegetation classification schemes that have been developed.

Plant Community Concepts: A Spectrum of Opinions

The basic vegetation unit for all the classification systems is the plant community (also commonly referred to as the plant
association, habitat type, or site type). Kent and Coker (1992) provide two reasons for choosing to classify vegetation to the community level:

1. Plant communities are the scale at which plant populations can be identified and grouped to characterize vegetative cover of an area; and

2. The community scale is the scale at which humans can best make sense of the value and variation of vegetative cover.

The nature of the plant community includes symbiotic, parasitic, competitive, and epiphytic inter- and intra-specific ecological interactions. In addition, the plants of the community are individually and collectively influenced by humans and other animals, e.g., insects, livestock, and native ungulates, and environmental factors such as climate, soil, and topography.

Mueller-Dombois and Ellenberg (1974) define the plant community as "a combination of plants that are dependent on their environment and influence one another and modify their own environment. They form, together with their common habitat and other associated organisms, an ecosystem." (p.27). Given the complexity and multiple levels of interactions it is not surprising, then, that the concept of plant communities is controversial and requires a brief discussion of the various representative viewpoints.

Two American ecologists, F.E. Clements and H.A. Gleason, expressed the most divergent viewpoints regarding the plant community
concept. Clements (1916, 1928; cited in Mueller-Dombois and Ellenberg, 1974) likened a plant community to an organism that undergoes identifiable stages in life history: birth, growth, maturation, reproduction, and death. In the organismic view, various species of plants were analogous to the organs and parts of the body of an animal. Putting all the parts together formed a super organism (plant community), in this view the plant community could not function without all its organs (plant species) present. The problem with this view is that plants within a community are, as a rule, not completely dependent on each other. The life processes for specific species take place at varying rates and each species is subject to replacement by other species through catastrophic events, competitive replacement, or a more gradual change in the environment.

The Clementsian approach emphasized the concept of "dynamic equilibrium" of the landscape. He divided the vegetation of North America into three broad categories which he called climaxes: forests, scrub, and grassland. These he further divided into formations and finally into associations. Clements defined these associations by the dominant species and believed that given sufficient time and relative long-term stability, these associations would equilibrate with the climate to form characteristic communities (climax communities).

Tansley (1920; cited in Mueller-Dombois and Ellenberg, 1974) offered a more moderate view than Clements. In contrast to viewing
plant communities as discrete organisms, he felt that certain populations were dependent upon the particulars of their environment, while others could establish themselves over a broad range of environments. Tansley introduced the term "ecosystem" and applied it to terrestrial plant communities. He emphasized that the organisms and their environment form a functional unit in nature and that an important aspect of vegetation ecology is studying vegetation from a holistic perspective.

Gleason (1926, 1939; cited in Mueller-Dombois and Ellenberg, 1974) rejected the approaches of Clements and Tansley and viewed all plant species as being distributed along a continuum. He argued that plant species respond individually to environmental factors and proposed the concept that plant communities are not distinct. The possibility of comparing or relating communities based on similarities, therefore, is precluded. Gleason's approach emphasized the spatial response of vegetation along an environmental gradient. Although it is true that no two communities are alike in every way, when compared on a relative basis they show degrees of similarities and differences to each other; it is the principle of relative similarities and differences that underlies all systems of classification (Mueller-Dombois and Ellenberg, 1974).

Probably the most commonly held modern view regarding the nature of plant communities falls somewhere between the extreme viewpoints represented by Clements and Gleason. Temporal and spatial factors influence vegetation so that plant communities are
rarely sharply delineated on the landscape. Rather, vegetation within a particular region is distributed as a mosaic consisting of gradually changing patterns of vegetation (Whittaker 1953; Whittaker and Levin, 1977; cited in Kent and Coker, 1992). Once again, it is essential to keep in mind the question of scale when considering the relative importance of spatial and temporal influences on community-types. An event, such as fire, that causes the death of individual plants or plant associations may be viewed as destructive at these levels, while it may serve as a diversifying or stabilizing factor when viewed at another scale.

The boundaries between vegetation types are often graded into one another across ecotones. These ecotone areas, ecologically important as habitat and as sources of unique flora and fauna, have been largely neglected by ecologists and vegetation classification schemes. Traditional sampling techniques used in classification select vegetation outside edges and ecotones so these landscape elements are not sampled. The importance of ecotones is discussed in greater depth later in this section.

Vegetation Classification and the Maintenance of Native Biodiversity

From an ecological standpoint, Coker and Kent (1992) provide three main reasons why it is important to be able to accurately sample and classify vegetation:

1. Vegetation is the most obvious physical representation of an ecosystem.
2. Vegetation (with a few exceptions) provides the habitat within which organisms live, grow, reproduce and die.

3. Vegetation represents the base of the trophic food web.

In addition, the fact that plants dominate the structure of terrestrial communities and, in most cases, are easier to study than animals makes them a logical focus of research efforts.

The relationship of animal distribution to a community classification of plants has been discussed by numerous researchers (see for example, Whittaker, 1975; Craighead et al., 1982; Noss, 1987(a); Scott et al., 1993). As was discussed previously, there is general agreement that the species-by-species approach to conservation has proven inadequate in many circumstances and that attempting to address the needs of all species in the landscape individually, and accounting for all of their interactions, is an impossible task.

Although many researchers advocate the development of a comprehensive plant community classification system that can be used at the landscape level there are many obstacles and difficulties implicit in this endeavor. Some of the difficulties relate to the inherent ecological complexity of biological diversity and the problems associated with determining the most appropriate level(s) of the biological hierarchy to address. Some of these types of problems are discussed in the following section. Another set of obstacles to developing a vegetation classification scheme originate
in social, political, and economic considerations; these issues will be examined in later chapters.

Classification of Vegetation: A Variety of Approaches

The approach used to classify plant communities depends upon which properties of the vegetation are emphasized: (1) properties of the vegetation itself; (2) properties outside the vegetation; or (3) properties combining vegetation and environment. The following discussion is intended to serve as a cursory overview of selected vegetation classification schemes and schools of thought based predominantly on information provided by Mueller-Dombois and Ellenberg (1974); Kent and Coker (1992); Whittaker (1975); and Shimwell (1971).

Classification schemes based on properties of the vegetation itself

The physiognomic approach

This approach classifies vegetation based on structure, i.e. external morphology, life-form, stratification and size - generally of the dominant growth form. This type of classification is considered "artificial" because the criterion for classification may group ecologically dissimilar vegetation into the same category. Classification systems based upon structure are particularly useful for classifying and mapping vegetation over large areas (such as biomes) where the gathering of floristic data would be too difficult and detailed.
Structural classification is also useful in tropical forest environments where floristic data are difficult to obtain and time consuming to analyze. Webb (1968) provides an excellent example of a hierarchical physiognomic classification scheme for the Australian rain forest vegetation. He correlates the vegetation structural types to climatic and edaphic factors to determine habitat types and to predict potential natural vegetation.

Another example of structural classification is Kuchler’s approach (1967; as cited in Mueller-Dombois and Ellenberg, 1974) which was intended to allow mapping of vegetation cover at all scales. The classification scheme separates the vegetation into two broad categories: (a) woody and (b) herbaceous. These categories are further subdivided and criteria (such as leaf characteristics and dominance of specialized life forms) are set forth at each successive level of the hierarchy. Appendix A includes a summary of Kuchler’s method for structural description of vegetation as an example of the structural classification approach.

The United Nations Educational, Scientific, and Cultural Organization (UNESCO, 1973) vegetation classification system is a widely used system that combines the physiognomic and floristic (discussed below) classification approach. Modified versions of the UNESCO classification scheme are currently being used in many vegetation classification efforts such as National Gap Analysis and The Nature Conservancy’s Heritage Program. These projects will be discussed...
in detail in later sections of this paper. Appendix B provides a more detailed description of the UNESCO hierarchical classification scheme.

The floristic and dominance-type approach
Floristic classification schemes identify individual species and various species characteristics such as composition, abundance, distribution, and presence/absence. Braun-Blanquet, (1928, 1932; as cited in Dombois-Miller and Ellenberg, 1974) a European botanist, developed a hierarchical system for classifying vegetation patterned after the Linnaean system of plant taxonomy. In Braun-Blanquet's view, a plant community was analogous to a species and represented the fundamental unit of the classification system. The system is based upon floristic criteria which in Europe has been defined by species with restricted ecological range that at the same time show a high degree of presence within the study area. European floristic studies have traditionally used plant species that are unique to a particular area as the defining characteristic for the study area. This approach works better in the relatively species-poor, highly human-modified European vegetation than in the species-rich communities of low-latitude environments (Orians, 1993).

Although many British and American ecologists also rely on the floristic approach to classify communities, they often concentrate on species dominance, particularly numerical dominance in the overstory. In contrast to the European approach that concentrates on unique plant species, the approach taken in North America defines
the dominant species as those that usually cover a wide ecological range.

In either case, it is often inaccurate (especially in a species-rich environment) to define an entire community by a single dominant species which may grow well under very different habitat conditions and in association with very different flora. Although these different habitat types share the same dominant species, it would be a mistake to classify them together. One solution to this dilemma was to create a more definitive system that classifies more than the single dominant species. In North America, dominant species for each layer are often used to better define the community types.

Classification schemes based upon properties outside the vegetation

Climax and habitat type approach
The conceptual basis of these types of classification schemes is that factors independent of the vegetation are the controlling forces defining the nature of the plant community. Numerous theories regarding plant succession, climax, and stability have been developed and are discussed in detail elsewhere (see for example, Mueller-Dombois and Ellenberg, 1974; Pfister and Arno, 1980; Meeker and Merkel, 1984).

One of the most widely used classification schemes for the western United States is the habitat typing approach. This approach focuses
upon the classification of potential climax vegetation rather than current vegetation. Proponents of habitat type classification believe that the system is a permanent and ecologically based approach that is valuable for helping predict the effects of land management activities. In their view, successional trends toward the climax are recognizable even in relatively young stands (referring to forest ecosystems). The habitat approach classifies vegetation according to potential for producing similar plant communities at climax; it does not necessarily reflect similarities in current vegetation. Others (Mueller-Dombois and Ellenberg, 1974; Shimwell, 1970) emphasize the difficulty of trying to predict the pathway of succession and the necessity of considering spatial and temporal parameters. Appendix C provides examples of the habitat typing approach of vegetation classification.

Classification schemes based upon properties combining vegetation and environment

Combined analysis of vegetation and environment

Krajina's (1965; as cited in Mueller-Dombois and Ellenberg, 1974) biogeoclimatic zonation scheme is based on mosaic patterns of vegetation within a specified geographic region with a uniform macroclimate (see Appendix D). Macroclimate plays the pivotal role and vegetation and soil are considered dependent upon climate. In addition to nineteen climatic parameters, each zone is described by elevation, latitude, zonal soil, and zonal soil forming processes. To develop such a classification system, in-depth studies of
ecosystems must be performed and the information integrated to delimit zonal boundaries. Krajina's biogeoclimatic zonation system is the basis for the classification scheme used in British Columbia.

Obstacles to Developing Vegetation Classification Schemes as Part of a Conservation Strategy that Helps Maintain Native Biodiversity

Mueller-Dombois and Ellenberg (1974) discuss the traditional approaches to classifying vegetation communities and relating them to animal communities:

Terrestrial communities, or associations, are usually defined by their vegetation according to some standard of homogeneity and based on dominant and/or characteristic plant species. Animal communities, in turn, often are associated with particular plant communities, although habitat structure in many cases is more important than floristics (the plant species present). (Emphasis added) (p.142).

The above quote touches on some of the problems associated with incorporating traditional plant community classification schemes into a strategy for maintaining native biodiversity (of both plant and animal species). The following sections explore some of these problems.

Classification of Heterogeneity in the Landscape

Traditional approaches to plant community ecology have been biased toward considering homogeneous plant communities during sampling of vegetation for classification purposes. For example, Daubenmire's classification system (habitat typing), which is used throughout much of the western United States, specifically relies
upon searching out homogeneous sampling areas within a varied landscape. Daubenmire urges that in a heterogeneous area comprised of ecotones, "one must search for the rare places which support small units of vegetation showing little gradient." (Daubenmire, 1978 as cited in Noss, 1987a).

A major problem with avoiding transitional areas in the landscape is that many animal species require a combination of habitats in which to complete their life cycles. If the vegetation classification system is designed to only record homogeneous community-types, then the habitat needs of wide-ranging species such as the wolf (*Canis lupus*) and grizzly bear (*Ursus arctos*) as well as species with highly specific habitat requirements may go unrecognized and unprotected.

Noss (1987a) and others have also pointed out the important role that disturbance plays in determining the structure and diversity of a region. For example, small-scale disturbances that create openings in the forest canopy create a mosaic of vegetation types. Superimposed on this level are large-scale disturbances such as insect infestation or fire which further diversify the landscape. Noss (1987a) writes, "disturbance regimes often do not operate and cannot be kept track of at the scale of the single community-type. Collectively, the evidence from these studies underscores the need to consider spatial units above the homogeneous community-type..."(p.22).
Classification of the Structural Characteristics of the Landscape

Community classification systems that are based upon the floristic or dominance-type approach fail to consider the importance of the structure of the vegetation to animal species. The structure of vegetation within both relatively homogeneous and heterogeneous communities may be as important as the species composition (Noss, 1987a; Whittaker, 1975).

Classification of the Culturally Modified Landscape

Vegetation classification schemes have largely ignored the classification of areas altered by human activities even though the degradation of habitat is often the primary threat to native biodiversity. A comprehensive classification system must address the combination of natural, semi-natural, and modified communities in order to develop a "real" picture of the landscape. Without a large-scale understanding of the status of habitat it is impossible to develop comprehensive conservation strategies for protecting remaining areas and prioritizing future restoration efforts.

Conclusion

The maintenance of native biodiversity is essential for a variety of reasons, yet the rate of degradation and simplification of ecosystems is careening along at a frightening pace. The traditional approaches of conservation and vegetation classification have not adequately addressed the issue of biodiversity. The development of one or more vegetation classification schemes as a tool for
maintaining native biodiversity is an important step in the conservation process and the remainder of this paper focuses on ways to meet this challenge.
methods

Who will speak for biodiversity?
-Noss (1989)

The Goal
Conservation biologist Reed Noss (1987a) has stated that classification is the first of four steps (followed by inventory, evaluation, and protection/management) in the development of effective conservation strategies. The two main purposes of my professional paper are to (1) explore the usefulness of vegetation classification as a means to document the status of native biodiversity at the landscape level; and (2) determine what should be included in any vegetation classification scheme designed to aid in this goal.

One key to accomplishing these two objectives is to determine the strengths and weaknesses of present classification schemes and develop viable alternatives that help bridge the gap between the current status of our efforts and an acceptable vegetation classification system that complements conservation objectives.

As I discussed in Chapter One, there are a multitude of vegetation classification schemes representing a variety of schools of thought and user needs. In order to develop a more realistic and complete understanding of how vegetation classification systems are developed and implemented, and their potential usefulness to
conservation efforts, I conducted a number of interviews with land managers, botanists, conservationists, and policy makers.

The goals were to interview a diverse group of individuals who use and develop vegetation classification systems and to use their 'on-the-ground' perspectives as the basis for making recommendations for improving vegetation classification efforts. I interviewed people who worked for, or were involved with, major federal land management agencies, conservation groups, and research institutions. Because the scope of this project focuses on the federal lands of Idaho and Montana, the majority of interviews involved people from this region.

Environmental policies that address the maintenance of native biodiversity and related issues should be based on sound biological information. However, the pursuit of scientific knowledge is influenced by both intrinsic factors such as funding constraints, agency and individual rivalries, as well as, external political, economic, and social pressures. In order to understand the interplay between science and other institutional forces, it is important to explore not only the science-based impediments that limit our vegetation classification efforts, but some of the social and political issues as well.

**Methods**
Based upon the suggestions of several people, I developed a contact list of people involved in various aspects of vegetation
classification. A cover letter and list of questions were sent to these people. A follow-up phone call to determine if the person was interested in being interviewed was made usually within a week of sending the letter, and, whenever possible, in-person interviews were scheduled. During the interviews and through phone conversations I learned of additional people to contact and was able to expand my contact list. A total of twenty-five letters were sent and twenty interviews were conducted. Of the five people who were not interviewed, three could not be reached by phone and two said they were not interested in being interviewed.

The interviews were tape recorded and the responses were summarized in writing for later analysis. Appendix E contains the cover letter and list of questions sent to each of the interview candidates. Eighteen of the twenty interviews were in-person, one by phone, and one via correspondence. The majority of interviews were conducted in one month. On two occasions group interviews were conducted (one interview consisted of two people, the other of three people).

Following the first five interviews I reviewed the responses and determined ways to improve the wording of questions to clarify their meaning and to generate more constructive dialogue. Appendix F includes the names, addresses, and professional titles of the interviewees, as well as the date that each interview was completed.
My list of questions was used to guide the interview process. If the interviewee had no experience or opinion in relation to a particular question, I shifted the focus of the interview. For example, in a case where the person was inexperienced developing vegetation classification systems but possessed extensive knowledge of the application of vegetation classification schemes, I asked questions to highlight issues surrounding the latter process.

Although I tailored the questions to the interviewees, it was important to consistently ask certain questions in order to gather useful information on key issues. I emphasized in the cover letter and during the interviews that the purpose of the interview was to explore the potential for developing and implementing a vegetation classification system that could be used to aid in the maintenance of native biodiversity. I asked the following list of questions of each interviewee (the key concept is indicated in bold type):

**Identification of main obstacles to developing a useful classification system**
What do you think are the main obstacles to developing a vegetation classification scheme?

**Possible solutions**
What are some feasible solutions to these obstacles?

**Identification of elements that should be in a vegetation classification scheme for biodiversity**
What components should be included in an "ideal" classification scheme, i.e. one designed to be used as a tool to help maintain native biodiversity?
Role of emerging technologies
What are some of the pros and cons associated with using emerging technologies such as geographic information systems (GIS) in vegetation classification and mapping efforts?

Cooperation and coordination among agencies, organizations and research institutions
Do you see value in developing a regional vegetation classification system that is complementary to and compatible with adjacent regions and is a subset of a national or global classification scheme?

Do you see any value for a vegetation classification system that is acceptable to state and federal agencies, university and private users? What are the biggest obstacles to developing a coordinated approach?

Standardization of vegetation classification schemes
Is it desirable/necessary to standardize vegetation classification efforts? If yes, what areas could benefit from standardization?

In order to gather general information about vegetation classification systems, I asked several questions designed to learn more about (1) the types of vegetation classification schemes currently being used or developed; (2) the types of projects that require the classification of vegetation; and (3) which classification schemes have the most support among users. The following questions were asked of each of the interviewees:

Current use and application of vegetation classification schemes
Have you, or are you, involved in work which requires the use of a vegetation classification system? If yes, what is the objective of
your project? What classification scheme(s) have you, or are you using?

Have they been satisfactory, why/why not? Are you conducting field work? If yes, what type (e.g., remote sensing, literature review)?

Each taped interview was summarized in writing, and key concepts were identified. For example, each interviewee was asked to identify what she or he felt were the main obstacles to developing a useful classification system. All potential "obstacles" to the development of such a system that were cited by the interviewees were identified and listed. This allowed me to review the interview results by subject area, compare the responses of different interviewees, and identify areas of consensus and differing opinions. A similar procedure was followed for each topic addressed through the interview process.

Not all of the interviewees responded to every question, therefore, the number of responses for each topic area is noted in the results section. Several people expressed no opinion or felt they did not have the expertise to address certain issues. One of the interviewees (Morgan, 1994) responded in writing and addressed only certain issues in her correspondence. Therefore, her response was incomplete.

The small sample size precludes any meaningful statistical evaluation of the responses. My intention was to conduct a small
number of in-depth interviews rather than gathering general information from a large number of users. The respondents were chosen because they represent diverse perspectives based upon their interests and professional pursuits. It is likely that some issues were not adequately represented by the group due to the small sample size. However, the responses are diverse and informative, and examining the responses in detail is a good starting point for understanding the areas of consensus and differences between users.
INTERVIEW RESULTS

Each land management agency has several systems, and each geographic area varies in the applicability and use of different classifications. The same features are sometimes described by different terms, and some terms are applied with numerous meanings. A common classification language, including terminology and definitions is urgently needed.

-Bailey et al. (1978)

This chapter summarizes the most commonly cited responses of the interviewees. Appendix G lists all responses to each of the questions. Analysis and discussion of the results follow in the Chapter Four.

Twenty respondents were interviewed (Table 1 in Appendix H lists the name, professional affiliation, and areas of interest of each interviewee).

Results

Identification of main obstacles to developing a useful classification system that could serve as tool for helping to maintain native biodiversity

Seventeen of the interviewees responded to this question. The most commonly cited obstacles are as follows:

1. Inadequate knowledge of existing vegetation (seven).
2. Lack of resources i.e. time, money, and/or technical assistance (six).
2. Hard to capture variability and detail in one vegetation classification scheme (six).
3. Not enough well-trained, experienced personnel in the field (five).
Identification of elements that should be included in a vegetation classification scheme for biodiversity

Rather than focusing on the pros and cons of existing vegetation classification schemes, I wanted to develop a “wish list” of the elements that experts thought were essential to a classification system that could be used to assess native biodiversity. Eighteen interviewees responded to this question. The most commonly mentioned desirable features were:

1. Information on vegetation structure (thirteen).
2. Classification of existing vegetation, not potential natural vegetation (seven).
3. Classification must be hierarchical and include different levels of resolution (four).
3. Classification schemes should include better information on grass, herb, and shrub layers (four).
3. Both site potential (including potential natural vegetation) and existing vegetation need to be considered in a single classification scheme (four).

Cooperation between agencies, organizations, and research institutions and coordination of efforts

Fourteen out of eighteen responded. The most common concerns were:

1. Not economically feasible to develop a usable, coordinated effort that would include the levels of resolution that would be acceptable to everyone (four).
1. Focus efforts on developing a common database and make the information collected by agencies and other entities accessible to the public (four).
1. Focus efforts on coordinating data collection methods, not on classification (four).
2. Increase the role of peer and scientific review as a means to resolve conflicts (three).
2. Use emerging technologies such as GIS as a tool to help facilitate cooperative efforts (three).

Standardization of vegetation classification schemes
Fourteen of the twenty responded to the question asked about the value of developing a standardized vegetation classification system. Opinions regarding which areas should be standardized varied greatly and no clear areas of agreement emerged.

1. GIS is an area that would be a good place to develop standardized approaches (four).
2. Focus efforts on standardization of data collection rather than upon the classification of vegetation (three).

Specific suggestions for developing strategies to initiate standardization efforts will be discussed in later chapters.

Role of emerging technologies
All twenty interviewees directly or indirectly work with Geographic Information Systems (GIS) (see Appendix I for an explanation of GIS) and all feel that it is an important management tool for displaying and synthesizing information. Fourteen of the sixteen interviewees responded to this question and made the following observations:

1. GIS is a valuable tool for synthesizing information and helping us to see the bigger picture. GIS information is a useful tool for landscape level analysis and for large scale management efforts (nine).
2. GIS is a valuable tool, however, it is unclear that the level of resolution is good enough to address many important aspects of vegetation classification (six).

3. Need to develop models that: (1) predict successional pathways; and (2) help us understand the role of natural processes in influencing the vegetation (five).

3. We must adequately ground truth remotely sensed information (five).

Solutions

It is often easier to identify problems than it is to formulate workable solutions. Nevertheless, the respondents did have some suggestions, albeit often general in nature that could be used to develop constructive solutions to some long standing issues. All twenty of the respondents made suggestions addressing a variety of issues. The respondents often made reference to specific projects or classification efforts. These references are explained in Chapter Four and in the following appendices: UNESCO and Driscoll (Appendix B); Geographic Information System, LANDSAT Thematic Mapper, and Gap Analysis (Appendix I); the Alaska Vegetation Classification (Appendix J); ECODATA (Appendix K). All of the solutions mentioned by the interviewees follow:

Identification of elements that should be in a vegetation classification scheme for biodiversity

- Develop a hierarchical system with levels of resolution to accommodate the needs of both lumpers and splitters. There should be three, four, or five different levels of resolution so as to give users enough choices. A good approach is that of The Alaska Vegetation Classification (Viereck et al., 1992).
• Incorporate structural information on vegetation. The UNESCO (1973) classification system is very useful and can be modified and refined to meet specific conditions. The system used by Mattson and Despain (1985) in Yellowstone National Park to map grizzly bear habitat is a good model. They looked at both habitat type and community type and developed a cover classification based upon existing vegetation.

• Incorporate more information on abiotic factors and landform patterns that influence the vegetation. The approaches used in Canada and Australia offer potential solutions.

• It is better to use one or more simple classifications rather than a single, complex classification. It is important to know the cover type. I like the criteria established by UNESCO (1973) and modified by Driscoll (1984).

• Structural classification must take into account size, density, and number of layers of the stand in order to develop an operational taxonomy that is useful for inventory, communication, and mapping.

• An operational structural classification system should include the following:
  1. Habitat type: (use potential natural vegetation data gathered from habitat type studies);
  2. Structural stage: age and size information;
  3. Cover type: use criteria of the Society of American Foresters (Eyre, 1980);
  4. Density: use criteria established by UNESCO (1973) and Driscoll (1984); and
  5. Dominant undergrowth by life forms or major species.
At the landscape level we should develop a classification that is based on very visible characteristics that can be identified using remote sensing and photo interpretation (cover type, canopy closure, upper layer size class). On the more detailed level we need composition and structure information.

The structural stage classification should include: species by layer, size, origin of regeneration, age, and rate of growth.

Need more detailed information on vegetation along a moisture/elevation gradient. Wildlife people want to know more about structure.

One thing to consider is habitat classification based on physical factors such as soils, slope and aspect, bedrock parent materials, geology, elevation. You can construct classifications that way independent of biological data. In some ways, that is a more robust classification, or a more robust basis for a long-term conservation strategy because vegetation is going to change due to factors such as climate change, extinction and speciation. If in fact we have accelerated climate change due to greenhouse effects then our classification we construct now based only upon vegetation might only be good for the next 10-20 years maybe 50 years at most. And that’s not good enough.

Ways to improve vegetation classification efforts:

Need to redo our vegetation maps and update information probably every two years. We need to be thorough and gather additional information each time we revisit areas so we can accumulate baseline data.

Need information on the distribution of humans on the landscape. Millions of dollars have been spent to classify and map vegetation, but I think if we had not done any of that and looked...
at distribution of people we would know just as much about
where the bears are and what is important to the bears.

• Update maps every five years.

• Develop three different classification systems: 1. current
vegetation; 2. ecological land units; and 3. structural stage
classification.

• Make the commitment to adequately train field personnel. This
will be accomplished by increasing wages and hiring more highly
trained people.

• In certain circumstances, the classification system that should
be used is obvious. We should develop a regulatory program that
requires that certain classification systems should be used. This
would ensure that the appropriate system is used (rather than
the most convenient).

• Update our information on existing vegetation every three to
five years. This shouldn't be too difficult using remotely sensed
information.

• Rely more on Landsat Thematic Mapper (TM) information. It is
repeatable and less subjective than traditional vegetation
sampling and classification efforts. We can't afford to send out
big field crews anymore so we need to tie our efforts to remotely
sensed data.

• Must develop simulation models so that we can look into the
future and explain the successional pathways of vegetation. One
of the main objectives of any classification system is to validate
simulation models. We need to develop comprehensive statistical
and analytical techniques to look at multivariate species
assemblages.
Vegetation classification systems should be developed at a local level. Researchers and managers should be given the tools to accomplish this.

Existing vegetation is the fundamental layer of information. We should throw out all existing classification and maps because they have been heavily influenced by the habitat typing idea. It would be great to do extensive surveys, but we don't have the time or the money. We are dealing with a biodiversity crisis and need to be able to predict our vertebrate species distribution and identify our current vegetation conditions.

I don't see any other long term solutions other than focusing on processes; we need to understand the causal mechanisms so we can predict the vegetation.

For certain land management decisions we need less detailed information on vegetation and more emphasis on understanding the distribution of humans in the landscape and patterns of culturally modified landscape.

Use the existing literature to put together an operational classification that can be used as a framework to look at landscape patterns, diversity and change over time. As soon as you start looking at landscapes you can't look at everything in detail and you need to simplify; classification becomes the tool

Suggestions for improving cooperation and coordination:

Standardize data collection methods so that the information can be incorporated into common databases. ECODATA is the system used by Region One of the Forest Service and it is a good start.

Require researchers to gather data that is usable by others and enter information into a common database.
• Develop sampling procedures. I think we can work across agency boundaries. The committee approach allows us to bring people together.

• Collection of data is usually the most expensive aspect of projects. We could keep costs down by coordinating efforts and sharing information. Develop adaptive and coordinated inventory efforts.

• One of the main reasons that classification systems go unused is that they are never published in the literature. Most of them remain as internal agency documents. They need to be published and critically reviewed.

• Need to educate managers about what is available to them. Professional symposia are important.

• Develop a set of publications that coordinate, explain, and compare classification schemes so that people know what’s available for them to use.

• Need to develop an effective way to crosswalk and translate from one classification to another.

• I think that we have the responsibility if we go out to collect data to make it available to all: mark location of plots using a global positioning system (GPS), take extra samples, use standardized methods.

• More important than deciding on a single classification system is establishing a permanent committee which could work to resolve issues related to vegetation classification. The Ecological Society of America should set up such a committee.
Specific examples of vegetation classification projects that could serve as models:

• Much of the data we need has already been collected and it can oftentimes be converted into a usable form. ECODATA is a good example of this type of effort. What we need is to find out what data exists, cross reference that data, and get it into a common database.

• Many problems will be solved by technology. We need to look at different scales and levels of resolution. We need broad-scale use of GIS and development of community databases with three or four scales. The system being developed by the U.S. Fish and Wildlife Service Gap Analysis under the supervision of Roly Redmond is a good approach that is helping to bridge the gap and integrate information from a variety of sources.

• There is no one best vegetation classification system but we do have three complementary systems that should be used and improved: (1) The Nature Conservancy’s Heritage Program to evaluate rare elements in the landscape; (2) Gap Program Analysis for larger scale evaluations and information on existing vegetation; and (3) habitat typing to gain information about the potential natural vegetation, site potential, and to help us model successional pathways.

General observations:

• We are in a testing and development mode and I think we ought to encourage that. I don’t think we should try to get everyone to come to consensus on one classification system. We need to do rigorous testing and development and see what works where and at what scale.

• Information gathered by remote sensing for landscape level management decisions is a tool that can help predict where
certain types of vegetation are likely (or unlikely to occur). Old
growth is a good example. GIS cannot identify old growth but it
can still help direct efforts to identify where it is likely to
occur. Providing that there are mandates and appreciation of
these unique areas, then GIS can help facilitate management
decisions.

• Classification efforts that are initiated at the top are one of the
biggest impediment to developing good systems. The people at
the top have forgotten what it is like in the field. I think it is
important to see what we have available and to discuss the
relationships between the existing information.
This chapter is divided into sections covering the major issues discussed during the interviews. Responses to specific questions, the general areas of agreement and disagreement among the respondents, and their opinions regarding the major obstacles to developing a useful classification scheme are explored.

**Identification of main obstacles to developing a useful classification system**

*Lack of information regarding seral vegetation*

The most commonly cited obstacle (identified by seven out of seventeen respondents) was related to the lack of information available regarding seral vegetation communities. A main reason for this is that in the western United States the traditional approach to vegetation classification uses climax potential vegetation (associations) to classify sites (habitat types) (Pfister, 1976). Habitat typing was primarily developed to characterize sites in timber inventories, in silvicultural stand examinations, and, to a much lesser extent, for wildlife evaluations (Pfister, 1975). In 1975, Pfister reported that "most of the current field research studies in the northern Rocky Mountains are utilizing habitat type classification as a tool." (p.315).
Habitat type is defined as those parts of the landscape capable of supporting a given plant association (climax) in the absence of disturbance (Daubenmire, 1968 as cited by Pfister, 1976). The primary unit of classification is the potential dominant climax tree species (in the case of forest habitat types). However, both trees and undergrowth species are used as indicators of environmental factors. The habitat type approach is a taxonomic classification based upon the development of a taxonomic key arranged in the following hierarchy (Pfister, 1976, p.3):

**SERIES**
A group of habitat types having the same climax dominant (tree) species; e.g. *Pinus ponderosa*

**HABITAT TYPE**
The basic taxonomic unit of the classification named by climax tree species and undergrowth indicator species; e.g., *Pinus ponderosa/Festuca idahoensis* h.t.

**ASSOCIATION**
(vegetation)

**PHASE**
The lowest subdivision of the hierarchy, representing relatively minor environmental differences; e.g., *Pinus ponderosa/Festuca idahoensis* h.t., *Festuca scabrella* phase.

Dr. Pfister's work on the cooperative research effort and development program through the Intermountain Forest and Range Experiment Station and the Northern Region of the Forest Service contributed to the present widespread use of habitat typing throughout the Northern Rockies. The habitat typing method was developed to meet the needs of forest managers and researchers to give them an overall understanding of the variation in vegetation and
to predict site capabilities (Pfister et al., 1977). Appendix C contains an example of habitat typing.

During my interview with Dr. Pfister, he acknowledged that the site classification approach based on potential natural vegetation leaves a gray area in terms of the transition vegetation (Pfister, 1994). One ramification of the emphasis being placed on climax vegetation is the possibility that land managers and other will devalue seral plant communities despite the fact that these communities are often very important to wildlife. Pfister shares the view of many of the interviewees that classification schemes that take into account existing vegetation need to be more fully developed. Pfister's current project plans include the development of an operational classification of existing vegetation to examine landscape patterns, diversity, and changes over time (Pfister, 1994).

As discussed earlier, one problem with habitat typing is that it ignores transitory vegetation and the successional pathways that characterize the patterns of existing vegetation. Some respondents felt that information on seral vegetation needs to be gathered and combined with the available information on potential natural vegetation. This would allow for the prediction of site potential (a valuable tool for understanding site characteristics and making management decisions) while gaining information on the present vegetation.
Others felt that the only truly important information is existing vegetation. To some of the respondents, habitat typing is more of an academic exercise that does not assist them in making land management decisions or addressing wildlife needs. Several stated that it is very difficult for land managers to deal with potential natural vegetation, they need to know what is going on today and where things are likely to head in the next ten years, not the next one hundred.

Another shortcoming of habitat typing and other vegetation classification systems used in the Northern Rockies is that they are not yet comprehensive. One respondent stated that there are many areas in Montana that are not adequately covered by any vegetation classification system. Most of the land that has been habitat typed is Forest Service land; many other areas such as private lands and non-forested lands have not been adequately sampled.

*Lack of resources (money, time, technical support)*

Two concerns were mentioned by six of the seventeen respondents: (1) lack of resources (including money, time, and/or technical support); and (2) difficulty capturing variability and detail in one vegetation classification scheme.

The unequal distribution of funding within agency departments was cited as contributing to a lack of intra-agency cooperation and coordination and preventing classification efforts from directly focusing on biodiversity related issues. For example, departments
whose responsibilities are related to timber production have traditionally received more money than departments such as wildlife.

Three of the interviewees specifically cited intra-agency conflict linked to an unwillingness to collect or share data. One respondent described his experience of trying to coordinate with other departments in the agency to gather information on wildlife habitat during timber inventories. The timber planners argued that they did not have the time or money to gather additional information nor were they willing to alter their field techniques so that the information they gathered on timber age classes would be compatible with the needs of the wildlife biologists.

This respondent concedes that things are slowly changing and that more collaborative efforts are occurring. In Region One, for example, the Forest Service is working with the Bureau of Land Management; Montana Fish, Wildlife and Parks; The Audubon Society; U.S. Fish and Wildlife Service; and The Nature Conservancy on a large-scale neotropical migratory bird study. The groups are coordinating their data collection and analysis techniques and the point counts and vegetation data are being shared with the U.S. Fish and Wildlife Service Gap Analysis project to develop a map of the existing vegetation for Montana (Christensen, 1994). The Gap Analysis program and the role of GIS are described in Appendix I.
The issue of lack of time was noted by several of the respondents. Land managers, botanists, and researchers felt that they had too many tasks to try to learn new classification schemes. The respondents identified the schisms that often exist between those that develop classification schemes and land managers and field researchers. The UNESCO (1973) vegetation classification system was cited by several respondents as a potentially useful classification system. However, three respondents thought that UNESCO was perceived as "too academic" by many agency people and because land managers are overworked, "these hierarchies aren't particularly important and my guess is that they probably never will be important." (Cooper, 1994). Dr. Pfister reiterated the point that it is difficult to get vegetation classification systems accepted, "You hope that you have educated people that have some familiarity with the literature so they realize what is happening but usually that is occurring in the research branches. Usually managers are so pushed to get things done that they don't have the time." (Pfister, 1994).

**Hard to capture variability and detail in one vegetation classification scheme**

Six of the respondents felt that given the inherent variability in natural systems and the diverse needs of land managers and other users that it was not possible to develop a "best" classification system. In addition, the issues of temporal and spatial scale make it unlikely that one classification system can meet the diverse array of research and management requirements.
As Roly Redmond, who works on the Gap Analysis Project at the University of Montana stated:

I personally don't believe that in 1994, and probably in the next decade, that any single classification can meet all purposes. If we are doing a detailed study we might want to pay attention to individual plant communities and individual plants; we are going to use a classification system to meet this need. But when you talk about mapping and working at regional scales - hundreds of thousands of square miles - we don't know the plant communities that exist. I've heard estimates that somewhere between 50-90% of the successional plant communities in Montana have yet to be described. (Redmond, 1994).

Lack of well-trained, experienced personnel in the field
The lack of adequately trained personnel was the third most cited concern (five of seventeen). The respondents felt that the agencies commonly employ inexperienced people (often seasonal employees that are paid low wages) for field projects. Often, these people do not possess the experience to accurately identify plant species and make crucial quantitative judgements regarding such factors as density and cover.

This issue of lack of trained personnel feeds into another concern expressed by three respondents that the information gathered by the agencies is highly variable and in some cases of dubious quality.
This lack of trust in the quality of data was identified as a main reason that researchers often repeat field work.

**Identification of elements that should be included in vegetation classification scheme for biodiversity**

*Structural information*

This question elicited some of the strongest opinions and the highest degree of consensus. Thirteen out of eighteen respondents felt that vegetation classification schemes would be improved by including information on structural aspects of the vegetation. As discussed in Chapter One, the physiognomic approach to the classification of vegetation is based upon factors such as external morphology, life-form, stratification, and size. The approaches of Kuchler (1976 as cited in Mueller-Dombois and Ellenberg) and Raunkaier's life-form classification (1934 as cited in Coker and Kent, 1992) are examples of structural classification schemes.

The respondents seemed less concerned with highly detailed structural information and more interested in a scheme that would complement a floristic-based system. The respondents had differing opinions regarding the amount and type of structural information that should be incorporated into classification efforts. Several of the respondents stated that for wildlife, information on vegetation structure is often as important as information on the composition of the vegetation.
All of the wildlife biologists and the land managers who focus upon wildlife issues identified the need for a systematic vegetation classification approach that incorporates structural information in order to answer questions regarding patterns of vegetation in the landscape and determination of corridors and barriers to movement. Dr. Pfister said that:

Based upon the experience of habitat types if we can come up with a system of classification for existing vegetation that addresses the basic questions of species composition, vertical structure in terms of layering, density and something on stage of development along the successional pathway - if we can handle those four characteristics in a reasonable way - we may have a classification system that will actually get used. (Pfister, 1994)

All twenty of the respondents felt that GIS was a useful tool for organizing and displaying information on vegetation structure. For example, information on size and age classes and down woody material can be gathered using satellite imagery and displayed using GIS. However, six of the fourteen respondents that discussed the role of GIS in a structural classification system questioned the resolution of satellite imagery. Pfister firmly believes that rather than try and build a new classification we should concentrate on modifying an existing one. He feels that the habitat typing that has been completed in the Northern Rockies over the last twenty years represents a wealth of information that should be used as a basis for developing a structural classification system (Pfister, 1994).
Wendell Hann, Landscape/Ecosystem Assessment Group Leader with Region One of the Forest Service felt that the fine scale approach envisioned by Pfister and others is necessary but that it doesn't work well at the landscape level of analysis. This type of structural classification is too detailed, includes too many community types, would require too many plots, and would generate an overwhelming amount of data that would be very difficult to organize and process. Both Hann and Redmond feel that the habitat type approach doesn't translate to the landscape level of analysis because the variables that are driving the classification are fine scale variables and are not indicated at the landscape level of analysis.

Hann and Redmond felt that the two approaches (fine and coarse scale) should not be considered mutually exclusive; there should be an interface so that the connection between the two scales is not lost. Such a connection would allow users to "zoom in and zoom out" depending on their needs. Rigorous testing and development are needed to determine the best way to reach this objective.

Wendell Hann described his approach as having three integral classification schemes: vegetation, ecological land units and structural stage. He envisions tracking activities or land uses separately and integrating the information using GIS. In terms of structure he sees creating the classification based upon such factors as size, origin of regeneration, age, rate of growth, and dominant species by layer (Hann, 1994).
**Focus efforts on classification of existing vegetation, not potential natural vegetation**

The second most common suggestion was based on the observation that too much time and money have already been spent on characterizing potential natural vegetation. These respondents felt that instead of trying to integrate the two approaches (potential and existing vegetation) we should focus on classifying existing vegetation. There appears to be a split in opinion regarding the usefulness of habitat typing. Some land managers feel that it is an excellent communication tool because of its widespread use and acceptance and that it helps land managers define site characteristics and productivity. Wildlife biologists and others who are concerned with the viability of specific species expressed misgivings regarding the value of habitat typing to fully meet their needs. For example, one land manager who is interested in grizzly bear recovery efforts said that from his perspective:

"Millions of dollars of vegetation mapping have been done, but I think if we had not done any of that and looked at distribution of people on the landscape we would know just as much about where the bears are and what is important to them...We need to know something about vegetation values, but right now, after all these years of looking at vegetation we would be a lot better off looking at human activities because there is so little we can do about vegetation. We can manage human activities." (Servheen, 1994).

In my interview with Angie Evenden, Program Manager for the Northern Region's Research Natural Areas (RNA) Program (U.S. Forest
Service), she made a similar observation. A major objective of the Forest Service's RNA program is to maintain a representative array of all significant natural ecosystems as baseline area for research and monitoring (USFS manual, 1991 as cited by Chadde, 1993). Evenden explained that within the RNAs they use habitat typing to classify vegetation because it is the most widely accepted approach. But she acknowledges that “in an ideal world we might have started over and developed something different, but that's what we have to work with...It doesn't adequately portray the different seral stages and structural stages.” She continued, “we are not abandoning habitat typing but we are modifying it.” (Evenden, 1994).

The question of habitat quality generated interesting discussion. Three out of eighteen respondents felt that descriptors would be useful to include in a classification system as a way to provide information regarding habitat quality. One wildlife biologist gave the example of classifying a white bark pine stand as excellent habitat for grizzly bears, when in fact, the pines were not producing cones and were of little value to bears or other animals that rely on the cones as a food source. Without descriptors to indicate the value of the habitat, the classification scheme can misrepresent and possibly over estimate the amount of suitable habitat. In another example, in the Swan Valley of Northwest Montana, the classification of vegetation alone might lead one to believe that the area is excellent grizzly bear habitat. It is only when the land use activities are evaluated i.e. roads, campgrounds, and towns, that it becomes clear that large areas are unsuitable for grizzly bears.
Developing descriptors is problematic for several reasons: (1) quality of habitat is dependent upon the species under consideration. Clearcuts, for example, are excellent habitat for certain native species such as robins (*Turdus migratorius*), while being poor habitat for other native bird species. Habitat descriptors would have to be developed for each species; (2) habitat quality is not static, rather, it changes over time and in response to environmental factors. For example, the white bark pines that are currently not producing cones may in the future become a valuable food source; (3) other factors are intangible but important indicators of habitat quality, for example, the attitude of the local human population towards specific wildlife species can greatly influence the viability of that species.

An ongoing debate among the users and developers of vegetation classification systems is which components are appropriate to include in a vegetation classification scheme. The question inevitably becomes how inclusive should the classification system be and when does the amount of information become too burdensome to gather and organize. Examples of different approaches include the Canadian system of biogeoclimatic zones (based on the work of V.J. Krajina, 1959 as cited by Meidinger and Pojar, 1991) that incorporates primarily climate, soil, and vegetation data. The system is hierarchical with three levels of integration: regional, local, and chronological (ecosystems are organized according to site
specific temporal sequences based upon site history and successional status) (Meidinger and Pojar, 1991).

One respondent liked the Canadian system because it is hierarchical and focuses on the landscape level of analysis. However, he felt that it does not adequately address the underlying disturbance regimes that influence the vegetation. The respondent felt that because the Canadian system does not consider the role that natural processes such as fire play in influencing the vegetation, that it lacks predictive or explanatory power. This argument could be made for many of the vegetation classification schemes currently being used (including habitat typing) which do not address many of the underlying processes that influence the vegetation.

Several respondents advocated an integrated classification approach that includes classification of landscapes to help elucidate spatial patterns which in turn help define the relationship between components of the landscape and physical and biological processes. As Bailey et al., (1978) pointed out, "Many natural-resource questions cannot be answered without some knowledge of the spatial pattern...Process is controlled by structure, and cannot be observed, much less inferred, from system components alone. It emerges only at the integrated system level which shows not only composition but structure and interactions" (p.653).

Another argument in favor of the integrated approach was mentioned by three respondents. They commented on the fact that the majority
of expenses incurred for most projects are associated with field work (one respondent said that as much as 95% of costs were associated with data collection while analysis was less than 5% of costs). These respondents felt that the field crews should gather a wide variety of data and that the collection methodologies should be standardized so the information can be readily shared among user groups and stored in a common database.

One of the ways that the Northern Region of the Forest Service is pursuing this approach is through the development of ECODATA. Jensen et al., (1993) describe ECODATA as a "set of relational databases and analysis programs developed for environmental assessment and ecosystem analysis. This system contains a series of multi-intensity sampling methods and databases that facilitate consistent and efficient descriptions of various ecosystem components (e.g., vegetation, soil, streams, wildlife, and topography) at the site or plot scale." (p.203). The system also includes ecosystem analysis programs (ECOPAC) which access data and produce standard reports, statistical analyses, and summaries. The output can then be used to describe different types of classification (e.g., existing or potential natural vegetation) in various classification databases (ECOCLASS) (Jensen et al., 1993). Furthermore, the databases can be linked to digitized mapping systems and the information processed by various LANDPAC software programs for spatial analysis of ecosystem information.
Since its inception eight years ago, the ECODATA system has continued to be refined and expanded to meet the diverse needs of user groups. Jensen et al., (1993) stated that the "first step in effects analysis is to ensure resource managers use common terms and databases when characterizing and analyzing the ecosystems they manage. Consequently, the primary objective in ECODATA development has been the creation of a platform for efficient and consistent environmental assessment." (p.214). ECODATA has been designed so that it can be used by other agencies and organizations including The Nature Conservancy, National Park Service, Bureau of Land Management, and various universities.

During my interviews, several respondents both within the Northern Region of the Forest Service and in other organizations shared their opinions regarding ECODATA. One respondent said that ECODATA suffered from the problem of generality and loss of specifics. However, he did feel that the third generation of ECODATA is much improved over earlier versions.

Another respondent commented on the difficulty, time, and expense involved in converting data from other sources into ECODATA. To him, the question was not whether it was possible to convert data to ECODATA, but whether or not it was worth it. He questioned how the data would be used. Large amounts of money are being spent to convert data, yet, the agencies and organizations have not entered the realm of analysis. He pointed out that "it is difficult enough to
figure out how to partition landscapes and classify them but the bigger question is what to do with the information.” (Cooper, 1994).

One respondent questioned the level of expertise of the field people who must gather the large amounts of data required by the ECODATA system. In general, respondents felt that ECODATA was good in concept but that there are shortcomings associated with the approach. Most of the criticisms were aimed at the sampling procedure aspect of ECODATA: (1) too general; (2) required too much of inexperienced field work teams; (3) not enough in-depth sampling; and (4) poorly placed plots (e.g., difficult to access, not representative of site conditions).

Four of the respondents advocated the development and use of vegetation classification systems that are as simple as possible. In their opinion, multiple simple classification systems make more sense than relying upon one single, complex classification scheme. Dr. Hann responded that both approaches are necessary. He used the example of the Upper Columbia River Basin Project with which multiple agencies (state and federal) and private conservation organizations are involved. Field work teams gather information on 10-15 quick variables such as cover type, size class, and canopy closure. The goal is to accumulate large amounts of data and develop an accurate legend for the maps that are being produced (Hann, 1994). In addition to this approach, detailed field work accompanies the structural and ecological land unit classification effort. This includes gathering detailed plot information such as
full species lists and other in-depth information. Few of these plots (probably 3-5 plots) will be done in a given structural stage of an ecological land unit (Hann, 1994).

The question of simple versus complex vegetation classification systems will probably never be resolved and perhaps is not worth arguing about. All of the respondents stressed the fact that there is no one "best system", rather there are different approaches that meet the diverse needs of users. The debate over whose system is best contributes to the contentious academic and professional wrangling that continues to hamper cooperative efforts. Academic and professional wrangling were cited by three of the respondents as a major obstacle. The inability of individuals to agree upon common definitions and terminology surrounding the issue of biodiversity was also mentioned by three people.

*Classification scheme should be hierarchical and include different levels of resolution*

Four out of eighteen respondents emphasized the requirement that the classification scheme should be hierarchical and include different levels of resolution. Brown et al., (1980) state that:

most classifications, moreover, are nonhierarchical or only partially hierarchical and, therefore, not readily subject to expansion and field modification. This has resulted in resource management agencies combining and adapting various partial classification systems. The result is that no standardized system that is
An example of a hierarchical vegetation classification scheme currently in use is the system developed for Alaska by Viereck et al., (1992). This system was mentioned by several of the respondents as an excellent model for Montana and Idaho. The Alaska classification was used by Craighead et al., (1988) to map a 33,768 square kilometer (13,034 square miles) area of Arctic vegetation in Northwest Alaska using the Landsat multispectral scanning system (MSS). Derek Craighead (1994) one of the principal investigators, expressed his satisfaction with the Alaska Vegetation Classification system. Craighead et al., (1988) predicts and encourages that, "as other ecosystems are digitally mapped and botanically described, a standardized systematic classification system can be developed for ecosystems around the world." (p.496).

The Alaska Vegetation Classification System (1992) is a hierarchical classification containing units at five levels of resolution:

**Level I:** The broadest, most generalized level consists of forest, scrub, and herbaceous.

**Level II-IV:** Represent intermediate levels of resolution. The number of units in these levels are as follows:

- level II contains 11 units;
- level III, 30 units;
- level IV, 146 units;
- and level V, 888 units.

**Level V:** The finest level of resolution. This level consists of discrete plant communities.
Appendix J includes an excerpt from the Alaska classification as an example of its hierarchical structure.

The system is designed to classify existing vegetation, not potential vegetation. Viereck et al. chose this focus in part because inadequate information existed on the successional relations and pathways of vegetation types in Alaska. The classification includes a review of the vegetation classification work done in Alaska, the hierarchical system, a detailed description of all five levels of the system in tabular form, and a detailed written description of levels I-IV.

The Alaska system is described by the authors as a "pure classification system; that is, one based, as much as possible, on the characteristics of the vegetation itself...Our classification is based on all the plants at any location-the relative abundance of individual plant species." (p.2).

The Heritage Program of The Nature Conservancy is presently working to develop a vegetation classification system for Montana. According to the interviewees involved in this effort, the Heritage Program is favoring an approach similar to that used in the Alaska Vegetation Classification System (Cooper and Hall, 1994).
Classification scheme should include better information on non-forested lands

The sentiment of four of the eighteen respondents was that our present level of knowledge of non-forested lands is inadequate and needs to be improved. The vegetation of the Northern Rockies consists of a mosaic of forest, shrubland, and grassland. Vegetation classification efforts have most focused on identifying a few commercially valuable plants. Muegglar and Stewart (1980) note that, "Little consideration has been given to the successional status of the existing vegetation or to the potential productivity of the environment as reflected by the climax vegetation...Development of habitat type classifications for nonforested wildland has progressed more slowly than that for forested land." (p.1).

Cooperation between agencies, organizations, and research institutions and coordination of efforts

The issue of cooperation and coordination among users of vegetation classification systems produced ambiguous responses. The issues and concerns raised by the interviewees are similar to those mentioned when they were questioned regarding the possibility of standardization of vegetation classification schemes. In general, respondents agreed that better cooperation and coordination are desirable and necessary but they remained skeptical that the issues will be resolved anytime soon.

The general tone of the respondents was that cooperation and coordination will inevitably evolve as a consequence of changes occurring within agencies. Increased dependence on GIS, the shift
towards ecosystem management, and the economic reality that agencies and organizations can no longer afford to maintain disparate approaches were cited as forces leading to increasing levels of cooperation. There was a general feeling among the respondents that such changes will "happen when they happened" and that little can be done to expedite change.

The call to unify various aspects of vegetation classification efforts to facilitate communication, coordination, and cooperation has been given by many people. The efforts of Driscoll et al., (1984) to produce a standardized land classification system is a classic example of a large-scale, multi-agency cooperative project. It involved the U.S. Department of Agriculture's Forest Service and Soil Conservation Service and the U.S. Department of Interior's Fish and Wildlife Service, Bureau of Land Management, Geological Survey, and the National Governor's Association Council of State Planning Agencies.

Three independent hierarchies were included: (1) Potential Vegetation, (2) Soil Taxonomy, and (3) Landform. The system was primarily designed so that inventory data could be aggregated upward into higher levels in linked or unlinked hierarchies. Although the document went through multiple reviews, the final project met with considerable resistance by those within the agencies that felt their needs had not been addressed (Pfister, 1991). Although the system might be useful for basic inventory needs, the National Land Classification did not adequately address mapping needs.
Despite the time and money that was devoted to this endeavor, the system never gained popularity. In fact, the Forest Service (one of the lead agencies) rejected the final product. Several of the interviewees mentioned the failure of this multi-agency initiative as emblematic of the problems associated with trying to introduce standardization into the realm of vegetation classification. Even though the agencies were involved in the effort from its inception, they often could not abide by the system that was developed and reverted back to their “parochial” approaches. As Pfister (1991) writes, “most regions simply proceeded with land mapping according to their regional procedures...The proposed integrated methods have not been widely accepted. Even today, individuals are interpreting the landscape independently by habitat types, soil types, range sites, landforms or remote sensing.” (p.12).

There was concern among most of the respondents that the effort to standardize would rob regional classification systems of the ability to capture variation. One respondent voiced this concern by noting that the important layer of information for most land management decisions affecting native biodiversity is at the lower levels of the hierarchy, where variation is important and hard to capture on the level of large scale, standardized vegetation classification schemes.

Currently, there is an effort underway by The Nature Conservancy, National Biological Survey, and National Gap Analysis Program to pull together a single consolidated list of cover types for the
western United States. The cover types (not species) would have the same elements and be defined consistently (Jennings, 1994).

Institutional barriers such as unequal distribution of funding, lack of trust between and within groups, and differing agency philosophies were mentioned as major underlying barriers to cooperation. The most common observation among the respondents was that it is not economically feasible to develop and implement a classification system that will be acceptable to all user groups. The amount of money and technological support for such an effort, given the assumption that consensus could be reached, would be prohibitive. One respondent observed that there would have to be compromise:

We just don't have the money to take the Northern Rockies from Canada to the Colorado border and know where every bush is. On the other hand, the agencies have the propensity to stay at too coarse a level...We are going to have to pick some level that takes care of a variety of our problems but not all of them. When you get to the level of rare elements in the landscape, trying to remote census that information won't work...The resolution depends upon the scale you want to look at. (Ruediger, 1993)

The irony is that the lack of coordination and cooperation in itself adds hidden costs both in time and money (Jensen et al., 1993). Respondents were able to identify reasons for inadequate cooperation and coordination much more readily than they could suggest solutions. However, they did make some specific
suggestions that could help bridge the gap between agencies and organizations. These suggestions are discussed in more detail below.

*Develop common databases and coordinate data collection methods*

Sharing information via the development of common databases would be a positive step toward increasing dialogue and cooperation between organizations and agencies. It would also increase the accessibility of information to the general public. One respondent was adamant regarding the public's right to know what data has been collected on the public lands.

Developing communal databases could also encourage the sharing of information and coordination of research efforts. The present work of the Northern Region of the Forest Service to promote the use of ECODATA and related databases is one example. Another widely used resource is the inventory and monitoring information available through the Nature Conservancy’s Heritage Program. This resource was cited as valuable by respondents working for the Forest Service (Christensen, Evenden, Ruediger), National Park Service (Kurth), and the Bureau of Land Management (Hirschenberger). Six respondents spoke highly of Roly Redmond's work for the U.S. Fish and Wildlife Service's Gap Analysis Program which they felt was helping to bridge the gap by incorporating information from other research efforts (e.g., The Nature Conservancy, the neotropical migratory bird study) to develop a map of current vegetation for the state of Montana.
Increase the role of peer and scientific review

Three respondents felt that the peer review process should play a pivotal role in all stages of the vegetation classification process. Michael Jennings, U.S. Fish and Wildlife Biologist and Coordinator for the National Gap Analysis Program, stated emphatically his feeling on this subject. He sees a need to implement a standing committee through the Ecological Society of America (ESA) which would work on issues related to classification within a professional society. The ESA committee would serve as the vehicle for building consensus among professionals and establishing a forum in which differences can be addressed. In doing so, Jennings sees a way to develop a common language for describing such factors as disturbance regimes and natural processes at the landscape level, resolving academic wrangling, and developing a systematic approach that deals with structural and taxonomic aspects of vegetation classification (Jennings, 1994).

Dr. Pfister made a related observation regarding the necessity of the peer review process. He believes that many classification systems have failed to gain recognition and widespread acceptance because they are not published in the scientific literature and subjected to peer review. It is not sufficient that the information is published in government documents; it needs to be circulated among a wider audience.
The Alaska Classification System is a good example of an approach that was subjected to intense peer review. The Alaska system took fifteen years to develop and went through several major revisions. The classification was widely circulated and workshops were held around the state to gather input from interested parties.

*Use technologies such as GIS as a tool to facilitate cooperative efforts*

Evaluating land management activities at the landscape level requires that agencies look beyond their jurisdictional boundaries and work with other agencies, organizations, and individuals to forge cooperative efforts. For many of the respondents, GIS and satellite imagery, seem like the logical rallying points upon which to focus cooperative efforts. Six of the respondents, however, were skeptical about the ability of the land managers to make the "quantum leap to landscape conservation."

One of the main advantages of GIS is that it is considered more "objective" than traditional vegetation classification analysis techniques. The technological approach tends to reduce the traditional sources of human-related variability in the data. However, it is important to point out that a different set of variables influences the quality and accuracy of remotely sensed data. There is also controversy regarding the way that satellite images are analysed and the extent to which the data is ground truthed.
The "garbage in garbage out" quandary is a real concern especially when data from a variety of sources (e.g., historical records, existing vegetation maps, and other research efforts) are combined to produce data layers (Pennisi, 1993). Developing consensus among users and standards of quality control are an important and potentially rewarding areas that should be pursued.

**Standardization of vegetation classification schemes**

Responses to this question were similar to those regarding the potential for cooperation and coordination between user groups. This make sense because the two areas are closely linked; without cooperation and coordination it is impossible to develop standardized approaches that are acceptable to the various concerned parties. Despite the pessimism expressed by seven of the interviewees regarding the likelihood of developing a widely accepted standardized approach eleven respondents felt that certain aspects of vegetation classification efforts should be standardized.

At the forefront of many people's minds is the role that technology should play in classification and mapping of vegetation. Some welcome the technology as a means to handle large amounts of data in a more objective and cost efficient manner, as a tool for improving communication among and within agencies, and as a valuable tool to survey large tracts of land. Others are more skeptical and feel that GIS, models, and complex databases are the newest "techno toys".
These respondents do not reject the emerging technologies, but they question the degree that we can rely upon technology to solve the complex problems we face. A concern voiced by four respondents was the problem of getting caught up in science for science's sake.

*Focus efforts on the standardization of data collection rather than upon the classification stage.*

This point reiterates the feeling among most of the respondents that there is no one "best system" and that given the variety of user needs and objectives it is futile to try to foist a system upon land managers and other user groups. The respondents felt a more constructive approach would be to work toward the development of agreed upon data collection techniques. Dr. Hann (1994) felt that some of the biggest differences occur in the descriptive data (e.g., plot data, average cover, leaf area index) that is collected on site conditions. The Northern Region of the Forest Service is hoping that ECODATA can help remedy this problem.

**Emerging technologies**

Most of the points regarding emerging technologies have already been addressed in previous sections. However, an interesting observation that was made by two respondents is worth mentioning. Both felt that GIS and other technologies hold great promise for helping address landscape level management problems. However, they felt that this potential is not being realized because of internal agency resistance. This resistance was identified as a form of denial on the part of agency personnel based upon the possibility
that remotely sensed data and GIS could be used to elucidate agency mismanagement of public lands, e.g., overharvesting, forest fragmentation, and misrepresentation of the available timber base.
CHAPTER 5

CONCLUSION

It should be understood that land classification and mapping call for specialized
techniques, good judgement, honest execution, and scientific knowledge.
-Bailey et al. (1978)

It is not enough to understand the natural world: the point is to defend and preserve it.
-Edward Abbey

The Role of Vegetation Classification Systems: Promises and Challenges

I began this paper with the assumption that a properly designed vegetation classification system could be used as a tool for helping to maintain native biodiversity. Based upon my interviews and research, I conclude that this assumption is partly true and partly false. It is true for the reasons outlined below that vegetation classification systems have a legitimate role to play in conservation efforts. However, it is not true that one vegetation classification system can satisfy the needs of all users and meet the objectives of all research projects.

Evaluation of vegetation at the landscape level, for example, involves different spatial and temporal considerations than evaluation at the community level. It is not appropriate, desirable, or realistic to expect one classification system to work across these diverse levels of analysis. There are, however, certain elements that should be included in any vegetation classification
system designed to play a role in conservation of biological diversity. In Chapter Six, I define some of these elements.

At the beginning of this paper I posed two specific questions. These questions were: (1) What are the various conceptual and practical reasons for developing a vegetation classification system? and (2) What elements should a vegetation classification system contain if it is to meet the objective of helping to maintain native biodiversity? In formulating answers to these questions, I have managed to generate additional, and more complicated questions, as well.

Vegetation classification plays a definite role in the development of conservation strategies that can aid in the maintenance of biodiversity. Conceptually, the vegetation classification process is essential to ordering information and making sense of the complexity of the natural world. From a practical standpoint, in terms of biodiversity, it is essential that we have organizational schemes that deal with vegetation for the following reasons: (1) vegetation is one of the most tangible representations of ecosystems; (2) vegetation provides the habitat that most organisms rely upon for survival; (3) vegetation classification systems are necessary to identify and help protect various types of rare and endangered plant communities i.e., old growth, native prairies, and wetlands.
The evidence gathered during my interviews with land managers, biologists, ecologists, and others supports the claim that vegetation classification systems play an important role in conservation efforts. Grizzly bear, neotropical migratory birds, and whitebark pine studies are all examples of work being done that relies on vegetation classification. Vegetation classification and analysis to determine the magnitude and rate of change due to human activities on the landscape level is another example of important studies now underway. However, it must be emphasized that vegetation classification *per se* does not protect native biodiversity, it can only provide the data upon which policy makers can base their decisions.

It is not enough that technological advances and ecological understanding are contributing to the growing body of knowledge regarding ecological processes and function. Somehow, we must translate these advances into action. The potential for constructive action clearly exists. GIS technology, for example, can serve as a valuable tool for helping us see the big picture and for determining if certain kinds of mismanagement are occurring on public and private lands.

However, GIS and remotely sensed information will not magically allow us to solve ecosystem level problems. Developing landscape level conservation prescriptions to protect bull trout, for example, will not be possible until fundamental shifts in management and political reality occur. These shifts in turn, will be difficult to
accomplish without societal approval. The real question then becomes: Given the social, political, and economic constraints placed upon conservation efforts, how can we most effectively harness the information derived from vegetation classification systems so that we can meet the objective of maintaining native biodiversity? In the final section of this professional paper I will address this question through specific recommendations.

The second question I asked was: What elements should a vegetation classification system contain if it is to meet the objectives of helping to maintain native biodiversity? In order to determine what people wanted to see included in a classification scheme, I had to explore both the impediments to the development of such a system and the respondent's suggestions for overcoming these barriers.

It is no secret that debates over the various approaches to classifying vegetation have often led to dissention which in turn has sometimes crippled cooperative efforts and constructive dialogue among users. However, the users are not as far apart from one another either ideologically or in their research needs as they often perceive. There is room for healthy debate and multiple approaches. What there is not room for is proprietary research efforts and egotistical endeavors. During my interviews I was often struck by the fact that individuals concerned with similar issues and working on projects of similar scale often had no contact with each other.
If the human race is truly in the midst of a biodiversity crisis as many conservationists contend, then it is imperative that we carefully evaluate our options and determine how we can best stem the tide of habitat destruction and ecosystem simplification. If we choose to continue on the present course of academic and professional wrangling and proprietary research efforts, we will expend an inordinate amount of time and money duplicating the work of others or possibly missing key issues entirely. If we are in fact entering a new era of enlightenment heralded by ecosystem management, then developing vegetation classification systems that can be used across political and agency boundaries is essential.

It is difficult to develop a comprehensive vegetation classification system while attempting to provide information to policy makers who will in turn make crucial conservation decisions. In our haste to provide decision makers with information, there is the danger of relying too heavily on computer models, multi-resolution databases, and GIS. These technologies represent tools that can be used to handle large amounts of data, but the information generated from these sources must be critically evaluated and, in the case of GIS-generated vegetation maps, rigorously ground-truthed.

If we must err in our conservation strategies, let it be on the side of caution. One of the interviewees contended that the issues surrounding biodiversity were too subjective, "too values-oriented", and that he preferred to remain in the scientific realm. On the
contrary, all decisions regarding natural resources are value-oriented and cannot be treated otherwise.

In the final section of my professional paper I present key findings and recommendations. Although the findings and recommendations are based largely upon the suggestions and comments made by the interviewees, they reflect my impressions of the issue, not those of any of the individual respondents. While I believe there is merit in all the solutions offered by the respondents, I have focused on a selected number of topics that I hope will facilitate the process of getting people together to discuss the various issues surrounding vegetation classification systems.
Below is a list of key findings and recommendations:

1. It is neither possible nor desirable to expect one vegetation classification system to meet the needs of all user groups. Picking the appropriate vegetation classification system is dependent on such factors as scale, funding, time, goals of the user, and project objectives. However, the requirement for specificity based upon user needs does not preclude the development of standards, guidelines, and criteria designed to improve vegetation classification systems.

2. People involved in the use and the development of vegetation classification systems need to set clear goals, i.e. What do we want our classification system to accomplish? GIS and related technologies are limited in the type of information they can provide. The limitations of GIS must be acknowledged and remotely sensed data must be rigorously ground-truthed by trained field crews. Concerned researchers and land managers must work together to develop acceptable guidelines to ensure that remotely sensed data is used responsibly.

3. There are areas of consensus among users which could yield improvements in current vegetation classification efforts. People
involved in the development and implementation of vegetation classification schemes must improve communication so as to avoid repetitive and inefficient use of time and funding. While no single vegetation classification system can meet all user needs, there is the possibility of developing a core group of complementary classification efforts that address different temporal and spatial scales. Vegetation classification systems designed to aid in the maintenance of biodiversity should include the following components:

**Structure:** Current classification efforts do not adequately portray structural characteristics of the vegetation. At both the fine scale (community level) and the coarse scale (landscape level) there is consensus among users that this aspect of vegetation classification effort needs to be developed. Inclusion of structural characteristics are scale-dependent. Efforts are currently underway to develop vegetation classification schemes that include information on structure. Therefore, the time is right to develop structural criteria for different classification approaches that accommodate the needs of a variety of users. Interested individuals should meet to discuss this topic and form a task force to determine what type of structural information should be included. Specific input from biologists should be collected.

**Existing vegetation:** Land managers, ecologists, researchers, and policy makers all agree that we need to develop more comprehensive classification approaches that deal with seral vegetation as well as
climax vegetation. Current efforts are underway and examples of systems in use in other parts of the country already exist: the Nature Conservancy is currently working with the U.S. Fish and Wildlife Service to develop a national hierarchical classification that describes vegetation cover types, compatible at the series level with existing regional and national classification systems; the Heritage Program of Montana is in the midst of developing a classification system similar to that used in Alaska (Viereck et al., 1992); Dr. Pfister and others are working to modify habitat typing to better address successional vegetation and structural stages. These are just a few examples of the classification efforts currently underway that address classification of existing vegetation.

Specific organizations and agencies should work to become involved with ongoing efforts rather than initiating their own, separate efforts. In order to facilitate this, an open letter should be sent to the various individuals interviewed for this professional paper inviting them to participate in a series of work sessions. One of these work sessions would specifically focus on a discussion of ongoing efforts and include an opportunity for different organizations and agencies to "plug in" to ongoing efforts.

**Develop Descriptors:** Vegetation maps are commonly constructed from remotely sensed data (the Gap Analysis approach described in Appendix I is a good example). The distribution of animal species (usually designated as presence/absence) is then predicted based upon the known association between the animal species and the
vegetation types. A shortcoming common to most vegetation classification systems is that no information on the quality of habitat is included. Currently, there are no widely accepted habitat descriptors or habitat quality rating system that can be used in conjunction with vegetation classification. The development of habitat descriptors that could be included in vegetation classification system for wildlife purposes would be advantageous.

**Standardization:** Most respondents negatively perceive efforts to standardize vegetation classification. Some feel that they would be forced to submit to outside interests while others feel strongly that standardization by definition implies a reduction of standards to some unspecified lowest common denominator.

Although respondents were resistant to the idea of standardization of vegetation classification systems, four felt that standardization of data collection techniques was necessary. The main objective would be to create uniformity and improve compatibility of data. Areas that could greatly benefit from standardization include:

- Standardization of map legends (colors, symbols, descriptors)
- Reporting of technical information (type of GIS technology used)
- Standardization of information regarding plot samples (including GPS coordinates)

Standardization does not mean forcing people to accept something they don't want. On the contrary, it means gathering people together

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to identify how to improve the systems to better meet user needs. Developing acceptable standards for gathering descriptive data on vegetation plots, insuring that ground truthing of remotely sensed data is adequate, and requiring that researchers contribute their data to common data bases and the development of coordinated inventories are all areas that should be addressed.

Agencies and organizations should develop and publish manuals that help translate information among classification schemes. An effort by Gebhardt et al., (1990) entitled "Riparian and Wetland Classification Review" is one example in which the researchers systematically evaluate various riparian and wetland classification systems. This type of work would help bridge the gap between the different classification systems and educate land managers about the different systems available to them. Publications that allow land managers to "crosswalk" between classification systems should be required of all agencies and organizations.

**Training and Education of Personnel:** Agencies and organizations must make the training and education of personnel a top priority. This includes getting experienced land managers back out in the field and involved in overseeing vegetation classification efforts. Money and time are required to insure that the information gathered is credible.

The lack of trust regarding the quality of data is a major impediment to developing coordinated efforts. Agencies and
organizations should sponsor joint training workshops and involve university students and faculty. One of the complaints voiced by respondents was that students are not receiving adequate training to prepare them for field work.

**Responsibility to contribute data to common databases:** Anyone who gathers data on vegetation should be required to contribute it to communal databases that will be set up through cooperative efforts. This requirement will break down the barriers both within and between agencies. It will also facilitate efforts to develop guidelines for standardizing data collection methods.

**Offer work sessions:** Interested parties could be invited to attend a series of work sessions sponsored by a local conservation organization or other non-agency organization. An initial inquiry to determine the degree of interest could be made by contacting people interviewed in my professional paper. If certain individuals express a high degree of interest, then a smaller organizational meeting could be held. It would be important that groups working on both small scale and large scale classification efforts should be included.

The goal of the work session would be to explore the potential for agencies and organizations to work together. The results of my professional paper could be used as a tool to bring people together to discuss various aspects of vegetation classification systems. The information included in the results and discussion sections could be
presented in a condensed form that highlights areas of consensus and areas where consensus is needed.
Appendix A
A Summary of Kuchler's Method
for Structural Description of Vegetation

<table>
<thead>
<tr>
<th>LIFE-FORM CATEGORIES</th>
<th>SPECIAL LIFE FORMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woody Plants</td>
<td>Climbers (lianas)</td>
</tr>
<tr>
<td>Broadleaf evergreen</td>
<td>B</td>
</tr>
<tr>
<td>Broadleaf deciduous</td>
<td>D</td>
</tr>
<tr>
<td>Needleleaf evergreen</td>
<td>E</td>
</tr>
<tr>
<td>Needleleaf deciduous</td>
<td>N</td>
</tr>
<tr>
<td>Aphylous</td>
<td>O</td>
</tr>
<tr>
<td>Semideciduous (B + D)</td>
<td>S</td>
</tr>
<tr>
<td>Mixed (D + E)</td>
<td>M</td>
</tr>
<tr>
<td>Herbaceous plants</td>
<td>G</td>
</tr>
<tr>
<td>Graminoids</td>
<td>H</td>
</tr>
<tr>
<td>Lichens, mosses</td>
<td>L</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEAF CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed (D + E)</td>
</tr>
<tr>
<td>Herbaceous plants</td>
</tr>
<tr>
<td>Graminoids</td>
</tr>
<tr>
<td>Lichens, mosses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STRUCTURAL CATEGORIES</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (Stratification)</td>
<td></td>
</tr>
<tr>
<td>8 = &gt;35.0 metres</td>
<td>c = continuous (&gt;75%)</td>
</tr>
<tr>
<td>7 = 20.0-35.0 metres</td>
<td>i = interrupted (50-75%)</td>
</tr>
<tr>
<td>6 = 10.0-20.0 metres</td>
<td>p = parklike, in patches (25-50%)</td>
</tr>
<tr>
<td>5 = 5.0-10.0 metres</td>
<td>r = rare (6-25%)</td>
</tr>
<tr>
<td>4 = 2.0-5.0 metres</td>
<td>b = barely present, sporadic (1-5%)</td>
</tr>
<tr>
<td>3 = 0.5-2.0 metres</td>
<td>a = almost absent, extremely scarce</td>
</tr>
<tr>
<td>2 = 0.1-0.5 metres</td>
<td>(&lt;1%)</td>
</tr>
<tr>
<td>1 = &lt;0.1 metres</td>
<td></td>
</tr>
</tbody>
</table>

source: Kent and Coker (1992, p. 34).
The hierarchical order of UNESCO is as follows:

- **Formation class**
  - **Formation subclass**
  - **Formation group**
  - **Formation**
    - **Subformation**
    - **Further subdivisions**

The vegetation units are listed in hierarchical order under each of the following seven formation classes (Mueller-Dombois and Ellenberg, 1974):

1. Closed forests
2. Woodlands or open forests
3. Scrub or scrubland
4. Dwarf-scrub and related units
5. Terrestrial herbaceous communities
6. Deserts and other sparsely vegetated areas
7. Aquatic plant formations

Terms referring to climate, soil, and landforms are included in the vegetation names and definitions, wherever they aid in the identification of the units. The units are based on the outward appearance of the stand and plant height characteristics.

The UNESCO format has been modified in the United States to meet specific needs. For example, in order to classify potential natural vegetation as a part of their effort to develop a standardized land
classification scheme for the United States, Driscoll et al., (1984) modified the UNESCO approach by adding two lower levels: series and association. Gap Analysis also builds on a modified version of UNESCO but is focused on the classification of existing vegetation. Therefore, Gap Analysis has added cover type and community type which refer to existing vegetation (see diagram below). Gap Analysis and GIS are further discussed in Appendix I.

<table>
<thead>
<tr>
<th>Category</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>Woodlands</td>
</tr>
<tr>
<td>Subclass</td>
<td>Mainly Evergreen Woodlands</td>
</tr>
<tr>
<td>Group</td>
<td>Evergreen Needle-Leaved Woodlands</td>
</tr>
<tr>
<td>Formation</td>
<td>Evergreen Coniferous Woodlands with Rounded Crowns</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Cover Type</td>
<td>Juniperus occidentalis</td>
</tr>
<tr>
<td>Community Type</td>
<td>Juniperus occidentalis / Artemisia tridentata (the codominant species of the plant community by canopy layers)</td>
</tr>
</tbody>
</table>

UNESCO vegetation classification format.

source: Jennings (1993, p.3)
## Appendix C

### Habitat Typing: Montana Habitat Field Form

<table>
<thead>
<tr>
<th>HABITAT TYPE</th>
<th>SERIES</th>
<th>PHASE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table of Vegetation Types

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Canopy Coverage Class</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Abies grandis</em></td>
<td>grand fir</td>
<td></td>
</tr>
<tr>
<td><em>Alyssum saxatile</em></td>
<td>Alyssum saxatile</td>
<td></td>
</tr>
<tr>
<td><em>Larix lyallii</em></td>
<td>Alaska larch</td>
<td></td>
</tr>
<tr>
<td><em>Larix occidentalis</em></td>
<td>Western larch</td>
<td></td>
</tr>
<tr>
<td><em>Picea glauca</em></td>
<td>White spruce</td>
<td></td>
</tr>
<tr>
<td><em>Pinus contorta</em></td>
<td>Lodgepole pine</td>
<td></td>
</tr>
<tr>
<td><em>Picea engelmannii</em></td>
<td>Engelmann spruce</td>
<td></td>
</tr>
<tr>
<td><em>Pinus albicaulis</em></td>
<td>Whitebark pine</td>
<td></td>
</tr>
<tr>
<td><em>Pinus ponderosa</em></td>
<td>Ponderosa pine</td>
<td></td>
</tr>
<tr>
<td><em>Thuja plicata</em></td>
<td>Western redcedar</td>
<td></td>
</tr>
<tr>
<td><em>Tsuga heterophylla</em></td>
<td>Western hemlock</td>
<td></td>
</tr>
</tbody>
</table>

### Notes
- Scientific Name
- Common Name
- Canopy Coverage Class

### Source
Pfister and Lee (1978, p.20)

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Appendix C

Habitat Typing: Generalized Description of Forest Trees in Southwestern and South-Central Montana

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**FIGURE 3.**--Distribution of forest trees in an area of northwestern Montana. Arrows show the relative elevational range of each species; solid portion of the arrow indicates where a species is the potential climax and dashed portion shows where it is seral.

---

**FIGURE 4.**--Generalized distribution of forest trees in southwestern and south-central Montana. Arrows show the relative elevational range of each species; solid portion of the arrow indicates where a species is the potential climax and dashed portion shows where it is seral.

*source: Pfister and Lee (1978, p.8)*

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Appendix D
British Columbia Biogeoclimatic Ecosystem Classification

Levels of integration in the classification system

source: Meidinger and Pojar (1991, p.18)
Appendix E
Sample Cover Letter and Interview Questions

Mr. Dennis Grossman
The Nature Conservancy
1815 North Lynn Street
Arlington, VA 22209

February 10, 1994

Dear Mr. Grossman

I am writing my master's thesis in environmental studies at the University of Montana. My goal is to begin to define attributes of a vegetation classification system to help inventory and protect native biodiversity within Montana and Idaho. Most land managers, ecologists, and botanists agree that from an ecological, social, and political standpoint it is necessary to develop a practical and applicable vegetation classification system.

A major part of my thesis is to interview people such as you who have a working understanding of the difficulties involved with classifying vegetation. I am interested in your thoughts regarding the development of a vegetation classification system that is functional, comprehensive, and most importantly could be used by land managers and field scientists. I hope that you can help me compile a concrete list of suggestions of what the ideal vegetation classification system should contain. I want to do this without losing sight of the main objective of this classification scheme: A system which will serve as a useful tool to help protect native biodiversity and augment efforts to develop long-term, landscape level conservation strategies.

Several conservation organizations have expressed interest in my project and I plan to share my results with them. The goal is to facilitate the development and implementation of a useful...
vegetation classification scheme. Your input is crucial to this process. Below are a list of interview questions I have included to give you an idea of the types of issues I am exploring. I thank you for taking time to consider these questions. I would like to meet with you in person and discuss your thoughts on these and perhaps other issues as well. I plan to call you early next week to schedule an appointment at your convenience. If you do not have the time to meet with me (or hold a telephone interview), or feel that there is a more appropriate person for me to speak with, I'd appreciate you letting me know how best to reach that person. Again, thank you for spending the time to consider my questions and helping me complete my project.

Sincerely,

Jennifer Ferenstein
228 S. 3rd W. #2
Missoula, MT 59801
543-0079
Defining biodiversity:

While there are divergent views as to the exact meaning of biodiversity and the correct way to measure it, for the purpose of this discussion I have used the following definition:

Biodiversity refers to the variety and variability among living organisms and the environments in which they occur and is recognized at genetic, species, ecosystem and landscape levels.

Please keep in mind that the purpose of this interview is to get your thoughts on how to develop a vegetation classification system that can be used as a tool to inventory and maintain native biodiversity.

INTERVIEW QUESTIONS

1. What information (such as landscape type, basic geographical and soil conditions [substrate, soil texture, and soil type, water regime, chemical properties] climatic data [climate type, average annual temperature and precipitation, specific climatic relations]) should be incorporated into the vegetation classification scheme? How?

2. Recognizing that different people are working at different scales how do you think we can best develop a classification system that is flexible and can accommodate the needs of specific users?

3. How should the classification system be structured? If the classification system is to be hierarchical, what are the appropriate levels of resolution?
vegetation classification survey
February 10, 1994
Jennifer Ferenstein

4. How can we incorporate temporal factors and management effects on ecosystems, e.g. fire, logging, roads into a classification scheme?

5. In your view, what are the biggest obstacles to developing a vegetation classification system.

6. Do you see any value for a new vegetation classification system that is acceptable to state and federal agencies, university and private users? What are biggest obstacles to developing a coordinated approach?

7. Who should collect information? How should the information be stored? How do you feel about the idea of developing a common database in which the information would be available to many different agencies and private organizations?

8. What do you see as the role of GIS technology in developing the "ideal" vegetation classification system?

9. Have you, or are you, involved in work which requires the use of a vegetation classification system? If yes, what is the objective of your project what classification scheme(s) have you, or are you using?

10. Have they been satisfactory, why/why not? Are you conducting field work, what type? Remote sensing, literature review, etc.

11. Do you see value in developing a regional vegetation classification system that is complementary to and compatible with adjacent regions (biomes) and is a subset of a national or global classification scheme?
## Appendix F

### Interview Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Interviewee Details</th>
</tr>
</thead>
</table>
| 7 February 1994 | Peter Stickney  
Plant Ecology and Plant Succession  
Intermountain Research Station  
USDA Forest Service  
(406) 329-3485 |
| 8 February 1994 | Troy Merrill  
PhD Candidate  
Gap Analysis Lab and  
Idaho Conservation Information Center  
University of Idaho  
(208) 883-1474 |
| 8 February 1994 | Michael Jennings  
Coordinator National Gap Analysis  
Project National Biological Survey  
Idaho Cooperative Wildlife Research Unit  
(208) 885-6960 |
| 10 February 1994 | James Habeck  
Professor Emeritus  
Department of Botany  
University of Montana  
Missoula, MT.  
(406) 243-2582 |
| 10 February 1994 | Robert Pfister  
School of Forestry  
University of Montana  
Missoula, MT  
(406) 243-6582 |
| 11 February 1994 | Christopher Servheen  
Coordinator Grizzly Bear Recovery Project  
Montana Cooperative Wildlife Research Unit  
University of Montana, Missoula, MT.  
(406) 243-5540 |
11 February 1994  Penny Morgan  
Associate Professor  
University of Idaho  
College of Forestry, Wildlife, and Range Science  
Moscow, ID 83843  
(208) 885-6226  
received written response

14 February 1994  George Hirschenberger  
Supervising Forester  
Bureau of Land Management  
Garnett Resource District  
3255 Fort Missoula  
Missoula, MT 59801

15 February 1994  Robert Keane  
USDA Intermountain Research Station  
Fire Lab  
P.O. Box 8089  
Missoula, MT 59807  
(406) 329-4846

15 February 1994  Alan Christensen  
Wildlife Program Manager  
USDA FS Northern Region  
P.O. Box 7669  
Missoula, MT 59807  
(406) 329-3291

22 February 1994  (group interview)  
Bernie Hall  
Conservation Director  
The Nature Conservancy  
32 S. Ewing  
Helena MT 59601  
(406) 443-0303

Dean Culwell  
Environmental Consultant  
West Tech  
P.O. Box 6045  
Helena, MT 59604  
(406) 442-0950

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Steven Cooper
Director, The Heritage Program
1515 East 6th Ave
Helena, MT 59620
(406) 444-3009

23 February 1994
Angie Evenden
USDA Intermountain Research Station
Research Natural Areas Manager
Missoula, MT
(406) 329-3485

23 February 1994
Bill Ruediger
Threatened, Endangered, and Sensitive Species Program Manager
USDA Forest Service Northern Region
P.O. Box 7669
Missoula, MT
(406) 329-3100

24 February 1994
Tom Puchlerz
National Grizzly Bear Habitat Coordinator
USDA Forest Service Northern Region
P.O. Box 7669
Missoula, MT
(406) 329-3561

2 March 1994
Laurie Kurth
Ecologist
Glacier National Park
(406) 994-5401
interviewed by phone

8 March 1994
Wendell Hann
(group interview)
Landscape/Ecosystem Assessment Group Leader
USDA Forest Service Northern Region
P.O. Box 7669
Missoula, MT
(406) 329-3214

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Appendix G
Interview Responses

Identification of main obstacles to developing a useful classification system

So many different vegetation classification systems it may not be possible to come to a consensus (among agencies)

Difficulty trying to capture the detail/information in one system

Controversy surrounding climax communities and seral (existing vegetation). Need to work toward classifying seral communities

Certain community types have not yet been adequately described

Have to find better ways to educate people on how to use classification schemes

"Unfriendly" nature of UNESCO-too academic, too global

Land managers are too busy/overworked to take the time to learn "academic" vegetation classification systems. They don't see relevance in the hierarchical approach.

Problem coming to an agreement about how to define biodiversity

Land management is politically driven. Political division precludes landscape level management decisions.

Large areas (in Montana and Idaho) that haven't been classified using habitat typing or any other method

Incredible range in the quality and detail of the vegetation information that's been gathered over the last 20 years

Agencies have been proprietary with their information
Agencies have had a problem training people to adequately identify plant species

Unclear how information gathered from vegetation classification will be used. We gather information but we don't know what to do with it. We haven't yet entered the realm of analysis

Habitat typing is an inadequate portrayal of seral stages and/or structural stages of vegetation

Habitat typing can't capture variability

Intra-agency rivalries

Generation gap in agencies. Many people are unfamiliar with new technologies and hierarchy theory

Many agency people are in denial. They don't want to acknowledge that problems exist

Too much bureaucracy

Thematic mapping is not meeting needs regarding vegetation structure and ground cover

Not enough information on shrubs and transitory vegetation

Subjective nature of classification (depends upon who did it)

Problem working on private land

Lack of trust regarding data collected by others

Not vegetation but the underlying causal mechanism (processes) that are important to understand

Management doesn't care and/or have time to use vegetation classification systems of great detail. They are looking at broad cover types

Lack of personnel and computer resources
No common language to discuss biodiversity
Psychological and institutional barriers are difficult to overcome. Generation gap in agency obstruct changes in the system

There is no best system for classifying vegetation

Keep vegetation classification systems simple

Vegetation classification task forces and committees agree on things but then their findings are never circulated and/or published, therefore, the documents are not critically reviewed, widely accepted and do not get used

Top down approach (standardization efforts) is one of the biggest impediments

Problems with the quality of information being used (garbage in garbage out)

No systematic, taxonomic approach for classifying existing vegetation

Coming up with a system that is agreeable to everyone would be too expensive to implement

Need to deal with underlying problems of uses of resources and number of people and stop relying on these indirect approaches

Academic wrangling and differences in opinion about what is the "best" system

Lack good terminology for discussing biodiversity

Most of our past work has been tied to economic concerns (unless you can graze it or cut it down we haven't been too interested in it)

Problem capturing variability and when we're talking about biodiversity that's the name of the game
Habitat typing ignores and/or devalues the vegetation that currently is on site

Temptation to play with fancy techno-toys

Trying to understand unique places that don’t fit into the system

Don’t have the time to do extensive surveys we are in the midst of a crisis. We need to protect what we have left

Not enough trained people doing field work

Denial of land managers that problems and mismanagement do exist

Academic wrangling - splitters versus lumpers

Fighting for funding

No good ways to spatially reference the vast amounts of information we already have

Too much emphasis on potential natural vegetation

Need to focus on habitat fragmentation issues by looking at the level of human activities in the landscape

Trying to find a classification system that meets your needs-constantly trying to fit your work into an existing classification scheme

Budget constraints

Finding trained people

Philosophical differences between agencies

Incompatibility of vegetation data

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Communication between agencies to look at patterns of existing vegetation in the landscape

Preferential intra-agency funding

Incompatibility of data gathered within and between agencies

Can't agree (intra agency)

Budget constraints

Identification of elements that should be in a vegetation classification scheme for biodiversity

Need to look at potential natural vegetation and be able to model successional pathways in order to understand not only vegetation but underlying processes. There are so many possible seral stages that you need to be able to identify potential.

Need to incorporate seral communities into vegetation classification

Use a hierarchical approach with different levels of resolution

Include structural aspects as outlined by UNESCO

Classify more plant species

More adequate portrayal of existing vegetation

More adequate portrayal of structural stages

Modeling of successional pathways (complementary to classification efforts)

Incorporate some abiotic factors and/or information on landforms

Include major species and successional stage

Better breakdown of grass, herb, and shrublands
Add descriptor that indicates the quality of the vegetation as habitat

Structure (somewhat important)

User friendly, needs to be specific enough to meet specific needs

Need a common database

Look at existing vegetation not potential natural vegetation

Vegetation structure

Include information on ground cover component

Need more information on shrub and transitory layers

Base upon Pfister's work - it is well accepted and understood

Needs to be tied to remote sensing

Combination of remote sensing and existing vegetation

Possibility of including descriptors (quality of habitat)

Include information on down woody material and snags

Standardization of data gathering rather than analysis technique

Need to look at causal mechanisms that are driving the process rather than the vegetation itself to develop and validate models of successional pathways

Hierarchical

Need to develop a complete ecological inventory

Importance of simulation models

Robust system in which information can be shared. Work to standardize data collection
Hierarchical/modular approach that starts at basic level of organization that can be built upon (add in modifiers later)

Existing vegetation, not potential natural vegetation

Need to update system (depending on site history)

Descriptors for structure

Systematic approach

Common database

Don't combine potential natural vegetation classifications with existing vegetation classifications

In terms of looking at vegetation in time and space we need to include structural classification

Maybe can combine more than one simple classification scheme that incorporates such factors as age and size. Use multiple single class rather than one complex one

Instead of building a new classification system why not modify an existing one?

Classification system cannot ignore the spatial aspect (must be compatible w/GIS)

Structural classification that accounts for size, density, number of layers and incorporates them into an operational taxonomy used for inventory, communication, and mapping

Species composition, vertical structure, density, and something that indicates the stage of development along the successional pathway

Keep classification as simple as possible

Existing vegetation
Structural information integrated with vegetation composition to look at patterns in the landscape.

Need to look at culturally modified landscape/habitat value.

Existing vegetation.

Need to know something of potential natural vegetation and still take into account existing vegetation.

Underlying landform characteristics, some aspects of site history (fire regimes, etc) in order to make predictions.

Incorporate descriptors.

More information on shrub component.

Collective database.

Tied to landforms or some other physiogeophysical processes.

Existing vegetation.

Structure.

Cooperation between agencies, organizations and research institutions and coordination of efforts.

Lack of coordinated mandates and goals (RNAs).

Probably not economically ready at this point to go to the level of resolution desired by some people. On the other hand, the agencies have the propensity to work at too coarse of a level. Needs to be some compromise.

Use the committee approach to bring people together.

Problem with lack of trust re: quality of information.
Importance of peer and scientific review (involve people outside of the agency)

Technology will help pull it together and allow a unified classification system to emerge

Responsibility to gather data and make it available to others.

Use ECODATA to foster cooperation between agencies and private users

Definite need to develop a coordinated/cooperative effort within agency (USFWS).

Create a professional committee to oversee issues related to classification.

Offer professional symposia to educate people about what’s available

Top down approach is one of the biggest impediments because people at the top have forgotten what it’s like in the field

Coming up with a system that is agreeable to everyone will be too expensive to produce

Motivation for cooperation will come from outside of the traditional land management agencies. The EPA will be a driving force. Certain agencies that are tied to habitat typing will resist. The interface will probably occur at the university or intermountain research station level.

Doesn’t see much more hope for cooperation than he did 10 years ago

Likes the Heritage Program approach. Could be used more

GIS technology will facilitate cooperative efforts by giving us the big picture

Collaboration among agencies is essential to hold down costs
Doesn't think it will work to try to get people to gather data for other than their own purposes. Factionalism among the departments and inequity in distribution of money keeps barriers up. Classification systems are picked and developed to meet specific purposes the data is not designed to be compatible

Should be required to gather some core of information that could be entered into a common database

Lack of coordinated efforts are often a function of lack of money

**Issue of standardization of vegetation classification schemes**

So many vegetation classification systems out there and academic wrangling is fierce. The Nature Conservancy is beginning to reach consensus regarding vegetation classification approach (within its own organization). Doesn't know if will be possible to develop systems that are acceptable across agency boundaries

Not a big problem for us. Most of our effort go through the Heritage Program. We are modifying habitat typing to meet our needs

The drawback of standardization of GIS is that in order to get simplicity you lose definition and clarity. Some sort of standardization needs to occur.

We can't afford to send out big crews anymore so we are going to have to rely more on remote sensing. Therefore, we need to come up with standardized sampling procedure

Need quality control of GIS

We need to involve statisticians in sampling, e.g., how many plots do we need to ensure adequacy of ground truthing?

The whole idea of standardization of vegetation classification is doomed to failure. Vegetation responds to the environment
and the environment is a continuum. It won't work trying to have one habitat scheme for Region 1 or the Northern Rockies.

We hope (through ECODATA) to collect the information into a common database. There's been talk of standardization of vegetation classification at least in terms of methodology. I don't think it will happen.

Vegetation classification is subjective and based upon user needs. We will not be able to develop standardization that is acceptable across research groups.

We should emphasize the standardization of data gathering rather than analysis.

5% of cost is analysis. Collection of data is much more. Standardization of data collection is a really good first start. ECODATA is a good place to begin. Work to improve ECODATA and to get cooperation between agencies and private lands: develop adaptive or coordinated inventories.

Need to develop standards designed for biodiversity purposes.

Develop common database.

Standardization is too expensive. We'll never develop a system that is acceptable to everyone.

Standardization can't meet the needs of individuals.

We will come up with a standardized system. We'll follow the lead of EPA, USGS, SCS.

A high degree of standardization will force the loss of all local variation in classification systems.

It will boil down to a technical question. The standards will be written by bureaucratic organizations. There is value in standardization but also losses.

We need to understand the unique places in the landscape. We need vegetation classification systems that can capture...
variability. Not possible to get this if the goal is to standardize

Roly Redmond’s (Gap Analysis) is work important because it creates consistency and communication across agency boundaries

**Role of emerging technologies**

Important role for modeling to delineate successional pathways

Nothing really all that new about GIS just creating overlays for maps. All we’re doing is playing with GIS. I think a lot of people get hung up on fun toys. Really just the same old thing

There is value in GIS, it is a tool for doing new types of visual analysis. Gives us a better perspective on the bigger picture

Remote sensing of rare elements won’t work and will have to done on a site by site basis. We are going to have pick some level that takes care of a variety of our problems but not all of them

I do think a lot of our problems will be solved by technology. Need to look at different scales and different levels of resolution

Need common databases

Thematic Mapper (TM) is not giving us a real good look at what is in the understory. Need something more to deal with structure

Although there are problems with remote sensing there is less variability than with traditional methods of sampling.

In terms of vegetation for our work with grizzly bears we can get all the information we need from TM.

Need to field check
Need to acknowledge that differences in resolution are important and separate the project level needs from the landscape level needs.

Stresses the importance of models. Focus on identifying the underlying processes (causal mechanisms) and develop predictive tools for determining site potential (causal factors that are driving succession).

Simulation models are just as important as vegetation classification.

People are relying too heavily on GIS. Although it is a good overall view to help summarize the landscape it has limits. It does not tell you exactly where you have a specific species.

Doesn't put much faith in models.

Has strong reservations about the level of resolution possible with LANDSAT.

Resolution on GIS not necessarily fine enough to pick up culturally modified landscape - it ends up getting lumped.

By using a vegetation classification system that incorporates structure and information displayed by GIS you can look at the question of adjacency - patterns of vegetation - how they stand together structurally. Can look at corridors and barriers to movement.

Believes that structural information can be gathered using GIS.

Don't know what information exists until ground truthing is done.

It is really tempting to play with all the fancy toys. However, it is pretty empty knowledge unless we improve our ability to statistically predict what is happening on the ground.

We are not improving our ability to analyse the information. We still don't know what it means to have a certain association let alone a combination of factors on the ground.
Need fieldwork there are not enough qualified people out in the field.

Just now beginning to solve problems dealing with spatially referenced information. Still have too much information. Need to be constantly critical.

Biggest problem is having to redigitize and update information.

GIS is useful in that it is a reasonable predictive tool but it's more important to understand the natural history. There's no way to get good refinement especially species composition or understanding anomalies in the vegetation without doing the sampling.

GIS technology will help foster cooperation. It will enable us to look at big scales, opens the door for discussion, and cuts down on costs if we share information.

Collective database where core types of information could be stored should be developed

Vegetation classification systems most commonly cited by respondents

The Heritage Program
UNESCO (Driscoll modified version)
Mattson and DeSpain (1985)
Viereck et al., (1992)
Gap Analysis
ECODATA
Habitat typing
# Appendix H

## Name, Professional Affiliation, and Area of Interest of Respondents

<table>
<thead>
<tr>
<th>Name</th>
<th>Professional Affiliation</th>
<th>Area(s) of Interest(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peter Stickney</td>
<td>USDA Intermountain Research Station</td>
<td>Plant ecology/plant succession Researcher</td>
</tr>
<tr>
<td>Troy Merrill</td>
<td>Idaho Conservation Information Center</td>
<td>Gap analysis specialist</td>
</tr>
<tr>
<td>Michael Jennings</td>
<td>USFWS Coordinator National Gap Analysis Program</td>
<td>Gap analysis specialist</td>
</tr>
<tr>
<td>Robert Pfister</td>
<td>University of Montana</td>
<td>Develop./implementation of vegetation class. systems</td>
</tr>
<tr>
<td>Chris Servheen</td>
<td>USFWS-Coordinator Grizzly Bear Recovery Project</td>
<td>Endangered species manager</td>
</tr>
<tr>
<td>Penny Morgan</td>
<td>University of Idaho</td>
<td>Vegetation classification</td>
</tr>
<tr>
<td>George Hirschenberger</td>
<td>Bureau of Land Management-Garnett Resource District</td>
<td>Land manager</td>
</tr>
<tr>
<td>Robert Keane</td>
<td>USDA Intermountain Research Station-Fire Lab</td>
<td>Classification and model development</td>
</tr>
<tr>
<td>Alan Christensen</td>
<td>USDA FS Northern Region-Wildlife Program Manager</td>
<td>Wildlife/habitat land manger</td>
</tr>
<tr>
<td>Bernie Hall</td>
<td>The Nature Conservancy-Conservation Director</td>
<td>Conservation</td>
</tr>
<tr>
<td>Dean Culwell</td>
<td>West Tech-Environmental Consultant</td>
<td>Develop./implementation of classification systems</td>
</tr>
<tr>
<td>Steve Cooper</td>
<td>The Heritage Program of Montana-Director</td>
<td>Develop./implementation of classification systems</td>
</tr>
<tr>
<td>Angie Evenden</td>
<td>USDA FS Intermountain Research Station-Natural Areas Manager</td>
<td>Land manager</td>
</tr>
<tr>
<td>Bill Ruediger</td>
<td>USDA FS Region One-Threatened, Endangered, and Sensitive Species Manager</td>
<td>Wildlife/habitat land manager</td>
</tr>
<tr>
<td>Tom Puchlerz</td>
<td>USDA FS Region One-National Grizzly Bear Habitat Coordinator</td>
<td>Wildlife/habitat land manager</td>
</tr>
<tr>
<td>Roly Redmond</td>
<td>USFWS</td>
<td>Gap analysis specialist</td>
</tr>
<tr>
<td>Wendell Hann</td>
<td>USDA FS Region One Ecologist</td>
<td>Landscape ecology dev./ and implementation of classification systems</td>
</tr>
<tr>
<td>Reed Noss</td>
<td>Editor, Conservation Bio.</td>
<td>Conservation biologist</td>
</tr>
<tr>
<td>James Habeck</td>
<td>University of Montana</td>
<td>Botanist</td>
</tr>
<tr>
<td>Laurie Kurth</td>
<td>Glacier National Park</td>
<td>Ecologist</td>
</tr>
</tbody>
</table>

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Appendix I
GIS, Satellite Imaging, and Gap Analysis Program

The following discussion is adapted from an article by Scott et al., (1993).

Geographic Information Systems
Geographic Information Systems (GIS) are computing systems for the storage, display, and analysis of spatial data. Remote sensing (e.g., aerial photographs, satellite imagery) and mapping data (e.g., U.S. Geological Survey, U.S. Department of Agriculture Forest Service Timber Survey maps, U.S. Fish and Wildlife Service's National Wetland Inventory map survey, U.S. Environmental Protection Agency's Land-Use and Land-Cover maps) are sources for information that are used in GIS. One common use of GIS is the storage of data layers such as vegetation or soil type maps, which can be superimposed on other data layer for analysis.

Satellite Remote Sensing
The main sources of satellite imagery suitable for regional land-use and land-cover mapping are: LANDSAT Thematic Mapper (TM) and Multispectral Scanner (MSS) and Systeme Probatoire d'Observation de la Terre (SPOT) imagery. There are advantages and disadvantages to the different satellites as related to such factors as relative costs, cartographic accuracy, and resolution. For example, TM costs 4 times as much as MSS but offers a higher level of resolution.

The satellite measurements are acquired and stored in GIS and classified by either supervised or unsupervised classification.
techniques. In supervised classification, pixels (the basic picture element that represents the radiation reflected or emitted from the Earth's surface) are assigned to land-use and land-cover classes based on spectral properties derived from pre-selected training sites (on-the-ground sites). The analyst interacts with the computer to classify the images in terms of their reflected multispectral brightness values. In unsupervised classification the pixels are assigned to spectral classes by the computer through cluster analysis (grouped by similar reflectance values). Then the spectral classes are assigned to land-use and land-cover classes based on information such as field observation, aerial photographs, and existing maps. By averaging reflectance values of pixels, a spectral signature is obtained for each vegetation complex. After the pixels have been grouped, using either the supervised or unsupervised approach (or a combination thereof), the pixel groups are assigned a “false” color and digital, color coded maps are produced.

The Gap Analysis Concept
Gap Analysis is a method of analysis for conservation evaluation of large areas. Gap Analysis relies on remote sensing of vegetation and the relationship of animal species to vegetation types to predict the distribution and current protection status of biodiversity. Gap Analysis uses the distribution of vegetation types (mapped from satellite imagery) and vertebrate and butterfly species as indicators of, or surrogates for, biodiversity. Scott et al., (1993) explain the utility of this approach as follows:
Digital map overlays in a GIS are used to identify individual species, species-rich areas, and vegetation types that are unrepresented or underrepresented in existing biodiversity management areas. Not a substitute for a detailed biological inventory, Gap Analysis organizes existing survey information to identify areas of high biodiversity before they are further degraded (p. 7).

**Gap Analysis and Vegetation Classification**

Vegetation is one of the basic data layers of Gap Analysis and vegetation maps provide the foundation for assessment of the distribution of biodiversity. In order to meet the criteria set by Gap Analysis, vegetation classification systems must share the following properties:

1. Vegetation classes must be discriminable in remotely sensed imagery and identifiable in large- to medium-scale aerial photographs.

2. Vegetation classes must correspond to or at least be compatible with recognized vertebrate habitat classification systems.

3. Vegetation classes must describe seral as well as climax vegetation.

4. Vegetation classes used in Gap Analysis by adjacent states should be compatible to allow for regional and national analyses.

The Nature Conservancy is in the process of trying to reconcile the various vegetation classification approaches to develop a national hierarchical classification describing vegetation cover types.
compatible at the series level with existing regional and national vegetation classifications.

Scott et al., (1993) emphasize the limitations of Gap Analysis in their review article, “We reiterate that Gap Analysis, as a coarse-filter approach to conservation evaluation, is not a panacea for conservation planners.” (p. 37). Some of these limitations are summarized below:

1. Vegetation maps do not show habitats smaller than the minimum mapping unit. Thus, many important micro-habitat elements such as meadows and wetlands in a forest matrix, are missed.

2. Vegetation maps do not portray stand age, except for the early successional stages of forests.

3. Boundaries between vegetation types along environmental gradients are seldom as sharp as implied by Gap Analysis. Ecotones and subtle gradients must be identified by higher-resolution analysis.

4. Maps of predicted habitat distribution do not reflect habitat quality. Gap Analysis predicts the presence or absence of a species, not whether it is rare or common in a particular area. Site-specific inventories are needed to provide abundance information.

5. We cannot overemphasize the need for field investigation before management changes are made or biodiversity management areas are established. Field studies or high priority areas should not only confirm the biodiversity values of the area, but should apply current concepts of conservation biology to the delineation of management unit boundaries and the development of management plans.
Appendix J
Alaska Vegetation Classification System

<table>
<thead>
<tr>
<th>Level I</th>
<th>Level II</th>
<th>Level III</th>
<th>Level IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Forest</td>
<td>A. Needleleaf forest</td>
<td>(1) Closed needleleaf forest (canopy 50-100 percent)</td>
<td>Picea sitchensis/Oplopanax horridus-Rubus spectabilis/Cornus canadensis (Alaback 1980b, Martin and others 1985, Neiland 1971a, Stephens and others 1969)</td>
</tr>
<tr>
<td></td>
<td>a. Sitka spruce—occupies wet sites in southeastern Alaska, primarily alluvial flood plains; occurs as a narrow coastal band in south-central Alaska and occupies much of the forested area on Atognak Island.</td>
<td></td>
<td>Picea sitchensis/Oplopanax horridus-Lyssichiton americanum (Martin and others 1985)</td>
</tr>
<tr>
<td></td>
<td>b. Western hemlock—is a widespread forest type in southeastern Alaska, usually with a Sitka spruce component.</td>
<td></td>
<td>Picea sitchensis/Oplopanax horridus/Circaea alpina (Pawuk and Kissinger 1989)</td>
</tr>
<tr>
<td></td>
<td>d. Western hemlock-Sitka spruce (western redcedar)—is a widespread forest type in southeastern Alaska. It also occurs in a narrow coastal band in south-central Alaska. Western redcedar is present only south of 57° N. lat.</td>
<td></td>
<td>Picea sitchensis-Tsuga heterophylla/Vaccinium spp./Rhytidiodendron boreale (Alaback 1980b, Neiland 1971a, Stephens and others 1969)</td>
</tr>
</tbody>
</table>

source: Viereck et al., (1992, p.15)
Diagram of ECODATA plot scale databases stratified by six general types of sampling needs. Each box corresponds to a sampling methodology, field form, and relational database.

source: Jensen et al., (1993, p.205)
Appendix K
ECODATA: Plot-sampling methods and databases

<table>
<thead>
<tr>
<th>Type of data</th>
<th>Sampling method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic site data</td>
<td>Sample</td>
<td>Describes the types of samples collected at a plot.</td>
</tr>
<tr>
<td>General</td>
<td></td>
<td>Broad vegetation and environmental site descriptors (e.g., elevation, aspect, tree cover, ground cover, fuel loading). Always used to describe a terrestrial plot.</td>
</tr>
<tr>
<td>Location and Linkage</td>
<td></td>
<td>Required information for locating and linking a plot to other databases (e.g., UTM coordinates, spectral values, watershed ID, stand ID).</td>
</tr>
<tr>
<td>Plant Composition</td>
<td></td>
<td>Visual estimates of plant cover, height, and synecological information for plant species on a macroplot.</td>
</tr>
<tr>
<td>Comments</td>
<td></td>
<td>User-specific comments concerning a plot.</td>
</tr>
<tr>
<td>Disturbance History</td>
<td></td>
<td>Information concerning the disturbance or treatment history of a plot.</td>
</tr>
<tr>
<td>User Information</td>
<td></td>
<td>Generic sampling method that accommodates user-specified optional data fields.</td>
</tr>
<tr>
<td>Replicated vegetation data</td>
<td>Cover and Frequency</td>
<td>Foliar cover and nested rooted frequency data are recorded by microplots within a macroplot sampling unit.</td>
</tr>
<tr>
<td>Line Intercept</td>
<td></td>
<td>Interception of foliar cover is recorded by species along line transects.</td>
</tr>
<tr>
<td>Density</td>
<td></td>
<td>Density (individuals per unit area) is recorded by item (e.g., plant species, deer pellets) within belt transects or circular microplots.</td>
</tr>
<tr>
<td>Production</td>
<td></td>
<td>Quantitative biomass estimates of individual species (or groups of species) are facilitated by clipping and weighing plant matter within a series of microplots.</td>
</tr>
<tr>
<td>Point Cover</td>
<td></td>
<td>Ground cover (or plant species cover) are recorded along systematically located points on line transects.</td>
</tr>
<tr>
<td>Measured Down Wood</td>
<td></td>
<td>Fuel loadings and decay classes of down woody material are measured along line transects.</td>
</tr>
<tr>
<td>Tree data</td>
<td>Tree</td>
<td>Basic tree attributes are recorded by species (e.g., incremental growth, crown ratio, disease status).</td>
</tr>
<tr>
<td>Estimated Down Wood</td>
<td></td>
<td>Visual estimates of fuel loadings and down wood biomass are recorded.</td>
</tr>
<tr>
<td>Tree Cavity</td>
<td></td>
<td>Information concerning tree cavity number, size, and shape are recorded by tree species.</td>
</tr>
<tr>
<td>Fire Effects</td>
<td></td>
<td>The fire effects present on a macroplot are recorded (e.g., duff consumption, soil oxidation, scorch height).</td>
</tr>
<tr>
<td>Fire Scar</td>
<td></td>
<td>The presence and timing between fire events are recorded by tree fire scar measurements.</td>
</tr>
</tbody>
</table>

source: Jensen et al., (1993, p.205)
References


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