GUIDELINES FOR DESCRIBING ASSOCIATIONS AND ALLIANCES OF THE U.S. NATIONAL VEGETATION CLASSIFICATION

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ABSTRACT

The purpose of this document is to provide guidelines for describing and classifying plant associations and alliances as formally recognized units of vegetation within the U.S. National Vegetation Classification (NVC), a regional component of the International Vegetation Classification (NatureServe 2003). The guidelines are intended to be used by anyone proposing additions, deletions, or other changes to the named units of the NVC. By setting forth guidelines for field records, analysis, description, peer review, archiving, and dissemination, the Ecological Society of America's Vegetation Classification Panel, in collaboration with the U.S. Federal Geographic Data Committee, NatureServe, the U.S. Geological Survey, and others, seeks to advance our common understanding of vegetation and improve our capability to sustain this resource.

We begin by articulating the rationale for developing these guidelines and then briefly review the history and development of vegetation classification in the United States. The guidelines for floristic units of vegetation include definitions of the association and alliance concepts. This is followed by a description of the requirements for field plot records and the identification and classification of vegetation types. Guidelines for peer review of proposed additions and revisions of types are provided, as is a structure for data access and management.

Since new knowledge and insight will inevitably lead to the need for improvements to the guidelines described here, this document has been written with the expectation that it will be revised with new versions produced as needed. Recommendations for revisions should be addressed to the Panel Chair, Vegetation Classification Panel, Ecological Society of America, Suite 400, 735 H St, NW, Washington, DC. Email contact information can be found at http://www.esa.org/vegweb or contact the Ecological Society of America's Science Program Office, 1707 H St, NW, Suite 400, Washington, DC 20006, Telephone: (202) 833-8773. The authors of this document work as volunteers in the service of the Ecological Society of America and the professional opinions expressed by them in this document are not necessarily those of the institutions that employ them.

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INTRODUCTION

1. RATIONALE

A standardized, widely accepted vegetation classification for the United States is required for effective inventory, assessment, and management of the nation's ecosystems. These needs are increasingly apparent as individuals, private organizations, and governments grapple with the escalating alteration and loss of natural vegetation (for examples, see Klopatek et al. 1979, Mack 1986, LaRoe et al. 1995, Mac 1999). Remnants of natural vegetation have become increasingly rare (Noss et al. 1995, Noss and Peters 1995, Barbour and Billings 2000). Some types are now imperiled because of habitat loss or degradation, and others have disappeared entirely from the landscape without ever having been formally documented (Grossman et al. 1994). Losses of vegetation types represent losses in habitat diversity, leading directly to more species[1] being in danger of extinction (Ehrlich 1997, Wilcove et al. 1998, Naeem et al. 1999). Predicted changes in climate, continued atmospheric pollution, ongoing invasions by exotic organisms, and land use changes are likely to cause further unprecedented and rapid alteration in vegetation (Overpeck et al. 1991, Vitousek et al. 1997, Morse et al. 1995), possibly altering existing land

1. Species: technically we typically mean both species and subspecies, and occasionally genera. The term "taxa" is the technical term for these and all other taxonomic entities. However, our focus is at the species and subspecies level and we use species as a common shorthand term for the object of our focus.

uses and local economies over large areas. Widespread changes in land use have led to increased social and economic conflicts, resulting in an increasing demand for more robust and timely information about remaining natural and seminatural environments. In addition to these environmental issues, a standardized classification is needed to place basic ecological and biodiversity studies in context. In its application to mapping vegetation, a standardized classification can form the basis for consistently defined and comparable units among different maps. We expect that this standardized classification will play a prominent role in guiding research, resource conservation, and ecosystem management, as well as in planning, restoration activities, and in predicting ecosystem responses to environmental change.

To meet the need for a credible, broadly-accepted vegetation classification, the Ecological Society of America (ESA: the professional organization for ecologists in the United States) joined with cooperating organizations such as the U.S. Geological Survey, U.S. Federal Geographic Data Committee, and NatureServe[2] to form a Panel on Vegetation Classification. To formalize this partnership, the four participating organizations signed a formal Memorandum of Understanding (MOU)[3] in August 1998. This MOU defines the working relationship among the signers for the purpose of advancing the National Vegetation Classification.

The objectives of the ESA Vegetation Classification Panel are to: (1) facilitate and support the development, implementation, and use of a standardized vegetation classification for the United States; (2) guide professional ecologists in defining and adopting standards for vegetation sampling and analysis in support of the classification; (3) maintain scientific credibility of the classification through peer review; and (4) promote and facilitate international collaboration in development of vegetation classifications and associated standards. In this document the Panel articulates and explains a set of standards and procedures aimed at achieving the first three of these objectives.

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2. In July of 2000 The Nature Conservancy's science staff that helped to develop the U.S. National Vegetation Classification transferred to a new organization, NatureServe, which now represents the interests of the Conservancy in the ongoing development of the NVC.

3. Forming a partnership to further develop and implement the national vegetation classification standards. Memorandum of Understanding among ESA, TNC (NatureServe), USGS, and FGDC. 1999. Ecological Society of America, Washington, D.C., USA. 6p. (http://www.esa.org/vegweb/#MOU).

2. BACKGROUND AND PRINCIPLES

The ESA Panel on Vegetation Classification recognizes the Federal Geographic Data Committee's (FGDC) "National Vegetation Classification Standard" (1997) as the starting point for developing a national vegetation classification. The FGDC classification standard is a physiognomic-floristic hierarchy with higher-level physiognomic units and lower-level floristic units (Figure 1). The FGDC standard, based on the International Classification of Ecological Communities or ICEC (Grossman et al. 1998; now referred to as the International Vegetation Classification, or IVC), introduced the classification hierarchy, documented the component elements of all except the floristic levels, and provided the context for defining those floristic levels. Between 1995 and 1996 the Panel concentrated on assisting the FGDC by reviewing proposed standards for the physiognomic categories (class, subclass, group, subgroup, and formation; Loucks 1996), as well as the specific physiognomic types within these categories.

The guiding principles established by the FGDC for the overall development of the NVC are shown in Box 1 (FGDC 1997, Section 5.3). In particular, the 1997 FGDC standard provided definitions for the floristic units of the classification: the alliance and association. These definitions begin with the premise that a vegetation type represents a group of stands that have similar plant composition and physiognomy, and that types must have diagnostic criteria to enable their recognition. Nonetheless, we recognize that, due to complex biophysical factors as well as chance, vegetation is a continuously varying phenomenon and that species are, to some extent, stochastic in their distribution. As a consequence, floristic vegetation units are not readily defined by precise and absolute criteria. Instead, some examples of vegetation can be seen to be unambiguously members of a particular type, whereas others are intermediate such that their assignment must be defined in terms of relative affinities with alternative types.

Although the 1997 FGDC standard includes the two floristic categories of the NVC hierarchy, Alliance and Association, it provides no list of recognized types, no details about nomenclature, nor methods for defining and describing alliances and associations. With respect to these categories, the document states "The current list of Alliances and Associations for the conterminous United States will be published by The Nature Conservancy in the spring of 1997." (FGDC 1997 Section 6.0). The list was published in 1998, in cooperation with the Natural Heritage Network (Anderson et al. 1998) and has subsequently been repeatedly refined and improved. Each alliance and association on the list is described in a standardized format (see Grossman et al. 1998, page 48) that contains a compilation of literature and field observations. Collectively, these descriptions constitute a comprehensive summary of our knowledge of the plant communities of the United States. The Panel anticipates that the recognized list of type descriptions will be enhanced and revised in accordance with the FGDC requirement that the alliance and association types must be based on field data conforming to standard methods (FGDC 1997, Sections 5.3 and 7.1) and that the types will be defined so as to meet standard criteria for acceptance. However, the precise standards and criteria were not spelled out by the FGDC. The standards presented here are intended to meet that need.

We have used the FGDC "Guiding Principles" and the definitions for association and alliance to guide the development of standards for defining, naming, and describing floristic units. Our goal for future revisions of the list of alliances and associations and supporting documentation is that they will be based on standardized field observation, type description, peer-review, and data management. Each of these activities is summarized next.

Field plot records. Vegetation associations and alliances should be identified and described through numerical analysis of plot data that have been collected from across the range of the vegetation type and closely related types (irrespective of political and jurisdictional borders). *We outline standards for plot data in Section 5.*

Type description. Proposals for new or revised floristic units must adhere to standards for circumscribing and describing types. Each type description should include sufficient information to determine the distinctive vegetation features of the type and its relation to other types recognized in the classification. Proposals for revision of recognized types must include comparison of the focal types with related types of that level to ensure that they do not duplicate or significantly overlap, but rather enhance, replace, or add to them. *We outline standards for type circumscription and description in Section 6.*

Peer review. Proposals for new and revised types need to be evaluated through a credible, open peer-review process. *Standards for the peer-review process are outlined in Section 7.*

Data management. Plot data used to define and describe an association or alliance must be permanently archived in a publicly accessible data archive, either for revisions to the descriptions of existing type concepts, new descriptions of proposed types, or other uses. A digital schema for sharing and integrating plot data from multisource heterogeneous data sets is vitally important to the development of a national vegetation classification. Such a schema must prescribe data content standards for plot data. Accepted proposals for addition or modification of vegetation types and all supporting documentation must be deposited in the NVC digital public archive. All plant taxa referenced in plot data or community type descriptions must be unambiguously defined by reference to a public database or publication of recognized taxa, or by reference to an authoritative, published circumscription. Unknown taxa should be placed as precisely as possible within the phylogenetic hierarchy of such a database or publication. All three types of data archives (for plant taxa, field plots, and associations and alliances) must be truly archival in the sense that the data will be able to be extracted in their original form and context at some indefinite future time by any reasonably diligent investigator. *Data management standards are outlined in Section 8.*

Summary of guidelines. Implementing the guidelines specified in Sections 4 through 8 will require unprecedented technical and organizational cooperation and collaboration among the nonprofit, academic, and governmental institutions that are concerned with the application of science to land use planning and management. *To facilitate their formal adoption and future improvement, these guidelines are summarized in list format in Section 9.*

2.1 DISCLAIMERS

The NVC is a classification of the full range of existing vegetation, from natural types that include old-growth forest stands and seminatural vegetation (including grazed rangelands, old agricultural lands undergoing natural succession, and stands dominated by naturalized exotics) to planted or cultivated vegetation, such as row crops, orchards, and forest plantations. Various uses and applications may require distinctions with respect to naturalness (see Grossman et al. 1998 Appendix E). Descriptions of types should aid users of the classification in differentiating among natural, seminatural, and planted types.

Consistent with the FGDC principles, the guidelines described here for floristic units relate to vegetation classification and are not intended as standards for mapping units. Nevertheless, types defined using these guidelines can be mapped and they can be used as the basis for mapping various other types of units as well, subject to limitations of scale and mapping technology. The criteria used to aggregate or differentiate within these vegetation types and to form mapping units will depend upon the purpose of the particular mapping project and the resources devoted to it (e.g., Damman 1979, Pearlstine et al. 1998). For example, in using the NVC Alliance class as a target for vegetation mapping by the Gap Analysis Program, not all alliance types can be resolved. In such cases alliance types are aggregated into map units of "compositional groups" or "ecological complexes" (see Pearlstine et al. 1998). Although not part of the NVC standard, such aggregates represent units of vegetation that meet the needs of the mapping activity and have an explicit relationship to established NVC units.

Although vegetation varies more-or-less continuously in time and space, classification partitions that continuum into discrete units for *practical* reasons. These include, for example, facilitating communication and information-gathering about ecological resources, documenting the diversity of ecological communities, and providing a framework for addressing scientific inquiries into the patterns of vegetation. Alternative classification approaches, particularly those that aggregate alliances and associations differently from the NVC and IVC (which use vegetation physiognomy as the major criteria for aggregating alliances) are available and may be more practical for some particular uses. For example, hierarchical levels of vegetation classifications have been defined based purely on floristic criteria (Westhoff and van der Maarel 1973), on ecosystem processes (Bailey 1996), or on potential natural vegetation (Daubenmire 1968). Each of these approaches meets different needs and the NVC associations that are defined using these guidelines can nest to varying degrees under any of these hierarchy types. In providing guidelines for implementation of the floristic levels of the U.S. National Vegetation Classification, we in no way mean to imply that this is the only valid classification approach.

3. A BRIEF HISTORICAL BACKGROUND

> *Vegetation classification attempts to identify discrete, repeatable classes of relatively homogeneous vegetation communities or associations about which reliable statements can be made. Classification assumes either that natural vegetation groupings (communities) do occur, or that it is reasonable to separate a continuum of variation in vegetation composition and/or structure into a series of arbitrary classes." (Kimmins 1997).*

As we reflected on the history of vegetation classification in the United States and elsewhere and on the opportunities that now lie before us, we became convinced that a clear set of standards for defining floristic units would advance the discipline of vegetation science and make a strong contribution to conservation and resource management. Because our goal is to develop standards informed by the rich historical debate surrounding vegetation classification, we begin this document where the ESA Vegetation Panel began its work: by reviewing the historical basis for some of the fundamental concepts that shape the floristic levels of the US National Vegetation Classification.

3.1. DESCRIBING AND CLASSIFYING VEGETATION

For over a century vegetation scientists have studied plant communities to identify their compositional variation, distribution, dynamics, and environmental relationships. They have used a multiplicity of methods including intuition, knowledge of physiological and population ecology (autecology), synthetic tables, and mathematical analyses to organize and interpret these patterns and relationships. Perhaps Shimwell (1971) expressed the situation best when, after reviewing the large and diverse literature on vegetation classification, he prefaced his book on the subject with the Latin maxim *quot homines tot sententiae*, "so many men, so many opinions." What follows is not a comprehensive review of vegetation classification; that has been done elsewhere (e.g., Whittaker 1962, 1973, Shimwell 1971, Mueller-Dombois and Ellenberg 1974). Instead, we focus on those elements most significant to the National Vegetation Classification enterprise and particularly those most relevant to the floristic levels.

Vegetation classification is a powerful tool employed for several purposes, including: (1) efficient communication, (2) data reduction and synthesis, (3) interpretation, and (4) land management and planning. Classifications provide one way of summarizing our knowledge of vegetation patterns.

Although different individuals conceptualize vegetation patterns differently, all classifications require the identification of a set of discrete vegetation classes. Several additional ideas are central to the conceptual basis for classification (following Mueller-Dombois and Ellenberg 1974, p. 153):

1. Given similar habitat conditions, similar combinations of species and subspecies recur from stand to stand, though similarity declines with geographic distance.
2. No two stands (or sampling units) are exactly alike, owing to chance events of dispersal, disturbance, extinction, and history.

3. Taxon assemblages change more or less continuously with geographic or environmental distance.
4. Stand composition varies with the spatial and temporal scale of analysis.

These fundamental concepts are widely shared, and articulating them helps us understand the inherent limitations of any classification scheme. With these fundamentals in mind, we can better review the primary ways in which vegetation scientists and resource managers have characterized vegetation pattern to meet their needs.

Physiognomic characterization

Physiognomy, narrowly defined, refers to the general external appearance of vegetation based on growth form (gross morphology) of the dominant plants. Structure relates to the spacing and height of plants forming the matrix of the vegetation cover (Fosberg 1961). Often physiognomy is used to encompass both definitions, particularly when distinguishing "physiognomic" classifications from "floristic" ones. The basic unit of many physiognomic classifications is the formation, a "community type defined by dominance of a given *growth form* in the uppermost stratum of the community**,** or by a combination of dominant growth forms" (Whittaker 1962). This is the approach used in the physiognomic portion of the NVC.

Physiognomic patterns often apply across broad scales as they typically correlate with or are driven by climatic factors, whereas floristic similarities are more regionally constrained as they reflect species composition, which in turn is strongly influenced by geographic discontinuities and idiosyncratic historical factors. Consequently, physiognomic classifications have more often been used in continental or global mapping applications, and floristic classifications in regional applications. A variety of classifications based on physiognomy (e.g., Fosberg 1961) preceded the development of the widely recognized international classification published by the United Nations Educational, Scientific, and Cultural Organization (UNESCO 1973, Mueller-Dombois and Ellenberg 1974). The UNESCO classification was intended to provide a framework for preparing vegetation maps at a scale of about 1:1 million or coarser, appropriate for worldwide comparison of ecological habitats as indicated by equivalent categories of plant growth forms.

Physiognomic classifications have, however, been used for natural resource inventory, management, and planning. Such classifications are based on measurements of vegetation attributes that may change during stand development and disturbance and which have management implications for wildlife habitat, watershed integrity, and range utilization. Criteria for physiognomic classification commonly include (a) plant growth forms that dominate the vegetation (e.g., forb, grass, shrub, tree), (b) plant density or cover, (c) size of the dominant plants, and (d) vertical layering (e.g., single stratum, multistrata). Physiognomic types have been used in numerous regional wildlife habitat studies (e.g., Thomas 1979, Barbour et al. 1998, Barbour et al. 2000), and they have also been used in conjunction with stand age and structure to assess old-growth status (Tyrrell et al. 1998).

Physiognomic classifications alone typically provide a generalization of floristic patterns. However, because they lack specificity at local or regional extents they are often used in conjunction with, or integrated into, thematically higher-resolution classifications that rely on floristics, that is, the taxonomic identity of plants. An exception to this is in certain kinds of floristically rich and complex or poorly understood vegetation, such as tropical rain forests, where physiognomic classification of vegetation remains the most common approach (Adam 1994, Pignatti et al. 1994).

Floristic characterization

Floristic characterization uses the composition of taxa to describe stands of vegetation. These characterizations are usually based on records of formal field observations ("plots"), which are fundamental to the definition, identification, and description of vegetation types. Methods range from describing only the dominant species to listing and recording the abundance of all species present in the stand (total floristic composition). Differences in these characterization methods have an important bearing on the definition and description of the alliances and associations, and are discussed next.

<u>Dominance</u>

One traditional way to classify vegetation is on the basis of dominant plant species of the uppermost stratum. "Dominance types" are typically based on the dominant taxonomic entity (or group of dominants) as assessed by some measure of importance such as biomass, density, height, or canopy cover (Kimmins 1997). Such classes represent the lower levels in several published classification hierarchies (e.g., Cowardin et al. 1979, Brown et al. 1980).

Determining dominance is relatively easy and requiring only a modest floristic knowledge. However, because dominant species often have geographically and ecologically broad ranges, there can be substantial floristic and ecologic variation within any one dominance type. The dominance approach has been used widely in aerial photo interpretation and mapping inventories because of its ease of interpretation and application. With the advances in remotely-sensed image acquisition and interpretation (spaceborne as well as airborne), there has been a significant increase in the level of effort in classifying and mapping dominant vegetation types across large areas (e.g., Scott and Jennings 1998, Lins and Kleckner 1996).

The term "cover type" is almost synonymous with "dominance type." Cover types are typically based on the dominant species in the uppermost stratum of existing vegetation. Forestland cover types may be variously assessed by a plurality of tree basal area or canopy cover (Eyre 1980). Similarly, rangeland cover types are typically based on those species that constitute a plurality of canopy cover (Shiftlet 1994). Although their limitations have been clearly articulated (e.g., Whittaker 1973), dominance types remain broadly used because they provide a simple, efficient approach for inventory, mapping, and modeling purposes.

<u>Total floristic composition</u>

Total community floristic composition has been widely used for systematic community classification. Two of the major approaches used in the United States are those of Braun-Blanquet (1928; also referred to as the "Zürich-Montpellier School", see Westhoff and van der Maarel 1973, Kent and Coker 1992), and Daubenmire (1952, 1968); see Layser (1974) and Kimmins (1997) for a comparison of the two approaches). Both approaches use an "association" concept derived from the definition of Flahault and Schröter (1910), which states that an association is "a plant community type of definite floristic composition, uniform habitat conditions, and uniform physiognomy" (Flahault and Schröter 1910; see Daubenmire 1968 and Moravec 1993).

Braun-Blanquet (1928) defined the association as "a plant community characterized by definite floristic and sociological (organizational) features" which shows, by the presence of diagnostic species "a certain independence." Diagnostic species are those whose relative constancy or abundance distinguish one association from another (Whittaker 1962). Identification of character species, those species that are particularly restricted to a single type, was considered essential to the definition of an association, whereas differential species (those species that delimit one association from another association only; not to be confused with the character species which distinguish one particular association from all other associations), defined lower taxa, such as subassociations (Moravec 1993). Patterns of diagnostic species are assessed using relevés (i.e., plots). A relevé is a record of vegetation composition that includes a comprehensive list of plants in a relatively small, environmentally uniform habitat (Mueller-Dombois and Ellenberg 1974), together with assessment of species cover. The Braun-Blanquet approach combines plant associations with common diagnostic species in a hierarchical classification with progressively broader floristic units called alliances, orders, and classes (see Pignatti et al. 1994). The association concept has been progressively narrowed as more associations have been defined, each with fewer diagnostic or character species (Mueller-Dombois and Ellenberg 1974). Today many associations are defined using only differential species (Weber et al. 2000). Classifications based on the Braun-Blanquet approach continue to be widely employed outside North America (especially in Europe, South Africa and Japan; see Mucina et al. 1993, Mucina 1997, 2001, Rodwell et al. 2002, but also see Borhidi [1996] as a milestone vegetation treatment from the Western hemisphere), and are now more often applied in the U.S. (e.g., Komárková 1979, Cooper 1986, Barbour et al. 1993, Peinado et al. 1994, Nakamura and Grandtner 1994, Nakamura et al. 1994, Walker et al. 1994, Peinado et al. 1998, Rivas-Martinez et al. 1999, Spribille 2002, Stachurska-Swakon and Spribille 2002).

Daubenmire (1952) purposely looked for and sampled the least disturbed and oldest plant communities ("near-climax") that he could find across a full range of environments as a basis to define "climax associations". This was based upon the premise that a classification "based upon climax types of vegetation best expresses the potential biotic productivity of a given combination of environmental factors" (Daubenmire (1953). Stands were grouped by traditional synecological synthesis tables for study of community floristics and evaluation of diagnostic species. Daubenmire (1968) narrowed the definition of association to represent a type of climax phytocoenosis and suggested the word "associes" could be used to indicate plant communities in earlier recognizable stages of succession. Later, many authors preferred to use a different term—"community type"—for seral and disclimax plant communities to avoid confusion between climax and seral types. In contrast to earlier definitions of "climax", Daubenmire and Daubenmire (1968) noted that their use of the term was relative to the longevity of seral, shade-intolerant tree species and that the "climax" condition was generally achievable in 300 to 500 years.

Although the Daubenmire and Braun-Blanquet methods have strong underlying similarities (see Layser 1974) the original approach of Daubenmire (1952) was to define climax associations as floristically stable reference points for interpreting vegetation dynamics and site attributes. Conversely, the Braun-Blanquet association was intended as a *systematic* unit of classification, irrespective of successional status. Thus, under the Braun-Blanquet approach, old fields, pastures, and forests were all described using the association concept, with no preconceptions as to how such types relate to a climax association or successional sequence. Another fundamental difference between the Braun-Blanquet and Daubenmire approaches is apparent in forest vegetation, where the latter assigns primary weighting to diagnostic members of the predominant growth form (tree species), particularly those expected to dominate in late-successional states, and only secondary weighting to diagnostic members of the undergrowth vegetation. Another difference is that the Daubenmire approach makes an explicit effort to use the late-successional natural vegetation to predict the climax vegetation. Because the two methodologies rely on similar vegetation data and analysis, the units defined for late-successional vegetation under these two methods may appear similar. However, if one considers trees and undergrowth vegetation equally in terms of total floristic composition, different types of associations could be defined for the same area, as illustrated recently by Spribille (2001).

Daubenmire's "habitat types" represent parts of the land surface capable of supporting the same kind of climax plant association (Daubenmire 1952, 1968). During the 1960s and 70s, with an emerging emphasis on natural resource management, Daubenmire's approach of using climax associations as a conceptual framework for a site classification gained preeminence in the western United States. Financial support was provided, particularly by the US Forest Service, for developing plant association and habitat type taxonomies on a systematic basis over large areas of the American West. With millions of hectares to cover, methods were optimized for efficiency (Franklin et al. 1971). In addition, sampling was no longer restricted to "climax" or "near-climax" stands; rather, vegetation was sampled with relevés from "late-successional" (maturing) stands across the full range of environmental conditions (Pfister and Arno 1980). The term "series" was introduced by Daubenmire and Daubenmire (1968) for grouping forest associations having a common climax overstory dominant species. Associations, nested within series, were defined by diagnostic species (identified from a synthesis of field samples) in the forest understory. By the 1980s, more than 100 monographs had been published on habitat types of forestlands and rangelands in the western United States (Wellner 1989), and accompanying keys were provided to identify the habitat types and to infer their potential climax association (also called potential natural vegetation type). However, it should be noted that all these efforts first classified late-successional existing vegetation associations as the starting point for inferring potential vegetation and habitat type interpretations.

Physiognomic-floristic characterizations

Descriptions of vegetation need not rely solely on either floristics *or* physiognomy. A classification that combines physiognomic and floristic criteria allows flexibility for characterizing a given area by both its physiognomy and composition. Driscoll et al. (1984) proposed a multi-agency ecological land classification system for the United States that consists of a combination of the physiognomic units of UNESCO (1973) and the floristic "late-successional" associations or habitat types. Subsequently, The Nature Conservancy developed a combined physiognomic-floristic classification of existing vegetation titled the International Classification of Ecological Communities (see Grossman et al. 1998) using modified physiognomic units of UNESCO for the upper levels and the floristic alliance and association units for the lower levels (see Figure 1). Units at all levels of the classification were developed across the United States, based on a synthesis of existing information and ecological expertise (Anderson et al. 1998). The Conservancy's definition of the association was based on Flahault and Schröter's (1910) association concept of an existing vegetation type with uniform floristic composition, habitat conditions, and physiognomy. Both the Driscoll et al. (1984) and the TNC classifications use a formation concept that incorporates some elements of climate and geography into the physiognomic units, and integrates them with floristic units based on variations of the association concept.

More strictly floristic classifications, such as those of the Braun-Blanquet school, occasionally find it convenient to organize vegetation classes by formations (Rodwell et al. 2002). Westhoff and van der Maarel (1973) note that since the "floristic-sociological characters of an association are supposed to reflect all other characters, a floristic-sociologically uniform association might be expected to be structurally uniform as well." Though not always true (Westhoff 1967), there is often sufficient structural or physiognomic uniformity to make such integration meaningful. Indeed, it may be possible to conceive of a "phytosociological formation," in which the definitions of the formation units are informed by the floristic units they contain (Westhoff and van der Maarel 1973, Rodwell et al. 2002).

Floristic classifications and community concepts

<u>Continuum concepts and vegetation classification</u>

Curtis (1959) and Whittaker (1956; also see McIntosh 1967) explicitly recognized that vegetation varies continuously along environmental, successional, and geographic gradients. In addition, these workers embraced the observation of Gleason (1926) that species respond individualistically to these gradients and that chance plays an important role in the composition of vegetation (but see Nicolson and McIntosh 2002 for an important recent view of Gleason's individualistic concept). The necessary consequence is that in many cases there are not clear and unambiguous boundaries between vegetation types, and that vegetation composition is not consistently predictable. Any decision as to how to divide the continuously varying and somewhat unpredictable phenomenon of vegetation into community types is of necessity somewhat arbitrary with multiple acceptable solutions.

A common approach to capturing vegetation pattern across landscapes is to describe change in floristic composition relative to gradients in geographic or environmental factors such as climate and soils. The set of techniques used to relate vegetation to known physical gradients is referred to as direct gradient analysis. In contrast, techniques for ordering vegetation along compositional gradients deduced from stand similarity and independently of knowledge of the physical environment are referred to as indirect gradient analysis (Gauch 1982, Kent and Coker 1992). Gradients observed using indirect methods can be divided to form a classification, or these gradients can be used to identify key variables driving compositional variation, and these in turn can be used to create an optimal direct gradient representation. Gradient analysis need not lead to classification, yet many researchers have "classified" or summarized vegetation into types based on gradient patterns (e.g., Whittaker 1956, Curtis 1959, Peet 1981, Faber-Langendoen and Maycock 1987, Smith 1995).

Many natural resource professionals and conservationists have used gradient analysis to develop local classifications. Practitioners have also used a "natural community" type concept to develop widely differing kinds of regional classifications, defining units by various combinations of criteria, including vegetation physiognomy, current species composition, soil moisture, substrate, soil chemistry, or topographic position, depending on the local situation (e.g., Nelson 1985, Reschke 1990, Schafale and Weakley 1990, Minnesota NHP 1993). This approach has been used with great success for conservation and inventory at the local and state level, but the utility declines with increasing spatial scale.

Ecological land classifications

There are a number of classification systems that include vegetation as one of several criteria for classifying ecological systems (e.g., McNab and Avers 1994, Avers et al. 1994). Vegetation physiognomy is often used at broad scales to help delineate biogeographic or bioclimatic regions (e.g., Loveland et al. 1999), whereas floristic information is often used at finer scales to define ecological types and delineate ecological land units (e.g. Bailey et al. 1994, Cleland et al. 1994). The habitat type approach is a vegetation-based site (land) classification system (Ferguson, Morgan and Johnson 1989). Once the classification of late-successional associations (existing vegetation) is completed, trends toward climax are interpreted and a key to habitat types (areas of similar potential natural vegetation) is developed for field identification and mapping purposes. Ecological land classification approaches typically use potential natural vegetation as one of several key elements to define ecosystem or ecological land units (Lapin and Barnes 1995, Bailey 1996). These classifications have often been used to guide forest management.

The site classification approach does not provide direct information on existing, or actual vegetation, and care must be taken not to confuse this distinct goal with the study of existing vegetation. Instead, once the ecological unit is defined, existing vegetation information may be used to characterize the current condition of the unit (Bailey 1996). As Cleland et al. (1997:182) state, "Ecological unit maps may be coupled with inventories of existing vegetation, air quality, aquatic systems, wildlife, and human elements to characterize...ecosystems." Thus, vegetation classifications can play an important role in other classification approaches. Site classifications are also used in the development of vegetation state-and-transition models (Bestelmeyer et al. 2003).

Existing vegetation and potential natural vegetation

Ecologists have developed classifications of both existing vegetation and potential natural vegetation. These should always be kept distinct in considerations of vegetation classifications as they support different, but possibly complementary, objectives and applications. By *existing vegetation* we simply mean the vegetation found at a given location at the time of observation. By *potential natural vegetation* we mean "the vegetation that would become established if successional sequences were completed without interference by man or natural disturbance under the present climatic and edaphic conditions" (Tüxen 1956, in Mueller-Dombois and Ellenberg 1974).

Classifying existing vegetation requires fewer assumptions about vegetation dynamics than classifying potential natural vegetation. Emphasis is placed on the current conditions of the stand. Classifications that emphasize potential natural vegetation require the classifier to predict the composition of mature stages of vegetation based on knowledge of the existing vegetation, species autecologies and habitat relationships, and disturbance regimes. For this reason, sampling to identify potential vegetation types is often directed at stands thought to represent mature or late seral vegetation. The 1997 FGDC vegetation standard pertains to existing vegetation and does not address issues related to the study of potential natural vegetation. This document has been written in support of the FGDC standard and is intended to support the study of existing vegetation.

3.2. A NATIONAL VEGETATION CLASSIFICATION FOR THE UNITED STATES

Agency and scientific consensus on classification

Vegetation classification, especially the concept of a unified, nationwide classification, received little support in the U.S. academic community prior to the 1990s. Most academic ecologists viewed classification as having little to contribute towards a general conceptual synthesis of broad applicability and were little interested in products of largely local or regional applicability. This view also stemmed in part from the diversity of approaches to interpreting and understanding the nature of vegetation patterns, as reviewed in the previous section

(Nicolson and McIntosh 2002). As a consequence, little attention was paid to creating a unified national vegetation classification.[4]

Individual federal and state agencies in the U.S. charged with resource inventory or land management often required vegetation inventories or maps of public lands, both of which depend on classification for definition of units. Prior to the 1990s most of these projects were generally limited in scope and geography and tended to use divergent methods and categories (see Ellis et al. 1977) such that their various products did not fit together as components of a larger scheme. Instead, the disparate, disconnected activities resulted in development of incompatible sets of information and duplication of effort (National Science and Technology Council 1997). Nevertheless, the importance of broadly applicable systems for coordination of efforts had already become apparent during the 1970s and 80s, and some useful and geographically broad classifications were produced, including the habitat type classification of western forests by the U.S. Forest Service (Wellner 1989) and the Cowardin classification of U.S. wetlands (Cowardin et al. 1979). The Society of American Foresters has historically used a practical dominance-based approach for classifying forest types in North America (Eyre 1980), as has the Society for Range Management (Shiftlet 1994). In addition, in the early 1980s, five federal agencies collaborated to develop an ecological land classification framework integrating vegetation, soils, water, and landform (Driscoll et al. 1984).

In the late 1970s, The Nature Conservancy (TNC) initiated a network of state Natural Heritage Programs (NHPs), many of which are now part of state government agencies. The general goal of these programs was inventory and protection of the full range of natural communities and rare species present within the individual states. Because inventory requires a list of the communities being inventoried, the various programs proceeded to develop their own state-specific community classification systems. As TNC started to draw on the work of the NHPs to develop national-level priorities for community preservation and protection, it quickly recognized the need to integrate the disparate state-level vegetation classifications into a consistent national classification.

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4. In contrast, classification has been a major activity in Europe throughout the twentieth century, with vegetation scientists largely using the methods of the Braun-Blanquet school. Moreover, vegetation classification gained new impetus in many European countries during the 1970s and 1980s (Rodwell et al. 1995).

In the late 1980s, the U.S. Fish and Wildlife Service initiated a research project to identify gaps in biodiversity conservation (Scott et al. 1993), which evolved into what is today the U.S. Geological Survey's National Gap Analysis Program (GAP; Jennings 2000). This program classifies and maps existing natural and semi-natural vegetation types of the United States on a state and regional basis as a means of assessing the conservation status of species and their habitats. Because a common, widely used, floristically based classification was critical to this work GAP supported TNC's effort to develop a nationwide classification (Jennings 1993). Collaboration between GAP and TNC led to a systematic compilation of alliance-level information from state natural heritage programs and from the existing literature on vegetation (e.g., Bourgeron and Engelking 1994, Sneddon et al. 1994, Drake and Faber-Langendoen 1997, Weakley et al. 1997, Reid et al. 1999). With support from TNC and an array of federal programs, Grossman et al. (1998) and Anderson et al. (1998) produced the first draft of what became the U.S. National Vegetation Classification (USNVC, referred to here as the NVC). The NVC was initially populated with a compilation of described natural vegetation types taken from as many credible sources as could be found and drawn from the experience vegetation ecologists with extensive regional expertise. Although the majority of the types described were not linked to specific plot data, they were often based upon studies that used plot data or on the knowledge of regional and state ecologists (Weakley et al. 1998, Faber-Langendoen 2001).

The Federal Geographic Data Committee and the ESA Vegetation Panel

In the early 1990's the US federal government formally recognized the need for a standard nationwide vegetation classification. In 1990 the government published the revised Office of Management and Budget Circular No. A-16 (Darman 1990)[5], which introduced spatial information standards. This circular described the development of a National Spatial Data Infrastructure (NSDI) to reduce duplication of information, reduce the expense of developing new geographically based data, and make more data available through coordination and standardization of federal geographic data. The circular established the Federal Geographic Data

5. The circular was originally issued in 1953 to insure that surveying and mapping activities be directed toward meeting the needs of federal and state agencies and the general public, and that they be performed expeditiously, without duplication of effort. Its 1967 revision included a new section, "Responsibility for Coordination." It was revised and expanded again in 1990 to include not just surveying and mapping, but also the related spatial data activities.

Committee (FGDC) to promote development of database systems, information standards, exchange formats, and guidelines, and to encourage broad public access.

Interagency commitment to coordination under Circular A-16 was strengthened and urgency was mandated in 1994 under Executive Order 12906 (Federal Register 1994), which instructed the FGDC to involve state, local, and tribal governments in standards development and to use the expertise of academia, the private sector, and professional societies in implementing the order. Circular A-16 was revised in 2002 to incorporate the mandates of Executive Order 12906. Under these mandates, the FGDC established a Vegetation Subcommittee to develop standards for classifying and describing vegetation. The subcommittee includes representatives from federal agencies and other organizations. After reviewing various classification options, FGDC proposed to adopt a modified version of the TNC classification. During the review period, ecologists from the National Biological Survey,[6] TNC, and academia discussed the need to involve the Ecological Society of America (ESA) to provide peer review as well as a forum for discussion and debate among professional ecologists with respect to the evolving NVC (Barbour 1994, Barbour et al. 2000, Peet 1994, Loucks 1995). The FGDC Vegetation Subcommittee invited ESA to participate in the review of the physiognomic standards as well as development of the standards for the floristic levels. This document is a direct product of the collaboration of ESA, FGDC, USGS, and NatureServe to provide formal standards for vegetation classification within the United States.

ESTABLISHING AND REVISING FLORISTIC UNITS OF VEGETATION

The following sections present formal guidelines for those seeking to propose or modify associations and alliances represented within the US National Vegetation Classification. It is our intent that these guidelines and procedures will facilitate continued rapid development, wide acceptance, and scientific maturation of the NVC.

6. Now the U.S. Geological Survey's Biological Resources Division.

4. THE ASSOCIATION AND ALLIANCE CONCEPTS

The historical record of vegetation classification, as well as recent developments shows a continuing convergence of the basic concepts that underlie establishment and recognition of associations and alliances. Ecologists have long recognized the need to communicate the context of ecological and biological phenomena and to understand interactions within and among biotic communities. These needs have led to frequent use of "community type" or "vegetation type" as a unit of vegetation. Vegetation types can be understood as segments along gradients of vegetation composition, with more-or-less continuous variation within and among types along biophysical gradients. Conceptualization of vegetation types is derived from analyses of vegetation samples (plots, transects, relevés etc.), as explained more fully in Sections 5-7, and these samples provide the fundamental data for describing vegetation. With the broad assortment of analytical tools and approaches that are now used to assess vegetation patterns, the basic and practical needs for classifying vegetation have led to a substantial unification in approaches to the classification of vegetation.

4.1. ASSOCIATION

The association is the most basic unit of vegetation recognized in the NVC. The earliest definition (Flahault and Schröter 1910a, 1910b) is usually translated as “a plant community of definite floristic composition, uniform habitat conditions, and uniform physiognomy”. Since the 1910 discussion was focused on vegetation types, rather than particular stands of vegetation, some translations insert “type” after "community" to clarify that it does not refer to an individual community or stand, but to a conceptual abstraction. Shimwell (1971:52) clarifies the "type" interpretation: "The central concept of the Association was its abstract nature, i.e. the field observer never saw an Association in the field; it was only a stand, just as a herbarium only contains a specimen of a species." Gabriel and Talbot (1984) provided numerous definitions of association, including "a recurring plant community of characteristic composition and structure." Curtis (1959, pg. 51, 53) defined the plant community type, a segment along a continuum, as “more or less similar groups of species recurring from place to place...their lack of an inherent discreteness, however, does not prohibit their orderly arrangement into groups for purposes of study and discussion.” The individual stand was defined simply as a “studiable grouping of organisms which grow together in the same general place and have mutual interactions." The commonalities evident in most definitions include four central ideas: 1) definite floristic composition, 2) uniform physiognomy and structure, 3) uniform habitat, and 4) a recurring distribution across a landscape or region."

Mueller-Dombois and Ellenberg (1974) recognized that "species assemblages change more or less continuously, if one samples a geographically widespread community throughout its range." Their phrasing highlights an important element, the variability within an association that occurs across its range. In addition, the early recognition of Gleason (1926) that chance plays a major role in the local expression of vegetation has become an important part of our understanding of vegetation composition. Many classifications, including the standards described in Section 6, have been framed around some characteristic range of variation in composition, physiognomy, and habitat rather than the "definite composition, uniform physiognomy and uniform habitat conditions of the original association definition of Flahault and Schröter (1910a, b.). Range of variation then, provides a measure of the breadth of species composition, physiognomy, and habitat that occur within a set of field plot data used to define the association.

Three other points should be considered:

1. Habitat" refers to the combination of environmental or site conditions and natural disturbances that influence the community. Temporal variation in floristic composition due to unusual severe weather events and seasonal variation in phenology are acceptable variation if they do not fundamentally change species presence. Ecological processes such as major disturbances (fire, insects, disease, grazing) and natural succession will generally produce different associations on the same site over time.
2. Characteristic physiognomy and habitat conditions may include fine-scale patterned heterogeneity (e.g., hummock/hollow microtopography in bogs, shrub/herb structure in semidesert steppe).
3. Unlike strictly floristic applications of the association (and alliance) concept, the definition for the NVC standard retains an emphasis on both floristic and physiognomic criteria as implied by membership of floristic types in higher order physiognomic units of the classification.

Accordingly, establishment of a plant association implies application of a standard set of methods for describing an ecological abstraction, while also pursuing practical classification. The result requires acceptance of a degree of variation in composition and habitat within the classification unit, the association. As a synthesis of the above considerations, we adopt the following definition of association as the basic unit of vegetation:

> *A vegetation classification unit defined on the basis of a characteristic range of species composition, diagnostic species occurrence, habitat conditions and physiognomy.*

In the context of this definition, diagnostic species refers to any species or group of species whose relative constancy or abundance can be used to differentiate one type from another. Guidelines have been proposed for the minimum number of diagnostic species required to define an association" (e.g., Schaminée et al. 1993). Obviously, the more diagnostic taxa that are used to define an association and the stronger their constancy and fidelity, the better the case for recognizing the unit. Moravec (1993) stated that associations may be differentiated by (1) character species, i.e., species that are limited to a particular type, (2) a combination of species sharing similar behavior (ecological or sociological species groups), (3) dominant species, or (4) the absence of species (groups) characterizing a similar type.

Despite the use of diagnostic species in vegetation classification, this is an intrinsically imprecise activity and it must be recognized that diagnostic species can never precisely define lines between two similar associations. In addition to the fact that vegetation varies continuously, species are stochastic in their distributions (given the vagaries of, for example, dispersal, reproduction, and establishment) and chance events influence their occurrence at any given site. For this reason vegetation classification is based on representative or modal plots that define the central concept of the type, but not the edges. Assignment of a plot to an association is determined by composition consistent with a characteristic range of diagnostic species occurrence or abundance. Intermediate plots can be assigned to associations based on measures of similarity, relative occurrence or abundance of diagnostic species, or considerations of habitat and physiognomy. Good practice requires quantitative description of species composition, diagnostic species, and other criteria that minimize ambiguity among associations.

There is no consensus on some fixed amount of variation that is acceptable within an association or alliance. Mueller-Dombois and Ellenberg (1974) suggest, as a rule of thumb, that stands with a Jaccard presence/absence index (of similarity to the most typical plot) between 25% and 50% could be part of the same association and that stands with greater levels of similarity may better define subassociations. The subject of "stopping rules" in classification is a complex one, and a variety of criteria are often applied, including physiognomic and habitat considerations. In addition, the nature of the particular vegetation itself strongly influences decisions about where to draw conceptual boundaries between vegetation types. Important considerations may include species richness, amount of variation among stands, degree of anthropogenic alteration, and the within-stand homogeneity of the vegetation. No simple rule can be applied to all cases.

4.2 ALLIANCE

The vegetation alliance is a unit of vegetation determined by the floristic characteristics shared among its constituent associations, and is constrained by the physiognomic characteristics of the higher levels of classification within which the alliance is included. Its makeup is broader in concept than the association (i.e., more floristically and structurally variable), yet it has discernable and specifiable floristic characteristics. We define alliances as:

> *A vegetation classification unit containing one or more associations, and defined by a characteristic range of species composition, habitat conditions, physiognomy, and diagnostic species, typically at least one of which is found in the uppermost or dominant stratum of the vegetation.*

This definition includes both floristic and physiognomic criteria, in keeping with the integrated physiognomic-floristic hierarchy of the NVC. It also builds directly from the association concept. In comparison with the association, the alliance is more compositionally and structurally variable, more geographically widespread, and occupies a broader set of habitat conditions. Characterizing alliances is ideally dependent upon fully documented associations within the alliance, but as a practical matter "low confidence" alliances (see Section 7.1 on classification confidence levels) often need to be created and used before all the component associations can be established (see Section 6). Alliances that are defined narrowly based on specialized local habitats, locally distinctive species, or differ primarily in the relative dominance of major species, are to be avoided.

The vegetation alliance concept presented here differs somewhat from the concept used in the more floristically-based Braun-Blanquet approach (Braun-Blanquet 1964, Westhoff and van der Maarel 1973). For example, using the Braun-Blanquet criteria, the Dicrano-Pinion alliance, which typically contains evergreen tree physiognomy, could include common juniper (*Juniperus communis*) shrublands (Rodwell 1991). The Vaccinio-Piceion (or Piceion Excelsae) alliance, with typically evergreen physiognomy, could include broadleaved deciduous birch (*Betula pubescens*) woodlands (Betulion Pubescentis alliance) (Ellenberg 1988, Rodwell 1991).

Nonetheless, alliances of the Braun-Blanquet system typically contain broadly uniform physiognomic and habitat characteristics comparable to the concepts and standards put forth here. Specht et al. (1974) used a similar approach to define alliances for Australia.

Many forest alliances are roughly equivalent to the "cover types" developed by the Society of American Foresters (SAF) to describe North American forests (Mueller-Dombois and Ellenberg 1974, Eyre 1980). In cases where the cover type is based solely on differences in the co-dominance of major species (e.g. Bald Cypress cover type, Water Tupelo cover type, and Bald Cypress-Water Tupelo cover type), the alliance may be broader than the narrowly defined cover types, or recombine them in different ways based on floristic and ecologic relationships. In cases where the dominant tree species extend over large geographic areas and varied environmental, floristic or physiognomic conditions, the alliance may represent a finer level of classification than the SAF cover type. In these situations, diagnostic species may include multiple dominant or co-dominant tree and understory species that together help define the physiognomic, floristic, and environmental features of an alliance type. For example, the broad ranging Jack Pine forest cover type (Eyre 1980, No. 1) may include at least two alliances, a more closed, mesic jack pine forest type and a more xeric, bedrock woodland type.

The alliance is similar in concept to the "series" of Daubenmire, a group of habitat types that share the same dominant species under apparent climax conditions (Pfister and Arno 1980). The series concept emphasizes the composition of the tree regeneration layer more than tree overstory composition in order to reveal the *potential* homogeneity of late-seral or climax canopy conditions based on the current tree population structure. Alliances differ from the series concept in that alliances, like associations, are based on existing vegetation, regardless of successional status. For example, a shrub type that dominates after a fire would be classified as distinct from both the forest type that was burned and the possible forest type that may eventually reestablish on the site.

The alliance is somewhat similar in concept to the "Series" widely used in the western United States for grouping similar late-successional associations (and interpreted habitat types) following the basic Daubenmire (1952) conceptual approach (Pfister and Arno 1980). The series concept (of associations) emphasizes the recognition of diagnostic potential climax dominant species based on age and/or size structure data and known relative autecological competitiveness. The presumed final stage of vegetation development is used to assign a stand or vegetation to a series, regardless of its status at the time of observation. For stands of an association where the potential climax species has attained a dominant position, the identified series may be identical to the alliance concept. However, for those stands of an association where the potential climax species is currently subordinate to a dominant seral species, the identified series and alliance would likely be different. Alliances and associations of the NVC differ conceptually from the Daubenmire approach because they are based only on existing vegetation, regardless of potential climax status.

5. VEGETATION FIELD PLOTS

A basic premise underlying these guidelines is that the alliance and association units are to be described and recognized through use of plot data (see guiding principles in Text Box 1, and the discussion of field plot records in Section 2 as well as in the first paragraph of Section 4). A second basic premise is that adherence to common guidelines for recording field plots is of critical importance for the development and consistent application of a scientifically credible NVC. Without data collected in compliance with such guidelines, recognition, description, and comparison of vegetation types could well be inaccurate, inconsistent and less than fully repeatable. The types of information that need to be collected in the field are discussed below and are listed in Appendix 1. A critical component to generating field data that can be integrated with other field data sets as well as used for multiple purposes is a digital schema that defines a data structure. Important progress in describing and understanding associations and alliances will hinge on the integration of plot data from multiple sources. The technical key to generating such plot data is a standard XML schema (see Sperberg-McQueen and Thompson, 2003). A schema for field plot data is discussed further in Section 8 and Appendix 4.

5.1. MAJOR TYPES OF REQUIRED DATA

The purpose of field plots is to record the *vegetation* and its *environmental context*. In addition, later interpretation of information collected in the plot requires *metadata*. Data recorded for field plots for the NVC fall into these three main categories.

1. Vegetation data: Floristic composition and physiognomy that can be used to classify vegetation constitute the key component of plot data. Floristic data consist of a list of the taxa observed, often recorded by the vertical strata they occur in, and usually associated with some measure of importance such as the relative amount of ground covered by

them. Vegetation structure is typically assessed in terms of overall cover by vertical strata and the physiognomic attributes of the taxa associated with those strata.

2. Site data: Vegetation is best interpreted in the context of habitat, geographic location, and stand history information. This includes
    a. abiotic factors such as soils, parent material, elevation, slope, aspect, topographic position, and climate,
    b. stand history and disturbance regime, and
    c. geographic location.
3. Metadata: Data that describe the methods used to obtain vegetation and environmental data, or that are critical for subsequent uses of plot data. Examples of required metadata are the method and precision used to determine plot location, field methods, the nomenclatural (taxonomic) source or standard for identifying and naming plant species, the field personnel (including contact information and institutional affiliation) and the sampling date. Optional metadata include interpretations and reidentifications of plant taxa and the assignment of the plot to a particular type or types within the NVC.

Not all studies that use vegetation plot data are focused on classification. Investigators may have a variety of objectives when collecting plot data including, for example, documentation of ecological patterns and processes, assessment of vegetation structure, assessment of long-term change and human impacts, determination of targets for restoration, and validation of remote-sensed data. This section describes the plot information needed to support the development of associations and alliances of the NVC. It is not intended to serve as a definitive guide to recording and describing vegetation; discussion of these issues can be found in other references (e.g., Mueller-Dombois and Ellenberg 1974, Kent and Coker 1992, Jongman et al. 1995). In particular, this section is intended to alert investigators to the major issues that must be considered when collecting vegetation plot data for the purpose of developing or supporting a vegetation classification and to inform them as to the critical data that must be collected for plots to be used in the context of the NVC. If plot data are to be used to support development, refinement and identification of NVC types, investigators need to collect the core data described next.

5.2. STAND SELECTION AND PLOT DESIGN

Plot Selection

Vegetation surveys typically focus on detecting the range of vegetation variation in a region, or on a range wide assessment of one or more vegetation types. To achieve adequate representation of the vegetation in a focal area or type, plot selection is usually preceded by reconnaissance (ground or aerial) to assess the major patterns of variation in vegetation (or its underlying environmental gradients) and to develop a method for stand and plot selection. For example, major environmental factors may be used to create an “abiotic grid within which to select plots (e.g., stratified sampling of Peet 1980, or the gradsect technique of Austin and Heyligers 1991). The selection method is a critical step because it determines how well the plots will represent the area under study.

Selection of stands (contiguous areas of vegetation that are reasonably uniform in physiognomy, floristic composition, and environment) may be made by either *preferential* (subjective) or *representative* (objective) means, or some combination of these (*sensu* Podani 2000). With preferential methods, stands are selected based on the investigator’s previous experience, and stands that are “degraded”, “atypical”, or redundant may be rejected. A stand selected for plot records is considered typical of the vegetation of which it is a part, and each plot recorded is expected to yield a more or less typical description in terms of both floristic composition and physiognomy (Werger 1973). The same is true of representative selection, except that this approach also involves selecting stands with some degree of objectivity so as facilitate characterization of the full universe of vegetation within which the study is being conducted. The selection of representative stands may be via a simple random, stratified random (including the environmental grid or gradsect approach noted above), systematic, or semi-systematic method (Podani 2000). Either preferential or representative methods will yield plots suitable for the NVC, but representative sampling will typically lead to a less biased set of plots. In contrast, the representative method may miss or under sample rare and unusual types. Consequently, it is often necessary to supplement representative sampling with plots from rare or unusual types encountered in the course of field work. When working in highly modified landscapes, preferential selection is often the only way to assure that reasonably natural vegetation is adequately observed and sufficiently understood to be compared to other vegetation. Stratification of a landscape into a priori units within which plots are randomly located represents a hybrid approach and is often the preferred method.

For a variety of reasons, stand selection may be limited to only part of the vegetation present in an area. Many studies focus only on natural vegetation, including naturally disturbed, and various successional stages of vegetation. Others may focus exclusively on late-successional or mature natural vegetation. However, in principle, the NVC applies to existing vegetation, regardless of successional status or cultural influence. Criteria used to select stands should be thoroughly documented in the metadata.

Plot Location

Following reconnaissance and stand selection, a plot or series of plots is located within all or some subset of stands. Each plot should represent one entity of vegetation in the field; that is, a plot should be relatively homogeneous in both vegetation and habitat and large enough to represent the stand's floristic composition. Specifically, plots should be large enough and homogeneous enough that the relative importance of the dominant species observed within the plot is comparable to that of the surrounding stand. Of course, the investigator must recognize that communities are never fully homogeneous. Indeed, the main requirements for homogeneity can be met as long as obvious boundaries and unrepresentative floristic or structural features present in the stand are avoided (Rodwell 1991). Decisions about plot placement and homogeneity must be included in the plot metadata. These initial decisions are important, as both stand selection and plot placement within stands affect data quality.

Vegetation can be homogeneous at one scale and not at another. Some within-plot pattern is inevitable; small gaps occur within forests owing to death of individual dominants, and bryophytes and herbs can reflect substrate heterogeneity such as occurrence of rocks or logs. Moreover, forests or rangelands examined at a scale of many kilometers can contain homogenous patches of differing age or disturbance history. For the purposes of the NVC the field worker should not seek homogeneity at the scale of either the mosses on a stump or the forests across a landscape, but rather homogeneous stands within which to place plots at some scale between 10 and 100,000 m^2 [(7)] reflecting a typical pattern of plants co-occurring under common environmental and historical conditions.

The floristic composition and structure of a plant community will vary not only in space but also in time. Seasonal changes, even during the growing season, can be dramatic in some types of vegetation. Large shifts in floristic composition over one to several years can occur in response to unusual weather conditions or fire. Some forest types (e.g., mixed mesophytic

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7. As used here, “m^2” denotes the amount in square meters (see Taylor 1995), e.g., 1,000 m^2 is the area within a 50 x 20 m plot.

forests) may have a diverse and prominent, but ephemeral, spring flora. Some deserts have striking assemblages of annuals that appear only once every few decades. Although plot records for the NVC are based on the existing vegetation at the time of observation, plots that are known or expected to be missing a substantive portion of the likely flora must be so annotated to enable future analysts to properly interpret the data quality. Repeated inventories may be made over the course of a season to fully document the species in the plot. Practically speaking, these repeat visits (which should be documented as such) can be treated as multiple visits to the same plot and recorded as one plot observation record. Conversely, multiple visits over a series of years should be treated as separate plot observations (Poore 1962).

Plot design

Two fundamentally different approaches are commonly used for recording vegetation: (a) a plot where the information recorded is taken from a single *entire* plot, or (b) *subplots,* where the information recorded is taken from a set of smaller plots from within the stand. Both types of plots can provide adequate data for vegetation classification, but each method has its own requirements and advantages. Each of these is discussed next.

Data taken from an entire large plot

This is an efficient, rapid method for collecting floristic and physiognomic data for classification. The plot size is chosen to ensure that the plot is small enough to remain relatively uniform in habitat and vegetation, yet is large enough to include most of the species that occur within the stand. This approach permits statistical assessments of between-stand variation, but not within-stand variation.

Recommended plot size varies, depending on the structure of vegetation (the size of individual plants, spacing, number of vertical layers, etc). Plot sizes have also been based on the need for the plot to adequately represent the vegetation being sampled such that an increase in plot area yields few new species within the stand, and none significant to the vegetation's physiognomy (see Moravec 1973 for a method of mean similarity coefficients). Plots larger than this are acceptable, but plots that are too small to represent the stand's composition and structure are not adequate for developing a vegetation classification. For instance, in most temperate hardwood or coniferous forests, plots of between 200 and 1,000 m^2 are adequate for characterizing both the herb and the tree strata, whereas in many tropical forests, plots between

1,000 and 10,000 m^2 are required. Grasslands and shrublands may require plots between 100 and 200 m^2, whereas deserts and other arid-zone vegetation may require large plots, typically between 1,000 and 2,500 m^2 because the vegetation cover is sparse and species may be widely scattered. These recommended plot sizes typically satisfy minimum area calculations (McAuliffe 1990). Specialized studies of fine-scale variation, such as zonation around small wetlands or small sized bryophyte assemblages may well require plots that are smaller still, perhaps only a few m^2, though such small plots are to be avoided in community classification studies wherever possible.

We do not specify or recommend any particular plot shape; in fact, plot shape may need to vary depending on stand shape (e.g., riparian stands tend to be linear). Whenever possible, plot size and shape should be kept constant within a study. Issues of efficiency in plot layout most often dictate the plot shape employed by an investigator.

<u>Data taken from a set of smaller subplots</u>

Data may be collected from multiple subplots within a stand as an alternative to observation of a single large plot. This approach yields data that can be used to assess internal variability within a stand and to more precisely estimate the average abundance of each species across the stand. It is often used to measure treatment responses or evaluate other experimental manipulations of vegetation. The approach also may be useful for characterizing average vegetation composition in topographically gentle terrain where boundaries between stands may be diffuse. This method is inappropriate for measures of species number per unit area larger than the subplot, but can be helpful for assessing the relative variation within and among stands.

Investigators using the multiple small plot methods may locate their sample units randomly or systematically within the stand. The observation unit can be a quadrat, line-transect or point-transect, and can be of various sizes, lengths, and shapes. Quadrats for ground layer vegetation typically range from 0.25 to 5.0 m^2 and anywhere from 10 to 50 quadrats may be placed in the stand, again, either randomly or systematically. Quadrats for trees, where measured separately, typically are on the order of one m^2 or more. Even though subplots may be collected over a large portion of the stand, the total area over which data are recorded may be smaller than if the investigator used a single large plot (e.g., 50 one m^2 quadrats dispersed in a temperate forest stand will cover 50 m^2, whereas a single large plot would typically cover 100-1000 m^2).

When deciding between multiple subplots and a single large plot it is important to consider the tradeoff between the greater precision of species abundance obtained with smaller, distributed subplots versus the more complete species list and more realistic assessment of intimate co-occurrence obtained using the single large plot. A major disadvantage of relying solely on subplots to characterize the stand is that it requires a large number of small sample units to adequately characterize the full floristic composition of the stand, a larger number than is generally employed. Yorks and Dabydeen (1998) described how reliance on subplots can result in a failure to assess the importance of many of the species in a plot. Consequently, whenever subplots or transects are used to characterize a stand, we strongly recommend that a list of "additional species present" within a larger part of the stand, such as some fixed area around the subsamples, be included. The classic Whittaker plot contains 25 one m^2 subplots plus a tally of additional species in the full 1000 m^2 macroplot, and the California Native Plant Society protocol incorporates a 50 meter point transect supplemented with a list all the additional species in a surrounding 5 x50 m^2 area (Sawyer and Keeler-Wolf 1995).

<u>Hybrid approaches</u>

Hybrid methods can combine some of the advantages of the two approaches. Sometimes, several somewhat large subplots (e.g., > 200 m^2 in a forest) are established to assess internal stand variability. The plots are sufficiently large that, should variability between plots be high, the plots could be classified separately as individual plots. A different strategy is for plots of differing sizes to be nested and used for progressively lower vegetation strata, such that plot size decreases as one moves from the tree layer to the shrub and herb strata owing to the generally small size and greater density of plants of lower strata. Although efficient with respect to quantitative measures of abundance, especially for common species, this method risks under representing the floristic richness of the lower strata, which are often more diverse than the upper strata. This problem can be ameliorated by listing all additional species found outside the nested plots but within the largest plot used for the upper layer. Again, the fundamental requirement is that the plot methods provide an adequate measure of the species diversity and structural pattern of the vegetation for the purposes of classification.

Because vegetation pattern and its correlation with environmental factors can vary with plot size (see Reed et al. 1993), no one plot size is *a priori* correct, and it can be desirable to record vegetation across a range of different plot sizes. The widely applied 1000 m^2 Whittaker (1960) plots and 375 m^2 Daubenmire (1968) plots contain a series of subplots for herbaceous vegetation. More recently a number of investigators have proposed protocols where multiple plot sizes are nested within a single large plot (e.g., Naveh and Whittaker 1979, Whittaker et al. 1979, Shmida 1984, Stohlgren et al. 1995, Peet et al. 1998). These methods allow documentation of species richness and co-occurrence for a broad range of plot sizes smaller than the overall plot. Typically, they have the added advantage of documenting all vegetation types at several consistent scales of resolution, thereby assuring compatibility with many types of plot data.

5.3 PLOT DATA

As discussed in section 5.1, three types of data are needed for effective vegetation classification: vegetation data, site data, and metadata. Of these, data on the floristic, structural, and physiognomic composition of the vegetation must meet especially strict criteria. Environmental, or habitat data, such as soil attributes, topographic position, and disturbance history, are also important. However, since the environmental variables most significant to the vegetation of a plot in one region may be insignificant in another region, the requirement of such variables is less amenable to standardization. Metadata are necessary in order to find certain types of data as well as to understand how, when, and where they were collected and who collected them (see Tables 2.1-2.6 of Appendix 1). Overall, it is the quality of the vegetation data, more than the site data or metadata, that determines whether a plot will be useful in the NVC.

In the following sections we discuss (a) the types of field plots that may be used, (b) methods for describing vegetation structure, and (c) methods for describing the floristic composition of a plot. For vegetation composition, the guidelines call for an estimate of the overall canopy cover of each plant species in the plot. In addition, the guidelines call for an estimate of the canopy cover of each species by each stratum. For vegetation structure, the guidelines call for an estimate of the canopy cover of each strata of vegetation (i.e., tree, shrub, field layer). These three measurements of leaf canopy cover—by species, species-by-stratum, and stratum—allow for a three-dimensional representation of the plot and, ultimately, a similar representation of associations and alliances.

Plot types

We have developed guidelines for two different types of plot data, depending on the objectives and uses of the data. Plots can be used to describe new or revise known alliances and associations for the NVC classification (*classification plots*). Alternatively, they can provide supplemental information relevant to the geographic or ecological distribution or abundance of known NVC types (*occurrence plots*). The minimum set of attributes that should be collected for classification plots and occurrence plots is listed in Appendix 1. Additionally, to ensure that as many kinds of plot data as possible are available for developing the NVC, Appendix 1 distinguishes between those data fields that are minimally *required* for classification and those data fields that are not required, but reflect best practice and are *optimal*. For classification plots, the minimal requirement covers information about taxon identity, taxon canopy cover, plot area, sampling method, date of collection, location, and those who collected the data (other information can be required if the observation is derived from literature rather than made in the field; see Appendix 1). Plots that meet only these minimal requirements are less valuable for classification than those that contain the optimal set of data fields.

The minimal information required for occurrence plots is driven by the information needed to simply report an observation of an association or alliance at a location. This information minimally consists of: the dominant species names and canopy cover values, geographic coordinates, the name of the association or alliance, and the names of those who collected the data. This is the information that must be provided for a plot to be archived in the NVC database (as with classification plots, other information can be required if the observation is derived from literature rather than made in the field). Additional information, such as the subdominant and characteristic species and their cover values, plot size and shape, and additional environmental variables, is important and should be recorded if possible.

In what follows we discuss the main features of the guidelines for *classification* plots.

Floristic composition

<u>Species List</u>

For field plots used to classify vegetation, measurements should be designed to detect and record the vascular plant species composition of the plot. Recording nonvascular species is expected in vegetation where nonvascular species are dominant. As a minimum standard, only one field visit is required. Generally, plots should be recorded only when the vegetation is adequately developed phenologically so that the prevailing cover of each species can be assessed. However, some plant species may not be visible in certain seasons (e.g., spring ephemerals) or may be unreachable (e.g., epiphytes, cliff species), and thus not identifiable. All reasonable efforts should be made to ensure that the occurrence of such species rerecorded is at least noted.

The phenological aspects of vegetation exhibiting clear seasonal changes in composition must also be noted (e.g., young grasses, whose abundances may be underestimated in late spring). In cases where phenological changes are pronounced (especially among dominants), repeat visits are recommended. If a repeat visit at another phenological period reveals a higher cover value for a species, that value should be used in analyses. In such cases, the sampling date of record should show that the plot data are derived from a given range of dates and times. Methods for recording data from repeat visits can be found in the NVC vegetation plots database (http://www.vegbank.org), which supports both multiple observations of a plot as well as a range of time periods for a single observation. It is vitally important that when data from such repeat visits are integrated to represent a complete species list and species importance values that a temporally related bias is not introduced from stochastic events such as disturbance or from succession.

At a minimum, data for classification plots must include a comprehensive list of all vascular plant species visible in the plot at the time of sampling together with an assessment of their cover. A conscientious effort should be made to thoroughly traverse the plot to compile a complete species list. Nonvascular plants (e.g. bryophytes and lichens) should be listed where they play an important role (e.g., peatlands, rocky talus). Detailed treatment of cryptogams is expected where they are dominant. We recommend, but do not require, that a list of additional species found in the stand *but outside the plot* also be compiled. It is important that species within the plot be distinguished from those outside the plot, in order that diversity estimates for the plot (or area) not be inflated.

All plant taxa should be identified to the finest taxonomic resolution possible. For example, variety and subspecies level determination should be made routinely where appropriate. In addition, it is essential that the basis for the name applied for each taxon be identified. Plant names have different meanings in different reference works, and it is imperative that the meaning of each name be conveyed by reference to a standard authoritative work. In lieu of an authoritative work, an investigator may specify an authoritative list such as Kartesz 1999 (*et seq.*), though this should only be done with great caution so as to avoid inadvertent misidentifications or plant name synonyms, where the same actual species is counted as two or more different species. Kartesz 1999 is the basis for (but slightly different from) the list maintained by the USDA PLANTS (2003) database as a taxonomic standard. If using USDA PLANTS as an authority, it is imperative that the version and observation date be provided.

Species by strata

It is desirable and considered best practice (although not required) that the individuals of a species listed in a plot also be assigned to the stratum or strata in which they are found. Not all plants will fit clearly into the strata recognized, but the purpose of listing species by vegetation structure is to document the composition of the most visible strata of the stand (see the section "Vertical structure and physiognomy of vegetation" on page 40). Although a species may occur in more than one stratum because of differences in size among individuals, an individual may only be assigned to the single stratum in which the majority of its leaf area occurs. When species cover has been recorded by a life form such as seedling or pole, these values may be assigned to strata using the crosswalk shown in Table 1.

Cover

Cover is a meaningful measure of abundance for nearly all plant life (Mueller-Dombois and Ellenberg 1974). Percent cover can be defined generically as the vertical projection of the crown or shoot area to the ground surface, expressed as a percent (Mueller-Dombois and Ellenberg 1974). The use of crown or shoot area results in two definitions of cover as follows:

Canopy cover: the percentage of ground covered by a vertical outermost perimeter of the natural spread of foliage of plants (SRM 1989).

Foliar cover: the percentage of ground covered by the vertical portion of plants. Small openings in the canopy and intraspecific overlap are excluded (SRM 1989). Foliar cover is the vertical projection of shoots; i.e., stems and leaves.

Canopy cover is the preferred method of collecting cover because it better estimates the area that is directly influenced by the individuals of each species (Daubenmire 1968). Canopy cover, or canopy closure, is easier than foliar cover to estimate from aerial photos and is more likely to correlate with satellite image analysis. A classification based on canopy cover is better suited for mapping vegetation than one based on foliar cover. For each species found in the plot, an overall measure of cover must be cover recorded, and additional species cover values by strata are recommended. Percent cover has been widely accepted as a useful measure of species importance that can be applied to all species. As discussed above, cover may be defined either as canopy cover or as foliar cover. Canopy cover is the recommended form of cover estimates. Cover values are relatively rapid, reliable, and, for the purposes of vegetation survey and classification, they accurately reflect the variation in abundance of a species from stand to stand (Mueller-Dombois and Ellenberg 1974).

Total cover should be recorded for all species in the plot. It is recommended that in addition to the overall cover value, separate cover estimates be provided for each species in each of the strata in which it may occur. Recording abundance of species cover by strata provides a three-dimensional view of the vegetation and facilitates the interpretation of physiognomic and floristic relationships within the FGDC hierarchy. Cover values should be absolute rather than a relative portion of a layer (e.g., if a species forms a monospecific stratum with a cover of 50%, the cover for the species is recorded as 50%, not as 100% of the stratum). The cover for all species in any single stratum (or overall) may be greater than 100%, as the foliage of one species within a layer may overlap with that of another. Cover can be converted from absolute to relative cover at a later stage, if it fits the needs of the investigator. For occurrence plots, only dominant taxa and their cover values (or another suitable measure of abundance), along with diagnostic or characteristic species, need be recorded.

Cover scales

Use of cover classes instead of continuous percent cover can speed up fieldwork considerably. A practical cover scale should be logarithmic, in part because humans can discern doublings better than a linear scale (e.g., it is far easier to tell the difference between 1 and 2% cover than between 51 and 52%). In addition, many species are relatively sparse across all stands and small differences in their cover may be particularly important for classification.

Generally, cover-class scale determinations that are repeatable to within one unit when used by trained field workers indicate that the precision being required is in balance with the accuracy that can be achieved. Table 4 provides a comparison of widely used cover-abundance scales. Among these, the Braun-Blanquet (1932) scale, which has been extensively and successfully used for vegetation classification purposes (Mueller-Dombois and Ellenberg 1974, Kent and Coker 1992), has a set of class boundaries at "few" (somewhere between 0 and 1%), 5%, 25%, 50%, and 75%. It provides a common minimal set of cover classes acceptable for classification. Any scale used for collecting species cover data needs to be convertible to this common scale by having boundaries at or near 0-1%, 5%, 25%, 50%, and 75%. By this criterion, the North Carolina (Peet et al 1998) and Krajina (1933) cover class systems are ideal in that they can be unambiguously collapsed to the Braun-Blanquet (1932) standard, and the Daubenmire (1959), Pfister and Arno (1980) and New Zealand (Allen 1992, Hall 1992) scales are for practical purposes collapsible into the Braun-Blanquet (1932) scale without damage to data integrity. The Domin (1928), Barkman et al (1964), and USFS Ecodata (Hann et al. 1988, Keane et al. 1990) scales all are somewhat discordant with the Braun-Blanquet (1932) standard.

When recording species cover in a plot, any species noted as being present in the stand, but not found in the plot, should be assigned a unique cover code, so that these species can be identified as not part of the plot itself.

Other measures of species importance

Species importance can also be measured as density (number of individuals), frequency (percentage of quadrats or points having a species present), biomass, basal area, absolute canopy cover, or some weighted average of two or more importance measures. Such supplemental measures of importance may add to the value of a plot, but are not required. For data sets having other measures of species importance than cover, but which are otherwise acceptable for classification, it may be possible to calculate an estimate of cover. For example, for trees this may be derived from individual stem measurements or from basal area and density. For forbs this may be derived from air dried weight. The methods used for this conversion, including appropriate calibration techniques, should be thoroughly documented.

In North America, tree species abundance has often been assessed using individual stem measurements, basal area totals, or density. Nonetheless, cover is a requirement for trees because by using cover it is possible to look at the abundance of all species across all strata and to assess relationships between and among the strata. However, it can be difficult to accurately estimate cover of individual tree species in large plots (e.g., > 500 m^2). In such cases, basal area and stem density measures can be used to supplement cover data. In addition, these data will allow comparisons with a wide variety of other forest plot data. For these reasons, collection of basal area and density (stem area and stem counts) for tree species is encouraged when such conditions are encountered.

Vertical structure and physiognomy of vegetation

Data on vegetation structure and physiognomy are needed to relate associations and alliances to the physiognomic and structural categories of the FGDC (1997) hierarchy, but are not strictly necessary for floristic analysis. Physiognomy and structure have overlapping but different meanings. Physiognomy is the external or overall appearance of vegetation (Fosberg 1961, Daubenmire 1968, Barbour et al. 1980). In this sense physiognomy is the result of the growth forms of the dominant plants along with vegetation structure (Mueller-Dombois and Ellenberg 1974, Barbour et al. 1980). Growth form includes gross morphology, leaf morphology, and phenological phenomena (Barbour et al. 1980). Vegetation structure relates to the spacing and height of plants forming the matrix of the vegetation cover. Structure is a function of plant height, stratification into layers, and horizontal spacing of plants (Mueller-Dombois and Ellenberg 1974). The physiognomy and structure of plots have historically been characterized by variety of methods. To be of value as a classification tool for the NVC, the description of physiognomy and structure must be standardized to permit consistent comparisons among data sets.

Strata and Growth Form

When characterizing vegetation structure, several related concepts should be carefully distinguished: (a) growth form, (b) size class, and (c) stratum. Growth form is a description of the morphology of mature individuals of a species. For example, a tree may be defined as a woody plant with a single dominant stem, generally taller than 5 m at maturity. A seedling or sapling of a tree species is still a tree growth form, even if only a few centimeters or meters tall. Table 4 lists commonly recognized growth forms of plant species. Size class refers to the size of individual organisms, not the size of the mature individuals of that species. The use of the terms "seedling" and "sapling," just above, is an example of size classes that are commonly recognized in woody plants.

As used by the NVC, a stratum is a layer of growing vegetation defined primarily on the basis of the height of the plants and to a lesser extent their growth forms (Figure 2). By convention, each stratum is named for the typical growth form that occupies that layer of vegetation. For example, the *tree stratum* is the zone of woody vegetation generally occurring above 5 m in height. However, tree saplings generally occupy the *shrub stratum*, tall shrubs may occur in the *tree stratum* as well. Individual plants are assigned to a stratum based on their predominant position or height in the stand, and, secondarily, their growth form. A plot having mature trees, seedlings, and saplings of the same species would include records of that species as occurring in each of several different strata. However, the herb growth forms are always placed in the *field stratum* unless they are epiphytic. Ground-level non-vascular species are placed in their own *ground stratum*. In describing the vegetation structure of a plot, the purpose is to record the essential features of the often complex stand conditions, rather than to describe the layers of vegetation in the greatest possible detail.

The Strata

In terrestrial environments, four basic vegetation strata should be recognized whenever they are present: *tree, shrub, field*, and *ground* (the ground layer is in the sense of Fosberg's [1961] layer of mosses, liverworts, lichens, and algae). In aquatic environments, *floating*, and *submerged* strata should be recognized where present. These six strata are needed to convey both the vertical distribution of overall cover and the predominant growth forms, and help to place a plot within the NVC hierarchy. Additionally, they are used to convey the abundance of each species in each stratum so as to provide a more detailed record of vegetation composition by strata (see below).

The six strata are defined as follows:

Tree stratum: the layer of vegetation where woody plants are typically more than 5 m in height, including mature trees, shrubs over 5 m tall, and lianas. Epiphytes growing on these woody plants are also included in this stratum. The contribution of each growth form (trees, shrubs, etc.) to the tree stratum can be specified using the growth form terms in Table 1.

Shrub stratum: the layer of vegetation where woody plants are typically more than 0.5 m tall but less than 5 m in height, such as shrubs, tree saplings, and lianas. Epiphytes may also be present in this stratum. Rooted herbs are excluded even if they are over 0.5 m in height, as their stems often die back annually and do not provide a consistent structure.

Field stratum: the layer of vegetation consisting of herbs as well as woody plants less than 0.5 m in height.

Ground Stratum: the layer of vegetation consisting of non-vascular plants growing on soil or rock surfaces. This includes mosses, liverworts, hornworts, lichens, and algae.

Floating aquatic stratum: the layer of vegetation consisting of rooted or drifting plants that float on the water surface (e.g., duckweed, water-lily).

Submerged aquatic stratum: the layer of vegetation consisting of rooted or drifting plants that by-and-large remain submerged in the water column or on the aquatic bottom (e.g., pondweed). In aquatic environments the focus is on the overall strata arrangement of these aquatic plants. Emergent plant growth forms in a wetland should be placed in the appropriate strata listed above (e.g., alder shrubs would be placed in the shrub stratum, and cattail or sedges in the herb stratum).

Epiphytes, vines and lianas are not typically treated as separate strata, rather they are treated within the strata defined above, but can be distinguished from other growth forms within a strata using the growth form data field (see Appendix 1). Herbs are restricted to the field stratum even if they exceed 0.5 m height because they typically die back annually. The moss or nonvascular stratum is recognized separately because it can form a distinctive stratum in some vegetation types (such as peatlands), and because it may be the only stratum present in some habitats. In addition, nonvascular species are not always described by vegetation ecologists (who may only record vascular species), and recognition of this stratum provides a simple means of documenting whether or not they were recorded.

Strata may be further divided into substrata. For example, the tree stratum may be divided into canopy trees and subcanopy trees; the shrub stratum may be divided into tall shrub and short shrub; and the field stratum may be divided into dwarf-shrub and herb or further into forb and graminoid. Such subdivisions of the main strata serve to illustrate how the layers of vegetation are based on both the vertical position and the growth form of the vegetation. Substrata should always nest within rather than span the six standard strata defined above.

For each stratum, the total percent cover and the prevailing height of the top and base of the stratum should be recorded. The cover of the stratum is the total vertical projection on the ground of the canopy cover of all the species in that stratum collectively, not the sum of each individual species' covers. The total cover of the stratum will, therefore, never exceed 100% (whereas, adding up the individual cover of species within the stratum could well exceed 100%

since species may overlap in their leaf cover). Details concerning the definition and estimation of vegetation cover are provided in the section on floristic composition below. The best practice for recording the canopy cover of strata is to record percent cover as a continuous value; however, it may be estimated using categorical values of, for example, 5-10% intervals or another recognized cover scale[8].

The percent cover of the three most abundant growth forms in the dominant or uppermost strata should also be estimated (see Table 3 for a list of growth forms). For example, in addition to total cover estimates for all trees in a stand dominated by the tree stratum, separate cover estimates of the dominant growth forms (e.g., deciduous broadleaf trees, needleleaf evergreen trees) should be made. These estimates will help place the plot within the physiognomic hierarchy of the NVC.

Data conversion

Vegetation sampling protocols may record vegetation structure by a variety of strata or growth forms. However, for NVC classification plots, vegetation structure should be provided using the standard criteria described in the previous section (also see Table 1.2 of Appendix 1). Doing so is important in order to have comparable descriptions of formally recognized types. When converting data of vegetation structure from another protocol, it is best if the categories can be readily converted to the strata criteria defined above. Table 1 shows a cross tabulation among some common growth form categories and the standard NVC strata.

In cases where species or growth form cover values must be composited to provide a single cover estimate for a given stratum, the percent cover of stratum *i* can be estimated as follows:

$$C_i = \left(1 - \prod_{j=1}^{n}\left(1 - \frac{\%\,\mathrm{cov}\; j}{100}\right)\right) * 100$$

where C_i is the percent cover of stratum *i* for species or growth form *j* in stratum *i*. The mathematical process for this calculation is shown in Table 2.

8 Cover scales that are typically used for species abundance are not very appropriate for strata cover, as strata do not exhibit the same range of cover that species do; namely, many more species are sparse than are abundant, leading to finer distinctions at the lower end of the cover scale. Thus strata cover scales, if used, should consist of a more evenly distributed cover scale.

Physical data

Physical data provide important measures of the abiotic factors that influence the structure and composition of vegetation (see Tables 1.4 and 1.5 of Appendix 1). For classification purposes, a select set of basic and readily obtainable measures is highly desirable. Physical features of the stand include elevation, slope aspect and slope gradient, topographic position, landform, and geology. Desirable soil and water features include soil moisture, drainage, hydrology, depth of water, and water salinity (where appropriate). The soil surface should also be characterized in terms of percent cover of litter (including dead stems < 10 cm), rock, bare ground, woody debris (dead stems > 10 cm), live woody stems, nonvascular plants, surface water, and other physical objects (see Table 1.4 of Appendix 1). Surface cover estimates should always add to 100% absolute cover. Habitat and stand conditions should be described, including landscape context, homogeneity of the vegetation, phenological expression, stand maturity, successional status, and evidence of disturbance. In many cases recommended constrained vocabularies (see Appendix 2 for recommended constrained vocabularies also used for automated "picklists") have been developed for these data fields and are documented at http://www.vegbank.org/. Plot data should conform to these vocabularies so as to facilitate data exchange.

Geographic data

All plot records must include geocoordinates in the form of latitude and longitude in decimal degrees as per the WGS 84 datum (also known as NAD83; see EUROCONTROL and IfEN 1998). An estimate of the precision of the coordinates should be provided as either a percentage (e.g., plus or minus 5%, or in meters. Where data were originally collected following some other system (e.g., USGS quadrangles with the NAD27 datum), the original data should also be included should it become necessary to assess conversion accuracy at some future time. These original data should include x and y coordinates, the datum or spheroid size used with the coordinates, and the projection used, if any. Geographic data should include a description of the method used to determine the plot location (e.g., estimated from a USGS 7.5 minute quadrangle, use of a geographic positioning system). An estimate of the accuracy of the plot's location information should also be included in the form of an estimate that the plot origin has a 95% or greater probability of being within a given number of meters of the reported location.

Additionally, it may be useful to provide narrative information for plot relocation (see Table 1.3 of Appendix 1).

Metadata

Metadata are needed as a high-level directory for specific data and to explain how the plot data were gathered (see Tables 2.1-2.6 of Appendix 1). All field plot metadata must include a project name and project description. The approach used in selecting the plot location, as described in Section 5.2, should be recorded as narrative text. Metadata on plot layout should include the total plot area in m^2 and the size of the homogeneous stand of vegetation in which the plot was located (see Table 1.3 of Appendix 1). Plot metadata should include whether the plot type is entire or made up of subplots (see Plot Design, Section 5.2). If the plot is made up of subplot observations, the total area of the subplots, not including the spaces in between the subplots, should be specified (see Table 2.2 of Appendix 1). Canopy cover method and strata method used must be included in the metadata, as should the name and contact information of the lead field investigators. Metadata can be readily generated if the plot data exist within the VegBank XML schema discussed in Section 8 and Appendix 4.

Legacy data

Legacy data are plot data collected prior to the publication of these guidelines or without any documented effort to comply with these guidelines. Given that collection of vegetation plot data has been going on in the United States for over a century, including extensive sampling of some parts of the country, these data may contribute substantially to the improvement of the NVC. Some plots may represent stands (or even types) that no longer exist. Others may contain valuable information on the historic distribution and ecology of a plant community, or may contain important structural data (such as on old-growth features) that may be difficult to obtain today. Legacy data have no special status and must conform to the same rules as other plot data. However, care should be taken in importing legacy data to assure maximum compatibility with current guidelines. In using legacy data there are some difficult issues that should be addressed in the plot metadata. Problems include: (1) uncertainty about plot location, which is especially common for data that exist only in published form rather than field records; (2) inadequate metadata on stand selection, plot placement, and sampling method; (3) uncertainty about species identity because of changes in nomenclature and lack of voucher specimens; (4) uncertainty about completeness of floristic data; (5) uncertainty about sampling season; and (6) incompatibility of the cover or abundance measures used.

6. CLASSIFICATION AND DESCRIPTION OF FLORISTIC UNITS

Quantitative plot data constitute the primary descriptor of the floristic units. The guidelines for describing alliances and associations are based on the assumption that the description of a type summarizes the analysis of field plots that are representative of the type and known similar types (Section 5).

6.1. FROM PLANNING TO DATA INTERPRETATION

An association represents a numerical and conceptual synthesis of floristic patterns (Westhoff and van der Maarel 1973, Mueller-Dombois and Ellenberg 1974, Kent and Coker 1992). It is an abstraction, representing a defined range of floristic, physiognomic, and environmental variation. Alliances represent a similar kind of abstraction, but at a more general level. The definition of associations and alliances as individual units of vegetation is the result of a set of classification decisions based on field observation and data analysis. The process can be conceptualized in three stages: (1) scope and planning of plot observation, (2) data collection and preparation, and (3) data analysis and interpretation.

Scope and planning of plot observation

For a classification effort to be effective, plots should be collected from as wide a geographic area as possible. Although only a few plots may be sufficient to determine that a distinct type is warranted, more widespread records (ideally covering the full geographic and environmental range expected) are generally necessary for a type to be adequately characterized and understood in comparison to others that may be conceptually similar. However, not all field observations can be this comprehensive, and we recognize the importance of drawing on field plots collected by multiple investigators. For this reason, those interested in contributing to the classification, even if they are not conducting extensive fieldwork, should conform to these guidelines so that their data and interpretations can be integrated with the data of others to contribute to a larger classification data set.

Data collection and preparation

Vegetation data from all available, high-quality data sets should be combined with any new field data and various supplemental environmental data to provide the basic information for comprehensive documentation of any given type. Where data are applied that do not meet minimum guidelines for quality, consistency, and geographic completeness, their limitations must be explicitly described.

Data preparation requires that plant identification be unambiguously documented by reference to both appropriate scientific names and published sources for documenting the meaning of those names. We recommend that, unless there are specific reasons for a different standard, plant nomenclature for the NVC follow Kartesz (1999), USDA PLANTS (http://plants.usda.gov/), or ITIS (http://www.itis.usda.gov/index.html), as explained in Section 6.3 and in Section 8.1.

In response to the need to combine field plot data sets from different sources, the ESA Vegetation Panel supports a public database of vegetation plots, known as VegBank (http://www.vegbank.org). VegBank is intended to facilitate documentation and reanalysis of data, ease the burden of data preparation, and facilitate mining of existing data from different sources, including standardizing plant names and their taxonomic concepts (see Section 8).

Classification analysis and interpretation

Two criteria must be met in order for any analysis of vegetation types to be robust. First, the plot records employed must represent the expected compositional, physiognomic, and site variation of the proposed vegetation type or group of closely related types. Second, there must be sufficient redundancy in plot composition to allow clear identification of the patterns of compositional variation.

Various methods are available for identification of environmental and floristic pattern from matrices of species occurrences in field plots. The substantial menu of available analytical methods allows individual researchers to select those methods that provide the most robust analyses for the available data (e.g., Braun-Blanquet 1932, Mueller-Dombois and Ellenberg 1974, Jongman et al. 1995, Ludwig and Reynolds 1988, Gauch 1982, Kent and Coker 1992, McCune and Mefford 1999, McCune et al. 2002, Podani 2000).

The approaches most commonly used in the identification and documentation of vegetation pattern are direct gradient analysis, ordination, and clustering (including tabular analysis). Direct gradient analysis typically involves representation of floristic change along specific environmental or geographic gradients, whereas ordination is used to arrange stands strictly in term of similarity in floristic composition. In both cases discontinuities in plot compositions can be recognized, or continuous variation can be partitioned into logical segments. Clustering is used to combine stands into discrete groups based on floristic composition. For each of these techniques a range of mathematical tools is available. The specific tools employed should be carefully documented and explained. For example, the initial matrix of species by plots should be documented directly or by reference to the plots employed and notes on taxonomic adjustments needs for cross-plot consistency. If analysis of the plots with respect to environmental factors is undertaken, the environmental data employed must also be documented and made available either by appendices to the proposal or by a permanent publicly accessible digital archive. An example of such an archive is VegBank.

Preparation of data requires identification of possible sources of noise and of outliers in the data. The narrative for a type description should include documentation of any significant assumptions, known limitations, or inconsistencies in the data employed. In particular, methods used for rejecting plots based on outlier analyses should be documented (examples of outlier identification for gradient analysis are provided in Belsey, 1980), and for ordination and clustering in Tabachnik and Fidell (1989); also see the outlier analysis function in McCune and Mefford (1999). If novel methods are used, they should be described in detail.

An important step in analysis is standardizing taxonomic resolution such that the taxonomic level at which organisms are resolved and the taxonomic standard employed are consistent across all plots. Potential causes for multiple levels of taxonomic resolution in a plot data set include (a) observer inability to consistently determine taxa to the same level, commonly resulting in the field notations such as "(genus) ssp"; (b) a group of taxa that intergrades, that are not readily distinguished on morphological grounds, or are not well described or understood; and (c) infraspecific taxa that are inconsistently recognized by field workers, resulting in some but not all occurrences in the data set being resolved at a very fine taxonomic level. Because of the variety of reasons for resolving individual taxa differently for any given plot, few standards for dealing with this important problem have been established. Nonetheless, some general practices should be followed. (1) The rules and procedures used by an investigator in standardizing taxonomic resolution within a data set must be carefully documented and explained. (2) Dominant taxa must be resolved to at least the species level. (3) Those plots having genus level entities with a combined total cover of >20% will generally be too floristically incomplete, and under some circumstances those plots having >10% of their entities resolved at the genus level or coarser may be excluded. (4) Ecologists should strive for the finest level of taxonomic resolution possible. When aggregation of subspecies and varieties to the species level is necessary, it should be carefully documented. Narratives about vegetation types that discuss the subspecies and varieties that were aggregated to the species level for the numerical analysis can be valuable for interpretation of the results reported.

Methods of data reduction and analysis should be described in detail and the rationale for their selection documented. Documentation should include any data transformations and similarity measures employed. Where possible, more than one analytical method should be used, and converging lines of evidence should be clearly presented. Tabular and graphical presentation of such evidence as biplots of compositional and environmental variation, dendrograms illustrating relationships among clusters, and synoptic tables summarizing community composition can be critical. Criteria used to identify diagnostic species, such as level of constancy, fidelity, etc, should be clearly specified. Tables and graphics by themselves do not determine associations, but can provide the quantitative basis for their identification.

A tabular summary of diagnostic and constant species should be provided. Constant species are those occurring in > 60% (i.e. the top two Braun-Blanquet (1932) constancy classes) of the field plots used to define a type.

Finally, care must be taken to assure that analysis incorporates appropriate geographic variation and that the resultant classification and associated summary tables are not distorted by spatial clumping of plot records. Plots sometimes tend to be spatially aggregated because of the local focus of field investigators. In such cases a set of plots may look distinctive using conventional numerical methods simply because of the intrinsic spatial autocorrelation of vegetation plots. This may be a particular problem when field data are generally scarce across a region but locally abundant in portions of the range where intensive surveys have been conducted. Further research on the significance of and methods for measuring the spatial autocorrelation of floristic composition are needed.

Insular vegetation can be particularly prone to spatially correlated discontinuities. Whereas the matrix vegetation of a region generally tends to vary continuously across the landscape, insular vegetation of patch-like habitats tends to be discontinuous owing to chance events of plant migration and establishment. It is not productive to recognize a unique association for every glade or rock outcrop in a region generally dominated by deep soils, yet this can result if associations are recognized solely based on discontinuities in compositional data or dissimilarity measures among local types. When classifying such insular vegetation, researchers should attempt to factor out similarity patterns driven simply by degree of spatial proximity and the associated chance events of plant dispersal. Yet, unique types of insular vegetation do exist and can only be identified with adequate field sampling.

There are a wide variety of methods and techniques that can be used to identify and describe an association, but the goal remains the same: to circumscribe types with defined floristic composition, physiognomy, and habitat that comprehensively tessellate (cover) the universe of vegetation variation. We do not prescribe any one technique or approach to achieve this end (see also Section 4); investigators are free to explore any number of techniques. The inevitable occurrence of alternative competing type definitions will be resolved through dialog and the peer review process (see Section 7).

Special consideration in the description of alliances

Development or revision of alliances is typically based on the same kinds of data and analysis used to define associations. Alliances can be defined as more generalized types that share some of the diagnostic species found in the associations, especially in the dominant layer. However, because the definition of alliances relies more strongly on the species composition of the dominant layer, and because alliances are often wide ranging, it may take more comprehensive analyses to resolve alliances based on a quantitative approach as compared to associations.

The methods for classifying alliances depend on the degree to which associations that make up a given alliance have previously been described and classified. Under data-rich conditions, alliances should be defined by aggregating associations based on quantitative comparisons of species abundances. If a number of associations have species in common in the dominant or uppermost canopy layer, and those same species are absent or infrequent in other associations, then the associations with those shared dominants can be joined as an alliance. Similarity in ecological factors and structural features should also be considered. Care is needed to ensure that a rangewide perspective is maintained when considering how to best aggregate associations. In cases where no truly diagnostic species exist in the upper layer, species that occur in a secondary layer may be used, especially where the canopy consists of taxa of broad geographic distribution, or the alliance occupies a diverse range of ecological settings (Grossman et al. 1998).

Under data-poor conditions, new alliances may be provisionally identified through quantitative analysis of data on species in the dominant stratum (e.g. comprehensive tree layer data in forests), combined with information on the habitat or ecology of the plots. Alliance types developed through such incomplete data fail to meet the highest standards for defining floristic units described in Section 7. To improve the confidence in these units, it is necessary to redefine them through analysis of full floristic information, such as plots that represent all of the associations that may be included in the alliance.

6.2. DOCUMENTATION AND DESCRIPTION OF TYPES

The classification process requires accurate documentation of how and why a particular vegetation type has been recognized and described, as well as a standardized, formal description, or monograph, of each named type. Although, vegetation types may be defined and published through many means and in many venues including the traditional scientific literature, their description may vary widely in methodology and approach, and lack the consistency needed for an accessible, standardized, comprehensive classification. Descriptions of alliances and associations need to: (a) explicitly document the vegetation characteristics that define the type, including any significant variation across geographic or environmental gradients; (b) summarize the relationship of the type to habitat, ecological factors and community dynamics; (c) identify the typical plots upon which the type is based; (d) describe the analyses of the field data that led to recognition of the type; (e) assess the confidence level of the type; and (g) provide a synonymy to previously described types (see Box 2) and document the relationship to similar NVC types. The rationale for these criteria is explained in more detail next, and an example of a type description is provided in Appendix 3.

Overview

The overview section provides a summary of the main features of the type. First, the names of the type are listed following the nomenclatural rules in Section 6.4 including Latin names and their translated names (i.e., species common names). A colloquial or common name for the type may be provided. Second, the association's placement within an alliance is indicated (if a new alliance is required, a separate description should be provided); for an alliance, placement within a formation should be indicated. Finally, a summary is provided that describes the type concept, including the geographic range, environment, physiognomy and structure, floristics, and diagnostic features of the type.

Vegetation

The association and alliance concepts are defined primarily using floristics and physiognomy, supplemented with environmental data to assess ecological relationships among the species and types.

1. Floristics: This section should summarize the species composition and average cover in the plots for all species, preferably by strata. Issues relating to the floristic variability of the type are highlighted. Tables are provided in the following form:
    a. A stand table of floristic composition, preferably for each stratum, showing constancy, mean, and range of percent cover (Table 6). Criteria for inclusion in the table should be specified. It is recommended that all species with greater than 20% constancy be included to facilitate comparisons of species patterns with that of other types. Where a more abbreviated, representative list is required, prevalent species (*sensu* Curtis (1959) can be listed as the "*n*" species with highest constancy, where "*n*" is the mean number of species per plot).
    b. A summary of diagnostic species, through a tabular arrangement, a synoptic table, or other means of identifying and displaying diagnostic species.
    c. The compositional variability of the type across the range of its classification plots should be discussed. A discussion of possible subassociations or variants may be useful, especially for future refinement of type concepts.
2. Physiognomy: This section should describe the physiognomy and dominant species of the types, including physiognomic variability across the range of the plots being used. Summary information is provided as applicable for each of the main strata (tree, shrub, herb, nonvascular, floating, and submerged; Table 5), including their height and percent cover. Dominant growth forms are also noted.
3. Dynamics: This section provides a summary of the successional and disturbance factors that influence the stability and within-stand pattern of the type. Where possible, a summary of the important natural or anthropogenic disturbance regimes, successional trends, and temporal dynamics should be provided for the type. Information on

population structure of dominant or characteristic species may be appropriate. In some cases a change of disturbance regime is itself an important irregular form of disturbance. These should be described and recorded as disturbances in and of themselves. For example a change in fire frequency may be seen as catastrophic disturbance to a fire adapted community, from which the community may not reassemble. In some landscapes today there is a positive feedback between changes to disturbance regimes and floristic composition, resulting in new types of ecosystems of yet unknown successional trajectories.

Environmental Summary

An overview should be provided of the general landscape position (elevation, topographic position, landforms, and geology), followed by more specific information on soils, parent material, and any physical or chemical properties that affect the composition and structure of the vegetation. Preferably, these data are also provided as summary tables of the available categorical and quantitative environmental variables.

Geographic Distribution

This section should include a brief textual description (not a list of places) of the geographic range (present and historic) of the type. A list of states and provinces where the type occurs, or may occur, can help describe the geographic scope of the type concept. The description should distinguish between those jurisdictions where the type is known to occur and those where the type probably or potentially occurs. Also, jurisdictions where the type is estimated to have occurred historically but has been extirpated should be provided if possible.

Plot Records and Analysis

This section should describe the plots and the analytical methods used to define a type, as well as where the plot data are archived. The plots used must have met the criteria for *classification plots* (see Section 5.3 and Appendix 1). The plot data must be deposited in a publicly accessible archive that meets the standards set forth in Section 8. Information should be provided on factors that affect data consistency, such as taxonomic resolution or completeness of physiognomic-structural or environmental information. Range-wide completeness and variability in the geographic or spatial distribution of plot locations should be described (see discussion of problems with spatial autocorrelation in Section 6.2). Finally, the methods used to prepare, analyze, and interpret the data should be described, including outlier analyses, distance measures, numerical and tabular techniques, and other interpretation tools. Occurrence plots that may have been used to generally estimate the geographic range of a type or some other characteristic should be identified.

Classification Confidence

This section summarizes the overall confidence level for the type: high, moderate, or low, following the criteria presented in Section 7. These levels reflect the quality and extent of data used and the methods employed to describe and define a type. Data gaps should be identified where appropriate and suggestions made for further analysis or research. Confidence level is an important tool for maintaining clear standards for the relative quality of the types that are included in the NVC. Formal designation of confidence level will be a role of the peer review process (see Section 7).

Relationships among types and synonymies

A section on synonymies is provided that lists other previously defined types that the author considers synonymous with the type. In addition, the relationships with closely related types are described here.

Discussion

Possible subassociation or suballiance types or variants, if appropriate, should be discussed in greater detail here along with other narrative information.

Citations

A set of citations of references used in the descriptive fields above is provided in this section, including references to the literature or other synoptic tables comparing this type to similar types.

6.3. NOMENCLATURE OF ASSOCIATIONS AND ALLIANCES

Rationale

The primary purpose of naming the units in a classification is to create a standard label that is unambiguous and facilitates communication about the type. A secondary goal is to create a name that is meaningful. Finally, a name must not be so cumbersome that it is difficult to remember or use. These purposes, though, are sometimes in conflict. For instance, the primary purpose of an unambiguous label is met by a number (e.g., “Association 2546”), but such a label is not meaningful or easy to remember. A long descriptive name is meaningful, but difficult to remember and use. To meet these varying requirements, the guidelines set forth here strike a compromise between these needs, including the use of alternative names for a type (see also Grossman et al. 1998, page 23).

There are two very different nomenclatural approaches to naming associations and alliances: (a) that based on a more descriptive approach, such as practiced by the habitat type approach in the western United States (e.g., Daubenmire 1968, Pfister and Arno 1980) as well as the current NVC (Grossman et al. 1998; see also similar approaches used by Canadian Forest Ecosystem Classification manuals in Sims et al. 1989), and (b) the more formal syntaxonomic code of the Braun-Blanquet approach (Westhoff and van der Maarel 1973, Weber et al. 2000). The descriptive approach uses a combination of dominant and characteristic species to name the type. No formal process for amendment or adoption of names need be followed. By contrast, the Braun-Blanquet approach follows a formalized code that allows individual investigators to assign a legitimate name that sets a precedent for subsequent use in the literature, much like species taxonomic rules. In the Braun-Blanquet approach only two species are allowed in an alliance name, and their name follows Latin grammatical requirements. Hybrid approaches have also been suggested, for example, by Rejmanek (1997, see also Klinka et al. 1996, Ceska 1999). Here we adopt the descriptive approach and, as explained in Section 7, rely on a peer-review process to maintain appropriate nomenclature. However, as tracking the ever-changing usages of names and concepts of organisms (which forms the basis for the names of associations and alliances) is a challenging task, we also rely on a technical implementation of concept-based taxonomy through the development of VegBank and as described in greater detail in Section 8 (also see Berendsohn 1995, Pyle 2004).

Nomenclatural rules

Each association is assigned a scientific name. The scientific name also has a standard translated name; that is, the Latin names of the nominal species used in the scientific name are translated to common names based on Kartesz (1994, 1999) for English-speaking countries. It is desirable that common names be provided in French, and Spanish if translation names exist. Finally, each association and alliance is assigned a database code.

The names of dominant and diagnostic taxa are the foundation of the association and alliance names. The relevant dominant and diagnostic taxa that are useful in naming a type are available from the tabular summaries of the types. Names of associations and alliances should include at least one or more species names from the dominant stratum of the type. For alliances, taxa from secondary strata should be used sparingly. Among the taxa that are chosen to name the type, those occurring in the same strata (tree, shrub, herb, or nonvascular, floating, submerged) are separated by a hyphen (-), and those occurring in different strata are separated by a slash (/). Species that may occur in a type with less constancy may be placed in parentheses (Box 4). Taxa occurring in the uppermost stratum are listed first, followed successively by those in lower strata. Within the same stratum, the order of names generally reflects decreasing levels of dominance, constancy, or diagnostic value of the taxa. Where there is a dominant herbaceous stratum with a scattered woody stratum, names can be based on species found in the herbaceous stratum and/or the woody stratum, whichever is more characteristic of the type.

Association or alliance names include the FGDC (1997) class in which they are placed (e.g., closed tree canopy, shrubland, herbaceous vegetation, etc; see Figure 1). For alliances, the term alliance is included in the name to distinguish these units from association units (Box 4).

In cases where diagnostic species are unknown or in question, a more general term is allowed as a "**placeholder**" (e.g., *Pinus banksiana* - (*Quercus ellipsoidalis*) / *Schizachyrium scoparium* - **Prairie Forbs** Wooded Herbaceous Vegetation), but only in the case of types with low confidence. An environmental or geographic term, or one that is descriptive of the height of the vegetation, can also be used as a modifier when such a term is necessary to adequately characterize the association. For reasons of standardization and brevity, however, this is kept to a minimum. Examples are: (a) *Quercus alba / Carex pennsylvanica - Carex ouachitana* **Dwarf** Forest, and (b) *Thuja occidentalis* Carbonate Talus Woodland. The least possible number of species should be used in forming a name. The use of up to five species may be necessary to define associations, recognizing that some regions contain very diverse vegetation, with relatively even dominance, and variable total composition. For alliances, no more than three species may be used.

If desired, a colloquial or regionally common name can also be created. The common name may be used to facilitate understanding and recognition of the community type for a more general audience, much like the common name of species.

Nomenclature for vascular plant species used in type names should follow USDA PLANTS (http://plants.usda.gov/), or the current version of ITIS (http://www.itis.usda.gov/index.html). The date(s) that the database was consulted should be included in the metadata, as these web sites are frequently updated.

Because of the broad use of PLANTS and ITIS in North America, their use must be accepted in the NVC. These two public databases are based on the work of Kartez (1994, 1999). The current lack of version numbers for these databases, however, presents a serious limitation since they are continuously changing. In lieu of version numbers, authors should report the year that the database was accessed. An additional and most serious limitation in using these sources as a nomenclatural reference is that they are not linked bibliographically to circumscribed taxonomic concepts. They are, nonetheless, the best and most widely used and electronically available public sources of plant names in North America. The Panel is currently working to link each name to a published taxonomic concept. Users of the NVC and VegBank are free to use any species list as long as they can map their names to names and concepts of a particular version (or year) of PLANTS or ITIS.

There is a very real probability that some applications of names will not fit those in PLANTS, in which case an alternative published work will need to be referenced. A critical remaining issue is that, in part because the plant names in PLANTS are not linked to specific concepts, there are often many name synonyms for a given concept and a variety of concepts are applied to a given name.

Cultivated vegetation

The nomenclature rules described above apply to natural (near-natural and seminatural) vegetation (see Grossman et al. 1998). We have not formally set guidelines for how to sample, describe, and define cultivated types of vegetation. However, the NVC is intended to be comprehensive for all vegetation, and the FGDC hierarchy separates the formations of cultivated vegetation and natural/semi-natural vegetation into different subgroups (Figure 1). For example, evergreen treed plantations are in separate formations from natural evergreen treed formations. Recognizing that the formal association and alliance concepts as such may not apply to planted or cultivated kinds of vegetation (Section 4), they can still be identified, named and placed below the physiognomic levels of the hierarchy by users who want to develop the “planted/cultivated” part of the NVC more fully. We recommend that the nomenclature for planted and cultivated types follow the nomenclature rules given above, with the exception that the term "alliance" not be included as part of the name, and the use of the physiognomic class name is optional, depending on the vegetation type. A descriptor of the kind of planted cultivated vegetation being described should always be included. Units at the "alliance" level should be pluralized and at the association level should be singular. For example, *Pinus ponderosa* Plantation Forests (at the alliance level), *Pinus ponderosa* Rocky Mountain Plantation Forest (at the association level), , *Zea mays* Crop Field.

7. PEER REVIEW

The USVC must be open to change in the sense that any person (independently or representing some institution) is free to submit proposed additions and changes, and that the rules, standards and opportunities are the same for all potential contributors, regardless of institutional affiliation. Although we describe a uniform set of guidelines for sampling, recognizing, describing, and naming types, these guidelines allow for a variety of approaches to defining associations and alliances. This is because the concepts themselves are somewhat general in that they capture assemblages of taxa whose individual local distributions are the result of complex biophysical interaction and chance, but which nonetheless produce landscape pattern as recognizable and mappable habitat.

There is no one single correct classification, rather, alternative synthetic solutions are possible. Choice among such alternatives should be based on established best practices and the good judgment of experienced practitioners. Thus, a key component of this process must be a formal, impartial, scientifically rigorous peer review process for floristic units, through which proposals to recognize new units or change accepted units are evaluated.

There are a variety of different ways to maintain a standardized set of alliance and association types for the NVC. One model is that used in plant taxonomy where an individual worker or group of workers use credible scientific methods to define a taxon, follows generally accepted rules for describing and naming the taxon, and publishes the results in a journal after which the results can be accepted or rejected by individual scientists as they deem appropriate. In some cases an expert source (a person or organization) maintains a list of taxa that it chooses to recognize as valid. Zoological nomenclature is similar, except that by convention the most recent publication takes precedence when publications are in conflict. A second model is for a professional body to administer a formal peer-review process, whereby individuals, who publish their results as they choose, also submit their results to a professional body. That body ensures that consistent standards are followed to maintain an up-to-date rigorous list of types and their descriptions. Such an approach is used by the American Ornithological Union[9] for North American bird lists. A third model is provided by the Natural Resource Conservation Service which maintains the USDA soil taxonomy (NRCS 2001) as one of its official functions. The peer-review process we outline here is a hybrid of the second and third models in that changes and additions to the classification must be made within the context of the current classification such that the resultant units continue to form a comprehensive and authoritative list, and the peer review is an open process maintained by professional organizations in collaboration with other interested parties.

An authoritative peer review process is necessary to maintain the consistency, credibility, orderly progress, and rigor of the classification. This process should be administered by an "NVC Peer Review Board" under the aegis of an institution capable of providing independent and disinterested reviewers of appropriate training and experience in plant community classification.

7.1 CLASSIFICATION CONFIDENCE

To maximize applicability of the NVC, coverage of vegetation types should be as comprehensive as possible. Consequently, it will be desirable to recognize, at least temporarily, some types that do not comply with all the best-practice standards identified in this document. As part of the NVC peer-review process, each type will be assigned a "confidence level" based

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9. Members of the American Ornithological Union's (AOU) Committee on Classification and Nomenclature keep track of published literature for any systematic, nomenclatural, or distributional information that suggests something contrary to the information in the current checklist or latest supplement. This could be, for example, on a revision to a taxonomic group or on a species new to the area covered by the AOU. A member then prepares a proposal for the rest of the committee, summarizing and evaluating the new information and recommends whether a change should be made. Proposals are sent and discussion takes place by email and a vote is taken. Proposals that are adopted are gathered together and published every two years in The Auk as a Supplement to the AOU Check-list (R. Banks pers. comm. 2000).

on the relative rigor of description and analysis used to define it. Two additional categories are described for associations or alliances that have not been formally recognized.

Classification confidence levels of accepted types

High: Classification is based on quantitative analysis of verifiable, high-quality classification plots that are published in full or are archived in a publicly accessible database. Classification plots must meet the minimum requirements specified in Section 5 and as shown in Appendix 1. High quality classification plots must represent the known geographic distribution and habitat range of the type. In addition, plots that form the basis for closely related types must be compared. For an alliance, the majority of component associations must have a high to moderate level of confidence.

Moderate: Classification is lacking in either geographic scope or degree of quantitative characterization and subsequent comparison with related types, but otherwise meets the requirements for a high level of confidence. For an alliance, many associations within the type may have a Moderate to Low level of classification confidence.

Low: Classification is based on plot data that are incomplete, not accessible to others, or not published; or, based on qualitative analysis, anecdotal information, or community descriptions that are not accompanied by plot data. Local experts have often identified these types. Although there is a high level of confidence that they represent significant vegetation entities that should be incorporated in the NVC, it is not known whether they would meet the guidelines for floristic types in concept or in the NVC classification approach if data were available. Alliances are classified as low if defined primarily from incomplete or unpublished and inaccessible plot data (e.g., plots may only contain information about species in the dominant layer), from use of imagery, or other information that relies primarily on the dominant species in the dominant canopy layer.

Status categories of types not formally recognized

In addition to the three levels of classification confidence, two categories are established to identify vegetation types that have been described to some extent but which have not been formally accepted as an NVC unit of vegetation. These categories are:

Proposed: Formally described types that are in some stage of the NVC Peer Review process, but for which the process is still incomplete. For example, indicating that a type is "proposed" can be used when investigators may have a need to refer to these types in publications or reports prior to the completion of the peer review process.

Provisional: Types not yet formally described, but which are expected to be additions to the existing list of NVC types for an area or project. Provisional types should only be used when a clear effort is being made to apply the NVC, but where some vegetation does not appear to have been covered by the concepts of known units for an area or project. For example, a report or publication may need to submit a list of NVC types and any additional types that have not been recognized by the NVC, nor have they been more formally submitted for peer review as a "proposed" type. Such types can be designated as "provisional."

7.2. PEER-REVIEW PROCESS

The process for submitting and evaluating changes to the classification must be formal, impartial, open, and scientifically rigorous, yet must be simple, clear, and timely. To facilitate timely review and efficient use of human resources, templates containing the components required for compliance with the guidelines in Section 6 should be used for submission of proposed changes to the NVC.

The Peer Review Board, in conjunction with the NVC partners, is responsible for ensuring that the criteria specified in the version of "Guidelines for Describing Associations and Alliances of the U.S. National Vegetation Classification" that is current at the time, are followed. This Board must adhere to the scientific and technical principles of the NVC and it must ensure the good order and scientific credibility of the classification. The objectives of the peer review process are to (a) ensure compliance with classification, nomenclature and documentation guidelines, (b) maintain reliability of the floristic data and other supporting documentation, and (c) referee conflicts with established and potential NVC floristic types.

Investigators wishing to contribute to the NVC by proposing changes to the classification must submit their methods and results to the Peer Review Board as specified in the contemporary version of this document. Investigators participating in NVC will use a defined template for type descriptions that can be readily reviewed and, if accepted, easily uploaded into the database system. Investigators who describe association or alliance types must place their proposed types within the context of existing NVC types so as to determine whether the type under consideration is distinct, or whether their data will instead refine or upgrade the definition of a type or types already on the list.

In order to establish effective peer-review, reviewers should have sufficient regional expertise to understand how a proposed change to the NVC (i.e., addition, merger, or splits of associations or alliances) would affect related associations and alliances. Our approach is to use a set of geographically based review teams. It is the peer-review team's job to (a) ensure compliance with classification, nomenclature, and documentation guidelines, (b) maintain reliability of the floristic data and other supporting documentation, and (c) referee conflicts with established NVC elements. Review methods used internally by these regional teams need to be compatible with those used by others, and changes to types that could potentially occur in more than one region will need to be evaluated by all the appropriate teams.

The Peer Review Board will maintain publicly available Proceedings of all official actions as described in Section 8. Full descriptions of types will constitute the NVC primary literature and will be published in the Proceedings. The Proceedings will publish official changes to the list of NVC associations and alliances, and it will include the required supporting information for all changes made to the list.

Two kinds of peer review are available (Figure 3). If an investigator proposes to describe a type at the high or moderate confidence level, a *full peer-review process* is required. If the investigator does not have sufficient information to justify high or moderate confidence, but is convinced that the type is new to the NVC, he or she can submit the type as a low confidence type and an *expedited peer-review process* will be used.

<u>Full Peer Review</u>

The review process for proposals to the NVC is overseen by a Review Board appointed by the ESA Vegetation Panel. The review Board consists of a Review Coordinator, Regional Coordinators, and other members the Panel may find appropriate. Full peer review is used when:

1. the type is thought to be entirely new to the NVC,
2. the type is an upgrade in confidence of an existing type without a type concept change, or
3. the type is a reworking/replacement of an existing type concept.

The full peer-review process will include a streamlined y web-based process for submitting type descriptions following procedures, templates, and required data fields (outlined in Section 6) to the NVC Review Coordinator. If the submission meets the established criteria, the Review Coordinator will ensure that the submission receives reviews would be solicited from qualified reviewers. Based on their input, the Coordinator will:

1. accept the type(s) as either a high, moderate, or low confidence level,
2. return proposal for modification or revision,
3. reject the proposal but recommend provisional status for the proposed type, or
4. reject the proposal altogether.

As part of the acceptance process, the Regional Coordinator will indicate what effect (if any) the submission may have on other types in the NVC not addressed by the submission. If an effect to other types is determined to be significant, the Regional Coordinator either proposes other updates to related NVC types or requests additional input from the investigator. The Regional Coordinator will then send the decision and all supporting reviews and documentation to the Review Coordinator. The Review Coordinator will inform the investigator of the results of the peer review. If a submission is accepted, the Review Coordinator ensures that the NVC list and database are updated and that the proposal is posted on the NVC electronic Proceedings.

<u>Expedited Peer Review (low confidence types)</u>

If the investigator does not have sufficient information to support high or moderate confidence but is convinced that a type is new to the NVC, he or she can submit it as a low confidence type and an expedited peer-review process will be used. Expedited peer review is only used when a type is thought to be entirely new to the NVC. As in the full peer review process, investigators electronically submit type descriptions following the outlined procedures, templates, and required data fields outlined in Section 6 to the Review Coordinator. The Review Coordinator (or his/her designee) evaluates the submission to determine whether it meets the criteria for expedited peer-review of a low confidence type. Provided, it meets those criteria, the Review Coordinator sends the submission to a Regional Coordinator. The Regional Coordinator consults as appropriate with regional experts to help assess the validity and acceptability of the type, and sends a decision and documentation to the Review Coordinator. The Review Coordinator informs the investigator of the results of the review. If submission is accepted, the Coordinator ensures that the NVC list and database are updated and that the proposal is posted in the NVC electronic Proceedings.

8. DATA ACCESS AND MANAGEMENT

Data availability and management are central to the organization and implementation of the National Vegetation Classification. Most issues regarding the organization of the NVC can be clarified by careful consideration of information flow into, through, and out of the three constituent databases of NVC: botanical nomenclature, field plots, and classified associations and alliances,. In effect, information flow defines and holds together the various parts of the NVC. The overall information required for the NVC enterprise is presented graphically in Figure 4 and is summarized next.

8.1 BOTANICAL NOMENCLATURE

All stages in the NVC process refer to specific plant taxa. Plant taxa used in the NVC need to be clearly and unambiguously recorded, especially in plot databases and in the classification database. However, the use of a plant name does not necessarily convey accurate information on the taxonomic concept employed by the user of that name. Vegetation plots are intended to include accurate records of taxa present at some time and place as observed by some investigator. This objective is made complex by the fact that taxonomic standards vary with time, place, and investigator. When plot data collected at various times and places by various investigators are combined into a single database the different taxonomic nomenclatures must be reconciled. The traditional solution has been to agree on a standard list and to map the various names to that list. For example, within the U.S. there are several related standard lists of plant taxa including Kartesz (1999), USDA PLANTS (http://plants.usda.gov/), and ITIS (http://www.itis.usda.gov/index.html). Each of these is intended to cover the full range of taxa in the U.S. at their time of publication and each lists synonyms for the taxa recognized. However, these lists do not allow for effective integration of data sets for several reasons. (1) The online lists are periodically updated but are not simultaneously archived, with the consequence that the user cannot reconstruct the database as it was viewed at an arbitrary time in the past. For this reason users should, at a minimum, cite the date on which the database was observed. (2) One name can be used for multiple taxonomic concepts, which leads to irresolvable ambiguities. The standard lists are simply lists and do not define the taxonomic concepts employed, or how they have changed as the list has been modified. (3) Different parties have different perspectives on acceptable names and the meaning associated with them. If one worker uses the Kartesz 1999 list as a standard, that does not necessarily allow others to merge his or her data with those of a worker who used the USDA PLANTS list as a standard (also see Section 6.3, Nomenclatural rules).

Much ambiguity arises from the biological nomenclature requirement that when a taxon is split, the name continues to be applied to the taxon that corresponds to the type specimen for the original name. Moreover, different authors can interpret taxa in different ways. In short, plant names can refer to multiple definitions of plant taxa, and a plant taxon can have multiple names. To avoid ambiguity, plant taxa associated with the NVC must be documented by reference to both a specific name and a particular use of that name, typically in a published work. All databases supporting the NVC must track plant types through documentation of such name-reference couplets. We follow the ideas of both Berendsohn (1995; a “potential taxon”) and Pyle (2004; an “assertion”) with respect to name-reference couplets. For the purposes of the NVC we term name-reference couplets a “taxon-concept”. A name-reference combination (a taxon-concept) provides a label (a name) for a circumscribed taxonomic entity (a concept). However, any particular label might be synonymous with, or otherwise relate to, one or more other concepts. Organism identifications (be they occurrences in plots, labels on museum specimens, or treatments in authoritative works), should be by reference to a concept so as to allow unambiguous identification of the intended taxonomic object. Identification of the appropriate concept to attach to an organism does not immediately dictate what name should be used for that concept. Different parties may have different name usages for a particular accepted concept.

An example illustrating the need for this approach is the species name *Abies lasiocarpa* (Hooker) Nuttall. The concept intended for this name by the PLANTS Database (USDA, NRCS 2000) is quite different than the concept intended for the same name by the Flora of North America (1993+). The taxon-concept *Abies lasiocarpa* (Hooker) Nuttall *sec* Flora of North Am. Vol. 2 refers to a subset (occurring in the Northwest USA and western British Columbia) of the broader taxon-concept *Abies lasiocarpa* (Hooker) Nuttall *sec* USDA PLANTS (2000). The PLANTS Database (USDA, NRCS 2000) taxon-concept includes the taxon-concepts of: (a) Abies lasiocarpa (Hooker) Nuttall *sec* Flora of North Am. Vol. 2, as well as (b) Abies bifolia A. Murray *sec* Flora of North Am. Vol. 2.

By using the name *Abies lasiocarpa* (Hooker) Nuttall without referencing which concept is intended, it is not possible to know if the name applies to the more general concept (which includes *Abies bifolia* A. Murray *sec* Flora of North Am. Vol. 2) or the more narrow concept intended by Flora of North America. Such differences are not trivial and we expect the concepts of taxa to change substantially in the future. The taxon-concept approach will allow for and facilitate such changes as knowledge of plant taxonomy expands, yet it will provide for an exact understanding of the concept intended by the use of any particular taxon name. We follow Berendsohn (1995) in using the term "*sec*" which means "in the sense of". The appropriate writing style for a taxon-concept is: [taxonomic name] *sec* [abbreviated reference].

Unknown or irregular taxa (such as composite morphotypes representing several similar taxa) should be reported with the name of the taxon for the first level with certain identification and must be associated with a note field in the database that provides additional information (e.g., Peet, R.K., plot #4-401, third "unknown grass", aff. Festuca, NCU 777777). For best practice provide a name field to follow the given taxon in parentheses (e.g., *Potentilla* (*simplex* + *canadensis*), Poaceae (aff. *Festuca*)).

8.2 PLOT DATA ARCHIVES AND DATA EXCHANGE

Field plot data and plot databases are to vegetation types what plant specimens and herbaria are to plant species types. Vegetation scientists use plots for formal observation and recording of vegetation in the field. The fundamental unit of vegetation information is the vegetation plot; without plot data there would be no tangible basis for classification (Section 5). At a minimum, a plot used for classification or to document a type occurrence contains information on location, spatial extent, dominant species presence and cover, select environmental data, and metadata. Investigators must include plot data summaries in their descriptions of vegetation types (see Section 6).

A plot database system is needed to hold the plot data that form the basis for documenting, defining, and refining the associations and alliances that constitute the floristic levels of the NVC. Vegetation plots used in the development or revision of the NVC must be archived in a permanent publicly accessible database system so that they can be examined and reinterpreted in light of future research. In addition, plot data used to support description of a vegetation type must be linked by accession number to the description of the type in the

Vegetation Classification Database and should be publicly available via a direct database query from a web browser. All such data must conform to the standard data schema shown in Appendix 4 to facilitate data exchange and analysis. While there is no requirement that the plot data supporting a proposed or accepted type be archived in VegBank, the ESA Vegetation Panel maintains VegBank (http://vegbank.org) for archiving, access to, and discovery of plot data. Plot data may be converted to the standard NVC XML Schema (Appendix 4) by entering it into VegBank, either as singular plot records or as batches of records.

Collection of plot data is a distributed activity external to the NVC per se, driven by the needs and interests of numerous organizations and individuals. All such organizations and individuals are encouraged to submit their plot data to a public plot database, either as components of proposals for changes in the NVC or as separate submissions of basic data. All uses of plot data with respect to the NVC must cite the original author of the plot.

Plot databases should accommodate user-defined fields so as to be more flexible in the kinds of data archived, which in turn should encourage greater participation. Similarly, opportunities should exist for qualified users to annotate plots such as by adding interpretations of community membership or plant taxon identifications

8.3 COMMUNITY-TYPE DATABASES

The Vegetation Classification Database must be viewable and searchable over the Internet, and must be regularly updated. The primary access point for viewing the classification is the NatureServe Explorer website (http://www.natureserve.org/explorer/). Although mirrors of this information may be found at other sites, the NatureServe Explorer release should be viewed as definitive. One of the advantages of websites is that they can be updated frequently. When citing an association or alliance, users of the NVC should cite the website and the explicit version observed (or date observed) so as to allow exact reconstruction of the community concepts employed and supporting information observed.

Maintenance of NVC data files is the responsibility of the NVC management team. (The NVC management team will be made up of individuals from the organizations responsible for the NVC, who directly operate the system. For example, team members from NatureServe will help maintain the classification database; team members from the ESA will help maintain the peer review process.) Individuals assigned to this function will be able to modify appropriate

NVC files. Minor changes based on new information, such as an increase in the range of a community, will be thoroughly documented and inserted without review. However, definition, redefinition, or change in the confidence level of a vegetation type would require approval of the peer-review team (see Section 7).

8.4 PROPOSAL SUBMISSION AND THE NVC PROCEEDINGS

Proposals for revisions in the NVC must be submitted in digital format using standard templates available through links that can be found at VegBank (http://vegbank.org) or NatureServe Explorer (http://www.natureserve.org/explorer/). Key components of successful proposals will be posted on the web as the Proceedings of the NVC and will be accessible through VegBank and NatureServe Explorer. The Proceedings will constitute the primary literature underpinning the classification. This literature will be used publicly document and archive changes to the classification database and it will be permanently and publicly available as a form of digital journal linked to the classification database.

9. DEFINTIONS AND GUIDELINES FOR FIELD APPLICATIONS

The purpose of this section is to make the definitions and guidelines described in the preceding sections more readily accessible for practitioners. The detail and complexity of those chapters is necessary for authoritative treatment of associations and alliances description and classification. However, the detail in those chapters may not be necessary for many users of the classification. The following sections summarize the NVC definitions and guidelines and provide direct reference to the detailed information in the preceding sections. The objectives of these guidelines are to: (1) facilitate and support the development, implementation, and use of a standardized vegetation classification for the United States; (2) guide professional ecologists in defining and adopting standards for vegetation sampling and analysis in support of the classification; and (3) maintain scientific credibility of the classification through peer review. These guidelines are not meant to preclude alternative classification approaches which may address different needs. They are intended to facilitate an orderly development of the USNVC as well as collaboration with other international classification activities.

Following the sequence of the previous sections, the definitions and basic criteria for associations and alliances are covered first, in Section 9.1. Guidelines for collecting field plot data are described next, in Section 9.2. Conventions for naming and describing associations and alliances are provided in Section 9.3. The process for peer review of proposals to change the names or concepts of alliances and associations is listed in Section 9.4. Finally, the component databases and the technical structure of the NVC information system are described in Section 9.5. The content of each of these sections is in outline format for practical application and referencing. Where appropriate, criteria that are minimally essential are indicated in order to focus attention on the most basic aspects of the work. Appendix 1 lists each type of data used by the NVC and indicates whether collecting the data is essential or nonessential but the best practice.

9.1 DEFINITIONS AND CRITERIA FOR FLORISTIC UNITS

Floristic criteria are the primary properties of the vegetation used to define the most basic units of the classification, the association and alliance. Association and alliance type concepts should be derived from analysis of field plot data in which the species and their abundance, the plot location, overall vegetation structure, and habitat setting are described. These field data provide the fundamental information for the numerical description of specific associations and alliances. The following paragraphs define the alliance and association terms and explain the diagnostic criteria. Additional information on the definitions of NVC floristic units can be found in Section 4 (page 22)

1. *Definitions of the floristic units*:
    a. Association: A vegetation classification unit defined on the basis of a characteristic range of species composition, diagnostic species occurrence, habit conditions and physiognomy.
    b. Alliance: A vegetation classification unit containing one or more associations, and defined by a characteristic range of species composition, habitat conditions, physiognomy, and diagnostic species, typically at least one of which is found in the uppermost or dominant stratum of the vegetation.
2. *Diagnostics*:
    a. Diagnostic species exhibit patterns of relative fidelity, constancy or abundance that differentiate one floristic type from another.
    b. Diagnostic criteria used to define the association and alliance should be clearly stated, and the range of variation in composition, habitat, and physiognomy and structure should be clearly described, including similarity with other related floristic types

3. *Existing vegetation*:
   Associations and alliances are categories of existing, or actual vegetation (i.e., the plant species present and the vegetation structure found at a given location at the time of observation).

4. *Classification hierarchy*:
   Associations and alliances recognized within the NVC must be defined so as to nest within categories of the recognized hierarchy (e.g. in FGDC 1997 *et seq*.; see Figure 1).

9.2 COLLECTING FIELD PLOTS

A fundamental goal of the NVC is to have associations and alliances described from quantitative analysis of field plot data (see Text Box 1 as well as Sections 2 and 5). The capability to describe associations and alliances from quantitative and repeatable measurements depends largely on field data that are collected and archived in a consistent manner and are publicly available. This section provides basic criteria for the types of and formats for information that should be collected in the field. It addresses: selecting stands of vegetation for inventory, plot design, recording species composition and site conditions, describing the vertical structure and physiognomy of a plot, the geographic information required, and the types of metadata that should be provided by field workers for each plot record. Each of these topics is covered briefly below. The focus here is on plot information that is complete enough to serve as *classification plots*; that is, plots which contribute to classification analyses that help define associations or alliances. Less information is required from plots that are gathered only for the purpose of documenting the occurrence of a pre-defined alliance or association. These plots are referred to as *occurrence plots*. Greater detail on each is provided in Section 5 (page 27). All of the data fields that are both minimally required and optimally desired are listed and defined in Appendix 1.

1. *Stand selection and plot design*:
   A stand of vegetation may be selected for plot sampling by either preferential or representative means, and the criteria used to select stands should be thoroughly documented. Each plot should represent one relatively homogeneous stand of vegetation in the field. A plot must be large enough to represent the stand in terms of total species composition and abundance. A plot may be either a single large comprehensively sampled plot, or a set of subsampled areas within a larger plot.

2. *Species composition of the plot*:
   The floristic composition of a plot consists of both the identity and the abundance of the genera, species, and lower taxa. The actual identity of a plant taxon can be

somewhat complicated since it consists of (a) a name, and (b) an entity concept. The coupling of an a name with entity concept is termed a "taxon-concept" (see Section 8.1, page 64, for more details on a taxon-concepts). The next sections provide the minimal guidelines for recording species occurrences, determining canopy cover as a measure of species abundance, and estimating the distribution of plant species by strata.

a. For vegetation classification plots, sampling should be designed to detect and record the complete assemblage of vascular plant species in the stand. Recording of nonvascular species is expected in vegetation where nonvascular species are dominant. Only one field visit at an optimal time of year is required, though additional visits can improve plot quality and are recommended for vegetation types with marked phenological variation.

b. For classification plots, cover is the required measure of species abundance. Measurement of canopy cover, as opposed to foliar cover, is recommended. If cover values are in discrete categories rather than continuous, the cover scales should be able to nest within the Braun-Blanquet cover-abundance scale classes of: "r" (solitary individual with small cover), "+" (few individuals with small cover), 0-5%, 5-25%, 25-50%, 50-75%, and 75-100% (Table 4). For occurrence plots, the minimum requirements are: names of the dominant taxa, their cover values (or another suitable measure of abundance), geographic coordinates, date of observation, name of the association or alliance observed, and name(s) of those who made the observation.

c. Although not required for classification plots, the best practice is for each species listed in a plot to be assigned to each of the strata in which it is found (tree, shrub, herb, moss, floating, submerged), with a separate cover estimate for its abundance in each of these strata. (For example, where subalpine fir plants that are seedlings cover 25% of a plot, they would be recorded as part of the herb stratum in addition to part of the overall cover of all subalpine fir plants in the plot regardless of stratum.) At a minimum, total cover of a species in the plot is required, though this may be calculated based on the stratum cover values. Epiphytes and lianas may be treated in the strata in which they occur, or treated as separate "strata."

d. The minimum requirements for taxon composition are:

    i. A plant name and plant reference (a taxon-concept, see page 64);

    ii. Taxon cover (and taxon stratum cover, if strata are used), with cover estimated to at least the accuracy of the Braun-Blanquet scale (Table 4).

    iii. The term species is used here to indicate the fundamental orientation of the plot sampling approach – that of a species-based approach. But it may include species or subspecies, or, if it is not possible to recognize these in the field at the time of sampling, it may include either higher units such as genera or family, or ad hoc units (i.e., "Carex fuzzy red base").

3. *Vertical structure and physiognomy of the plot*:

While not required, it is the best practice to describe the structure and physiognomy of vegetation by recording the canopy cover of a core set of vegetation strata: tree, shrub, herb, moss, floating, and submerged strata as defined on page 41 (also see Figure 2). Subcategories of these strata (e.g., canopy tree and subcanopy tree, tall shrub and short shrub) can be used, but these should always nest within rather than span multiple standard strata. Canopy cover of each of the NVC stratum types may be derived from composites of other classifications, such as from growth forms (see the method for converting data for this purpose on page 43 as well as Tables 1 and 2). If strata are characterized, the following rules should be followed:

a. Plants are assigned to a stratum based on their predominant position or height in the stand, and secondarily by their growth form or growth form stage. Consequently, a tree *species* that has both seedlings and saplings in a plot could be listed in several strata. However, an *individual* plant may be assigned only to one stratum, which is the stratum in which the majority of its leaf area occurs.

b. Provide the prevailing height of the top and the base of each stratum.

c. The cover of the stratum is the total vertical projection of the canopy cover of all species collectively on the ground, not the sum of the individual covers of all species in the stratum. The total cover of the stratum will, therefore, never exceed 100% (whereas, adding up the individual cover of species within the stratum could well exceed 100% since species may overlap in their cover).

d. The percent cover of at least the three most abundant growth forms in the dominant or uppermost stratum should also be estimated (see Table 3 for a list of growth forms).

e. Epiphytes and lianas are handled in different ways by various field protocols. When treated as individual species for cover assessment, they may be treated as a special growth form-stratum, independent of the strata mentioned above, or they may be assigned to the standard strata on the basis of the location of their predominant canopy cover. Bryophytes (including liverworts) and lichens growing on the same substrate as vascular plants are treated as part of the nonvascular strata. When assessing total cover of the primary strata, an epiphyte or liana should be included in the primary stratum where it has its predominant canopy cover.

f. The field stratum (sometimes called herb stratum) includes all woody or semiwoody plants or creeping vines where these overlap in height. This is a compromise between strata based strictly on height versus growth form. More specific distinctions of growth form (forbs, grasses, dwarf-shrubs) composition within this stratum can either be recognized directly in the field or can be estimated after the fact by assigning species within a stratum to a growth form category and calculating an approximate percent cover of the growth form.

g. The ground stratum (sometimes called nonvascular, bryoid, or moss stratum) is reserved strictly for cryptogams (mosses, lichens, liverworts, algae and bacteria), even where herbs or woody plants may be reduced to very short heights.

4. *Physical data of the plot*:

   The physical variables relevant to any interpretation of plot data vary widely across the range of vegetation types. It is, therefore, difficult to require any absolute minimum set of specific environmental criteria. Rather, we provide a set of environmental variables that should be given serious consideration in any vegetation survey, most especially for classification plots. In addition, the vegetation plots database and vegetation classification database provide recommended fields for collecting environmental data and these should be consulted. More detailed information is provided in the section on environmental data (Section 5, page 44), Table 1.4 of Appendix 1, and Appendix 2. The following site variables should be considered:

   a. Physical features of the stand should be described, including elevation (in m), slope aspect (in azimuth degrees of 0 to 360), and slope gradient (in degrees or percent), topographic position, landform, and geologic parent material (see Appendix 2 for constrained vocabularies for landform and geologic material).

   b. Soil and water features, including soil moisture, drainage, hydrology, depth of water, and water salinity (where appropriate), should be measured or estimated.

   c. The soil surface should be characterized in terms of the percent cover of litter, rock, bare ground, coarse woody debris, live vascular stem, nonvascular species on the soil surface, surface water, or other important surface features.

   d. Site conditions should be described, including landscape context, homogeneity of the vegetation, phenological phase at the time of observation, stand maturity, successional status, and evidence of disturbance.

5. *Geographic data for plots:*

   Information on the location of a plot is vitally important and should be carefully recorded in a standard format. For historical, or “legacy”, data where the geographic information may have been recorded in different formats and measurements, the original information must be preserved and the methods used to transform this information should be described and reproducible. Additional details can be found in Table 1.3 of Appendix 1 as well as in the section on geographic data (Section 5, page 44). The following guidelines should be followed when recording geographic information for field plots:

   a. Latitude and longitude in decimal degrees and WGS 84 (NAD83) datum.

   b. The coordinates that were collected in the field and the datum used. If a nonstandard projection was used, then the projection name, spatial units (decimal degrees, meters, etc.), size of the spheroid, central meridian, latitude of projection's origin, and any other vital parameters such as false easting and false northing.

   c. Description of the method used to determine the plot location (e.g., estimated from a USGS 7.5 minute quadrangle, GPS, etc.).

   d. An estimate of the accuracy of the plot’s location information in the form of the radius in meters for a 95% certainty.

   e. Narrative information useful for plot relocation.

f. The minimum requirements for geographic data are:

i. Latitude and longitude in decimal degrees and WGS 84 (NAD83) datum and an estimate of the precision of these coordinates in meters.

ii. The method used to determine latitude and longitude. For example: (a) collected in the field with a geographic positioning system (this should include the datum used, or specify if a nonstandard projection) or (b) through a narrative that describes how the plot location was determined, including a precision estimate, and the means of locating the plot centroid (e.g., the plot location was estimated from the USGS Assateague Park 7.5' map quadrangle; the centroid for locating the plot is the geographic center of Assateague Park).

6. *Metadata for plots:*

Careful attention to recording metadata for each plot record is essential to maximizing the long term utility of the record. Because many type descriptions will necessarily be derived from a variety of plot sources, it is the plot metadata that facilitate searching for and identifying useful records. All plots should have a project name and description associated with them, the methods used to select and lay out the plots, the level of effort expended in gathering floristic data, cover scale and strata types used, and the name and contact information of the lead field investigators. See Tables 2.1 – 2.6 of Appendix 1 for detailed criteria as well as the section on metadata on page 45. The minimum requirements are:

a. An author plot code.

b. An author observation code (if there are multiple observations of a plot over time).

c. Observation date and date accuracy.

d. Lead field investigator's name, role, and address.

e. Plot selection approach.

f. Plot characteristics including:

i. Plot area in m^2.

ii. Plot type, indicating if vegetation data were recorded in the entire plot or using subplots in a specified configuration.

iii. If subplots are used then specify the species (taxon) observation area in terms of size and total area of subplots (e.g., a plot may be 100 m^2, but if 10 1 m^2 subplots are used then the taxon observation area is 10 m^2).

iv. Cover dispersion (if subplots are used, how they are distributed).

g. Vegetation layer (strata) methods, if any.

h. Description of cover method for species composition.

9.3. CLASSIFYING AND DESCRIBING ASSOCIATIONS AND ALLIANCES

The most fundamental unit of information for describing and classifying associations and alliances is the field plot. The description of a vegetation type is a synthesis of data from many plots through what is termed here "classification analysis." This section summarizes the essential steps needed for data preparation, classification analysis, and interpretation of a proposed association or alliance, naming conventions for new types, and criteria for describing types. Complete details on classifying and describing associations and alliances are provided in Section 6 (page34).

1. *Data preparation:*

   When preparing plot data for classification analysis one should:

   a. Ensure that the plots used sufficiently sample the expected geographic and environmental range of the type.

   b. Ensure that the plots represent the expected compositional, physiognomic, and site variation of the type of interest.

   c. Ensure a unique and standardized identity for each taxon-concept (see especially Section 8.1 on botanical nomenclature on page 64).

   d. Document possible data limitations, such as insufficient geographic extent of sampling, or inadequate sampling of variation within the type.

2. *Classification analysis and interpretation*:

   A variety of statistical methods are available for classification analysis, including direct gradient analysis, ordination, and clustering. No single methodological formula is suitable for all possible analyses. It is therefore incumbent on those proposing new or modified types to apply contemporary methods of vegetation science for implementing a sound statistical approach, and to explain clearly the rationale for the approach used. The general components of a classification analysis are:

   a. The plots records used must be clearly referenced and accessible by others (see Section 8 and the section on classification analysis on page 47).

   b. An outlier analysis of the initial set of plots should be provided and the criteria used for identification and elimination of plot records should be provided.

   c. Show that there is sufficient redundancy in plot composition to identify a threshold of significant pattern in compositional variation. That is, that the data set has the statistical power needed to be convincing. One example would be to explore a null hypothesis that a given collection of plots is more self-similar than would be expected of a random collection of plots.

   d. An exact description of the analysis procedure should be provided, including careful documentation of assumptions and limitations of the data, methods of dimensional reduction, and value transformations.

e. Results should be presented in tabular and graphical formats as well as narrative.

f. Criteria used to identify diagnostic species, such as constancy and fidelity should be specified.

g. A tabular summary of diagnostic and constant species should be provided (see Tables 4, 6, and 7).

3. *Description of association and alliances*:

Formal description of an association or alliance requires that each of the following items be addressed. These are discussed in detail in Section 6.2 (page 51). The topical sections that are required for describing vegetation types are also shown in Text Box 2 and a worked example is provided in Appendix 3.

a. Name. Develop a scientific name for the floristic type using the nomenclatural standards in the above section.

b. Floristic unit. A description should indicate whether the vegetation type being described is an association or an alliance. For planted or cultivated types indicate "Planted/Cultivated."

c. Classification placement. Indicate the full name of the alliance or formation under which the type should be placed. The FGDC and NatureServe will provide the current list of accepted alliances and formations. One source for the NVC database of vegetation types is http://www.natureserve.org/explorer.

d. Classification comments. Describe any classification issues relating to the definition or concept of the type. Any assessment of the proposed type's natural or seminatural status should be clearly identified.

e. Rationale for choosing the nominal taxa (the species by which the type is named). Explain the choice of nominal species; for example, whether or not they are dominant, or if they are indicative of distinctive conditions such as alkaline soils, elevation, geographic region, etc.

f. Summary. Provide a 1-paragraph summary of the structure, composition, environmental setting, and geographic range of the type. This paragraph summarizes information from items g through k below. The summary should start with a sentence or two that provide an overall concept of the type.

g. Floristics. Species composition and average cover for all species (preferably by stratum) should be provided in the following summary form:

i. A stand table of floristic composition (preferably by stratum) showing constancy and mean cover (and preferably the range of species cover values). All species should be listed that have more than 20% constancy (Tables 6, 7).

ii. A summary of diagnostic species, through a tabular arrangement, synoptic table, or other means of identifying and displaying constant and diagnostic species. Constant species are those occurring in > 60% (i.e. Table 7 constancy classes IV, V) of the field plots used to define a type.

iii. Taxonomic usage in floristic tables must include reference to a taxonomic standard so as to define the meaning associated with a name. Reference to and consistency with the current version of USDA PLANTS or IT IS, coupled with the specific date of observation of the site, is sufficient.

iv. Compositional variability of the type across the range of its classification plots. A discussion of possible subassociations or variants may be useful, especially for future refinement of type concepts.

h. Physiognomy. Provide the following summary information for the plots:

i. The physiognomy, structure, and dominant species, including an assessment of the physiognomic variability of the type.

ii. Complete a summary table (Table 5) incorporating each stratum present (tree, shrub, herb, nonvascular, floating, submerged).

i. Dynamics. Provide a summary of the successional status of the type and the disturbance factors that influence stability and within plot variation for the type. Describe the extent to which this information is known and the limitations and assumptions of the assessment.

j. Environmental description. Provide a detailed description of important factors such as elevation (in meters), landscape context, slope aspect, slope gradient, geology, soils, hydrology, and any other environmental factors thought to be determinants of the biological composition or structure of the type.

k. Description of the range. Provide a brief textual description (not a list of places) of the total range (present and historic) of the type. List national and subnational (states or provinces) jurisdictions of occurrence across the entire range of the type. Distinguish between areas where the type: (a) definitely occurs; (b) probably or potentially occurs; and (c) is believed to have historically occurred. It is recommended that subnational administrative units such as states, provinces, or counties be used for this purpose.

l. Identify field plots. Identify plots used to define the type and indicate where the plot data are archived and the associated accession numbers. All plot records used must conform to the minimum standards for classification plots described in Section 5 and be deposited in a publicly accessible archive that itself meets the standards described in Section 8. Identify any observation plots that may have been used to help describe the geographic range or other characteristics of the type.

m. Evaluate plot data. Describe all factors that affect plot data adequacy and quality, including such factors as incomplete sampling throughout the range or poor floristic quality of plots.

n. The number and size of plots. Justify the number of and sizes of plots used in terms of the floristic variability and geographic distribution.

o. Methods used to analyze field data. Discuss the analytical methods used by the author of the type description to define the types. Include software citations.

p. Overall confidence level for the type. Recommend a level of confidence of high, moderate, or low, based on criteria described in Section 7. The peer-review process will ultimately establish the formal confidence level (see Section 7) for a given type.

q. Citations. Provide complete citations for all references used in the above section.

r. Vegetation type synonymy. List any names already in use in the NVC or other classifications to describe this or closely related types, either in whole or in part. Where possible, include comments or explanations on the relatedness of the type to other types that are adjacent in the classification. For example, is a type listed as being synonymous, broader in concept, more narrow, or equal to the type concept being proposed?

4. *Nomenclature of associations and alliances*:

The nomenclature of associations and alliances is not to be confused with the nomenclature of taxa, even though species names are used in the names of associations and alliances. A full discussion of the rules that follow is provided in Section 6.3 (page 54).

a. Community nomenclature must contain both scientific and common names, e.g., *Pinus taeda - Quercus* (*alba, falcata, stellata*) Forest Alliance as well as Loblolly Pine - (White Oak, Southern Red Oak, Post Oak) Forest Alliance. It is desirable that common names be provided in English, French, and Spanish if translation names exist. For associations, it may also include a colloquial name, e.g., Ozark Dolomite Glade. The relevant dominant and diagnostic species that are useful in naming a type should be selected from the tabular summaries of the types. Dominant and diagnostic species should include at least one from the dominant stratum of the type.

b. Nomenclature for vascular plant taxa used in scientific type names must follow the current version of USDA PLANTS or ITIS. Every plant taxa used in a scientific name will have a unique common name that will form the basis for the common name of the type.

c. For alliances, taxa from secondary strata should be used sparingly.

d. Among the taxa that are chosen to name the type, those occurring in the same stratum (tree, shrub, herb, nonvascular, floating, submerged) are separated by a hyphen (-), and those occurring in different strata are separated by a slash (/). Taxa occurring in the uppermost stratum are listed first, followed successively by those in lower strata.

e. Within a single stratum, the order of taxon names generally reflects decreasing levels of dominance, constancy, or other measures of diagnostic value based on character or differential value.

f. Association or alliance names include as a descriptor the FGDC (1997) physiognomic class in which they are placed. For alliances, the term “alliance” is included in the name to distinguish these units from association units (e.g., *Pinus ponderosa* Forest Alliance).

g. In cases where diagnostic taxa are unknown or in question, a more general term is currently allowed as a "placeholder" (e.g., *Cephalanthus occidentalis / Carex* spp. Northern Shrubland). Associations and alliances with placeholders in the name cannot be considered of high or moderate confidence (Section 7.1) since the diagnostic taxa of these higher confidence types are known and should be used to name the type. Furthermore, for reasons of standardization and brevity, the use of placeholders should be kept to a minimum.

h. The least possible number of taxa is used in a name. Although, up to five species may be necessary to define associations in some regions that contain very diverse vegetation with relatively even dominance and variable total composition. For alliances, no more than three species may be used. The scientific names for associations and alliances must be comprised of a unique set of plant species names, regardless of the order in which the plant names are used. For example, neither of the two names:

Picea mariana – Larix laricina / Chamaedaphne calculata Forest
Larix laricina – Picea mariana / Chamaedaphne calculata Forest

are acceptable as labels for two different associations since each one does not contain a unique set of plant species names.

i. The nomenclature for planted and cultivated types follows the same rules as above, except that the term "alliance" will not be used in the name; rather the name will be pluralized. Nor is the physiognomic class name required; rather, it is recommended that a useful descriptor of the vegetation type be used. Examples of such names include "*Pinus ponderosa* Plantation Forests" at the level of alliance, or "*Pinus ponderosa* Rocky Mountain Plantation Forest," and "*Zea mays* Crop Field" at the level of association.

9.4 PEER REVIEW OF PROPOSED VEGETATION TYPES

Peer review of proposals for new vegetation types, as well as for changes proposed to type concepts that are already recognized, is essential to the long term utility and progressive development of the NVC. While we have fixed the conceptual basis for associations and alliances, the data model continues to be somewhat variable. For example, environmental values may or may not be included directly in the statistical transformations. Even more, a number of quite different statistical models may be used in the classification analysis, and it is incumbent on those proposing new types to make a convincing case based on a clear explanation of the data, methods, and results. A unified classification of plant communities for a continent such as North America can only be viable if peer review of proposed types is an integral part of it. The essential components of a peer review system for the NVC are summarized below and detailed discussion of each component is provided in Section 7 (page 59).

4. *Rationale*:

    Floristic types will be established through an authoritative peer review process. An authoritative process is necessary to maintain the consistency, credibility, orderly change, and rigor of the classification.

5. *Classification confidence*:

    Each type will be assigned one of the confidence level shown below (and discussed in Section 7.1) based on the relative rigor of the data and the analysis used to identify, define, and describe the type:

    a. <u>High</u>: Classification is based on quantitative analysis of verifiable, high-quality classification plots that are published in full or are archived in a publicly accessible database. Classification plots must meet the minimum requirements specified in Section 5 and as shown in Appendix 1. High quality classification plots must represent the known geographic distribution and habitat range of the type. In addition, plots that form the basis for closely related types must be compared. For an alliance, the majority of component associations must have a high to moderate level of confidence.

    b. <u>Moderate</u>: Classification is lacking in either geographic scope or degree of quantitative characterization and subsequent comparison with related types, but otherwise meets the requirements for a high level of confidence. For an alliance, many associations within the type may have a moderate to low level of classification confidence.

    c. <u>Low</u>: Classification is based on plot data that are incomplete, not accessible to others, or not published; or, based on qualitative analysis, anecdotal information, or community descriptions that are not accompanied by plot data. Local experts have often identified these types. Although there is a high level of confidence that they represent significant vegetation entities that should be incorporated in the NVC, it is not known whether they would meet the guidelines for floristic types in concept or in the NVC classification approach if data were available. Alliances are classified as low confidence if defined primarily from:

        i. incomplete or unpublished and inaccessible plot data (e.g., plots may only contain information about species in the dominant layer),

        ii. non-standard, anecdotal, or local vegetation types, or

        iii. imagery, or other information that relies primarily on the dominant species in the dominant canopy layer.

6. *Peer review process*:

    a. The objectives of the peer review process are to:

        i. ensure compliance with classification, nomenclature and documentation guidelines,

        ii. maintain reliability of the floristic data and other supporting documentation, and

        iii. referee conflicts with established and potential NVC floristic types.

b. The peer review process will be administered by the NVC Peer Review Board under the aegis of an institution capable of providing independent and disinterested reviewers of appropriate training and experience.

c. The Peer Review Board is responsible for ensuring that the criteria specified in the version of "Guidelines for Describing Associations and Alliances of the U.S. National Vegetation Classification" that is current at the time, are followed. This Board must adhere to the scientific and technical principles of the NVC and it must ensure the good order and scientific credibility of the classification.

d. Investigators wishing to contribute to the NVC by proposing changes to the classification must submit their methods and results to the Peer Review Board as specified in the version of "Guidelines for Describing Associations and Alliances of the U.S. National Vegetation Classification" which is current at the time.

e. The Peer Review Board will maintain publicly available Proceedings of all official actions. Full descriptions of types will constitute the NVC primary literature and will be published in the Proceedings. The Proceedings will publish official changes to the list of NVC associations and alliances, and it will include the required supporting information for all changes made to the list.

f. Reviewers should have sufficient regional expertise to understand how a given proposed change to the NVC would affect related associations and alliances.

g. Investigators participating in NVC will use a defined template for type descriptions that can be readily reviewed and, if accepted, easily uploaded into the database system.

h. Investigators who describe association or alliance types must place their proposed types within the context of existing NVC types so as to determine whether the type under consideration is distinct, or whether their data will instead refine or upgrade the definition of a type or types already on the list.

i. Two kinds of peer review are available.

    i. Full Peer Review: If an investigator proposes to describe a type at the high or moderate confidence level, a full peer-review process is required. Full peer review is used when;

        1. the type is thought to be entirely new to the NVC,

        2. the type is an upgrade in confidence of an existing type without a type concept change, or

        3. the type is a reworking/replacement of an existing type concept.

    ii. Expedited Peer Review: If the investigator does not have sufficient information to support high or moderate confidence but is convinced that the type is new to the NVC, he or she can submit the type as a Low confidence type, and an expedited peer-review process will be used. Thus expedited peer review is only used when a type is thought to be entirely new to the NVC.

j. The peer review process should occur in a reasonable time frame, and should balance the need for improvement to the quality and to the stability of the NVC.

9.5. MANAGEMENT OF VEGETATION DATA

The unified vegetation classification described in these sections cannot succeed without careful and explicit rules for data management. The classification hinges on the three dynamic and interacting databases of (a) botanical taxonomy and nomenclature, (b) vegetation field plots, and (c) classified alliance and associations. It is the synthesis of these databases that will provide a consistent working knowledge of the vegetation of North America. To be the viable and stable resource envisioned here, a NVC management team must be identified and empowered to maintain the NVC process and its information system. The minimum requirements for ensuring the integrity of NVC data are outlined in the sections that follow, and details are provided in Section 8 (page 64).

1. *Information components*:

   The main information components of the NVC floristic levels are separate standard databases of:

   a. botanical taxonomy and nomenclature (the "Taxonomic Database").
   b. vegetation field plots (the "Plots" database).
   c. classified alliances and associations (the "Vegetation Classification Database").

2. *Web access*:

   a. Each of these databases must be publicly viewable and searchable over the web, and must be regularly updated.
   b. There must be a primary access point for viewing and retrieving information from these databases over the web. Although mirrors of this information may be established at other sites, the primary access point will be the definitive source of information on taxonomy and nomenclature, field plots, and recognized alliances and associations, respectively.
   c. The website will contain an explicit date and version, so that users of the NVC can cite the website and the explicit version observed (or date observed) so as to allow exact reconstruction of the taxonomic and community concepts employed as well as the observation data provided from field plots.

3. *Component databases*:

   a. The Taxonomic Database

      i. Each taxon must be reported as a name-and-reference couplet known as a "taxon-concept". For example, if the plot author based all the taxa on Fernald (1950), then the names of each taxon would each be linked to Fernald (1950). If USDA PLANTS or ITIS was used, then an observation date for these sources must be also provided so that their exact version can be determined. All databases supporting the NVC must track plant types by using taxon-concepts. An example of a taxon-concept is "*Abies lasiocarpa* (Hooker) Nuttall *sec* Flora of North Am. Vol. 2", where the name *Abies lasiocarpa* (Hooker) Nuttall refers explicitly to the concept described in the Flora of North America Vol. 2. The term "*sec*" means "in the sense of" (see the section on botanical nomenclature on page 64).

ii. Unknown or irregular taxa (such as composite morphotypes representing several similar taxa) should be reported with the name of the taxon for the lowest taxonomic level with certain identification, and must be associated with a note field in the database that provides additional information (e.g., Peet, R.K., plot #4-401, third "unknown grass", aff. Festuca, NCU 777777). For best practice, provide a name field to follow the given taxon in parentheses (e.g., *Potentilla* (*simplex* + *canadensis*), Poaceae (aff. *Festuca*)).

b. The Plots Database

i. Plot data used to support changes in the NVC must be archived in a publicly accessible and searchable database such as VegBank.

ii. Plot data used to support description of a vegetation type (classification plots) must be linked by accession number to the description of the type in the Vegetation Classification Database and should be publicly available via a direct database query from a web browser. All uses of plot data with respect to the NVC must cite the original author of the plot.

iii. The Plots Database must support concept-based species (taxon) taxonomy (see Section 8.1, and Table 1.2 of Appendix 1).

iv. All databases used to archive plot data supporting the NVC must have assured data permanency and must be able to export plot data in a format consistent with the Field Plot Data Exchange Schema (Appendix 4).

c. The Vegetation Classification Database

i. The management team will be able to make minor changes to Vegetation Classification Database files based on new information, such as an increase in the range of a community. Such minor changes will be inserted without review only after proper documentation is completed.

ii. Definition, redefinition, or change in the confidence level of a vegetation type requires approval and documentation from the NVC Peer Review Board.

iii. The Vegetation Classification Database will contain a schema that includes the fields needed for a type description (Section 6, also see the fields required for classification plots in Appendix 1).

iv. The Vegetation Classification Database must support concept-based species (taxon) taxonomy (see Section 8.1, Table 1.2 of Appendix 1).

4. *Proposal format*:
   Proposals for revisions in the NVC must be submitted in digital format using standard templates available from primary access points for the NVC and its Plots and Classification databases.

5. *Publication*:
   Successful proposals for recognized associations and alliances will be published in the Proceedings of the NVC and will be accessible at the primary access point for the Vegetation Classification Database. The Proceedings will be the end product of the classification, constituting the primary literature underpinning the NVC. It will be permanently and publicly available as a peer reviewed digital journal linked directly to the Vegetation Classification Database. The Proceedings of the NVC will seek to serve the needs of the community of vegetation classification scientists and users.

LOOKING AHEAD

10. INTERNATIONAL COLLABORATION, PROSPECTS AND DIRECTIONS

10.1 INTERNATIONAL COLLABORATION

Vegetation does not recognize political boundaries and the classification of vegetation is most effective if undertaken as an international collaboration. The US National Vegetation Classification developed as one national component of a larger, international initiative, the International Vegetation Classification (IVC). Accordingly, the guidelines presented in this document are designed with the expectation that they are consistent with the needs of the greater IVC enterprise and that a unified set of such guidelines will be adopted by all IVC partners.

Application of these guidelines toward the improvement of the IVC must be understood as a continuing process. Five critical elements of this process are: (a) collection and incorporation of new data, (b) evaluation and incorporation of new methods for analysis and synthesis, (c) publication of new and revised vegetation types, (d) new applications of present knowledge about vegetation, and (e) integration of national classification activities into a single, consistent IVC. The ESA Panel encourages international collaboration in the future development and implementation of these guidelines.

10.2 BUILDING THE CLASSIFICATION CONSORTIUM FOR THE FUTURE

Development and implementation of the IVC as a viable scientific activity depends on the support and participation of scientists and their institutions. A consortium for the advancement of the NVC had developed in the US, formalized by a Memorandum of Understanding (see Section 1, Rationale). Future activities of these and other partners will include revisions to the guidelines described here, provision of open access to databases containing the supporting information for classification, and maintenance of a review process for changes in the floristic units of the classification. Within this initial framework, the FGDC represents the needs of US federal agencies, and it will coordinate testing and evaluation of the classification by these agencies. NatureServe uses its long-term experience with the development and management of the National Vegetation Classification to ensure a practical continuity in classification applications, as well representing the network of natural heritage programs and conservation data centers in provinces, states and countries throughout the Americas. The ESA represents the professional scientific community. Its long experience with publication and independent peer review ensures the credibility of the classification. The ESA Panel provides an objective, neutral arena for all interested parties in the evaluation of proposed changes to these guidelines as well as the recognized classification units.

International development and application of the IVC requires collaboration among national programs. Like the US-NVC, the Canadian National Vegetation Classification (C-NVC) uses the general approach of the IVC (Ponomarenko and Alvo 2000). In particular, The Canadian Forest Service is working closely with provincial governments, Conservation Data Centers (CDCs, which are also member programs within the Natural Heritage Network supported by NatureServe), and other federal agencies and organizations to define forest and woodland types consistent with the association concept used in these guidelines. In addition, individual provinces have conducted extensive surveys using standardized plots, and they either have well-established vegetation classifications or are in the process of building them. Some have already develop alliance and associations units using the same standards, nomenclature and codes for types used in the U.S. and developing additional names and codes for new types (Greenall 1996). This approach ensures that associations developed in the U.S. and in Canada have the potential to be integrated as part of an IVC that is global in scope.

10.3 PROSPECTS FOR SCIENTIFIC ADVANCEMENT

Prospects for new data

The implementation of national-level guidelines, the development and broad application of the IVC, and the development of one or more national-level plot archives, are expected to catalyze the collecting of significant amounts of new field data as well as greatly increase access to legacy data. Using the guidelines and processes presented here, these new data should meet the need for consistency in identifying, describing, and documenting vegetation types and lead to advances in our understanding of vegetation as a whole.

Prospects for new analytic methods

One goal of the NVC is to create a framework for developing and characterizing vegetation alliances and associations. With a common and more organized approach to this goal, as well as generating more consistent field data that collectively can provide greater statistical power, the ability for experimentation and development of new analytic methods are expected to improve. In this regard, the prospects are quite good for new technical solutions to a host of unresolved problems in vegetation science.

Discovery and description of vegetation types

A true comprehensive classification of vegetation conformant with the guidelines contained in this document will emerge only as plot databases become comprehensive and the process of analysis and monographing is completed. A significant part of this work is the continuing reassessment of names and type concepts already published and proposed for consideration at the alliance and association level. The needed careful analysis and documentation is expected to be undertaken by the community of scientists working in agencies and other institutions, and to be published in papers or monographs.

Peer-review teams ensure that proposals for changes in types, nomenclature, and description take place within a systematic, credible and consensual peer-review process.

Researchers are encouraged to submit proposals for both new vegetation types and for revisions of types already described.

Another area of work concerns changes in described units of vegetation resulting from the effects of invasive species, climate change, fire-suppression, edaphic change, and other broad-scale biophysical dynamics. For example, the enduring changes resulting from invasive species are not well understood, and the effect of the current episode of rapid global mixing of species on vegetation types with respect to stability, distribution, dynamics, functioning, has not been evaluated. The effects of climate change on species distributions are only beginning to be considered. All such factors need to be understood and their consequences reflected in the classification of vegetation.

New applications of present knowledge

The primary reason for establishing guidelines for vegetation classification has been to ensure compatibility of applications across federal agencies, state agencies, universities, and private organizations. While different applications may require map units unique to a project, use of an underlying standard vegetation classification as the basis for those map units will allow comparability. With advances in mapping and inventory, these applications are likely to expand in breadth. Some important applications include the following:

Resource inventory, conservation, and management: Government and private agencies need to know which vegetation types are rare or threatened, which are exemplary in quality, and where they occur. These needs have initiated a new genre of vegetation inventory application. Recognition that many rare species are found in uncommon vegetation types has led to biodiversity conservation through maintenance and restoration measures focused on those types.

Resource mapping: Established guidelines for vegetation classification should lead to improved consistency and reliability of vegetation mapping. Major land development projects, including those associated with, for example, Habitat Conservation Plans (see Endangered Species Act 1982, Kareiva et al. 1999), also will use fine-grained vegetation classification in development conservation management plans.

Resource monitoring: Throughout North America, studies have been initiated to monitor changes in vegetation. Agencies are often mandated to monitor specific resources, such as forests or grasslands, or to assess ecosystem health. However, results from many of these efforts are too coarse in spatial or thematic resolution to be readily useful to land managers, and until recently there has been no consistent method used to define species assemblages to monitor, or the deviation of a community occurrence from the normal expression of that community. Such research requires clear definition and documentation of vegetation types as a baseline condition, followed by repeated measurements and comparisons over decades.

Ecological integrity: Vegetation provides a fundamental framework for documenting and understanding the complexity and integrity of ecosystems. Vegetation is habitat for hundreds of thousands if not millions of species. As it changes over space and time, a ripple effect can be expressed throughout the world's ecosystems, and because vegetation can be mapped through remote-sensing technologies, it can be used as a surrogate for tracking and understanding many changes in ecosystems.

The approach to and framework for an international classification of vegetation as described in this document are intended to facilitate long-term developments in resource conservation and management, environmental management, and basic vegetation science. Undoubtedly, new applications to vegetation classification will emerge and lead to further improvements. The guidelines described here provide a point of departure toward those ends.

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LITERATURE CITED

Adam, P. 1994. Australian rainforests. Oxford University Press, New York. 308 p.

Allen, R.B. 1992. RECCE: an inventory method for describing New Zealand's vegetation cover. For. Res. Inst. Bull. 176. Christchurch, New Zealand.

Anderson M., P.S. Bourgeron, M.T. Bryer, R. Crawford, L. Engelking, D. Faber-Langendoen, M. Gallyoun, K. Goodin, D.H. Grossman, S. Landaal, K. Metzler, K.D. Patterson, M. Pyne, M. Reid, L. Sneddon, and A.S. Weakley. 1998. International classification of ecological communities; terrestrial vegetation of the United States. Volume II. The national vegetation classification system: list of types. The Nature Conservancy, Arlington, Virginia, USA. 502p.

Arno, S.F., D.G. Simmerman, and R.E. Keane. 1985. Forest succession of four habitat types in western Montana. U.S. Department of Agriculture, Forest Service General Technical Report INT-177.

Austin, M. P. and P.C. Heyligers. 1991. New approaches to vegetation survey design. In: C.R. Margules and M.P. Austin (eds.). Nature conservation: cost effective biological surveys and data analysis. CSIRO, Clayton South, Victoria, Australia. pp. 31-36.

Avers, P.E., D. Cleland, W.H. McNab. 1994. National hierarchical framework of ecological units. In: Foley, Louise H., comp. Silviculture: from the cradle of forestry to ecosystem management. Gen. Tech. Rep. SE-88. Asheville, North Carolina: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. pp. 48-61.

Bailey, R.G. 1996. Ecosystem geography. Springer-Verlag, New York. 204 pp.

Bailey, R.G., M.E. Jensen, D.T. Cleland, and P.S. Bourgeron. 1994. Design and use of ecological mapping units. In: Jensen, M.E. and P.S. Bourgeron (eds.) Ecosystem management: Principles and applications, Volume II. USDA Forest Service General Technical Report PNW-GTR-318, Portland, Oregon, USA. pp.95-106.

Barbour, M. 1994. Special committee on vegetation classification. *Bulletin of the Ecological Society of America* 75:252-253.

Barbour, M.G., R.F. Fernau, J. M. Rey, N. Jurjavcic, and E. B. Royce. 1998. Tree regeneration and early succession following clearcuts in red fir forests of the Sierra Nevada, California. *Journal of Forest Ecology and Management* 104:101-111.

Barbour, M. G. and W. D. Billings (eds.). 2000. North American terrestrial vegetation, 2nd ed. Cambridge University Press, New York. 708 p.

Barbour, M., D. Glenn-Lewin and O. Loucks. 2000. Progress towards North American vegetation classification at physiognomic and floristic levels. Proceedings, International Association of Vegetation Science Symposium, Opulus Press, Uppsala, Sweden. pp. 111-114.

Barbour M., A. Solomesch, C. Witham, R. Holland, R. Macdonald, S. Cilliers, J.A. Molina, J. Buck, and J. Hillman. 2003. Vernal pool vegetation of California: variation within pools. *Madroño* 50: 129-146.

Beard, J.S. 1973. The physiognomic approach. In: R.H. Whittaker, Ed. Ordination and classification of communities. *Handbook of Vegetation Science* 5:355-386. Junk, The Hague.

Berendsohn, W.G., 1995. The concept of "potential taxa" in databases. *Taxon* 44:207-212.

Bestelmeyer, B.T., J.R. Brown, K.M. Havstad, R. Alexander, G. Chavez, and J. Herrick. 2003. Development and use of state-and-transition models for rangelands. Journal of Range Management 56(2):114-126.

Borhidi, A. 1996. Phytogeography and vegetation ecology of Cuba. Akadémiai Kiadó, Budapest. 923 p..

Bourgeron, P.S., and L.D. Engelking (eds.). 1994. A preliminary vegetation classification of the western United States. Unpublished report prepared by the Western Heritage Task Force for the Nature Conservancy, Boulder, Colorado, USA.

Braun-Blanquet, J. 1928. Pflanzensoziologie. Gründzuge der Vegetationskunde. Springer-Verlag, Berlin, Germany. 330 p.

______. 1932. Plant Sociology: the study of plant communities. McGraw-Hill, New York, New York, USA. 439 p.

______. 1964. Pflanzensoziologie, Grundzüge der Vegetationskunde. Springer-Verlag, Vienna, Austria. 865 p.

Brown, D.E., C.H. Lowe, and C.P. Pase. 1980. A digitized systematic classification for ecosystems with an illustrated summary of the natural vegetation of North America. USDA Forest Service General Technical Report RM-73. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Bruelheide, H. 2000. A new measure of fidelity and its application to defining species groups. *Journal of Vegetation Science* 11:167-178.

Ceska, A. 1999. Rejmanek's proposal to simplify phytosociological nomenclature. Botanical Electronic News 228:1-2

Cleland, D. T., J. B. Hart, G. E. Host, K. S. Pregitzer, and C. W. Ramm. 1994. Ecological classification and inventory system of the Huron-Manistee National Forest. U.S. Forest Service, Region 9, Milwaukee, Wisconsin, USA.

Cleland, D.T.; Avers, P.E.; McNab, W.H.; Jensen, M.E.; Bailey, R.G., King, T.; Russell, W.E. 1997. National Hierarchical Framework of Ecological Units. In: Boyce, M. S.; Haney, A. (eds.), Ecosystem Management Applications for Sustainable Forest and Wildlife Resources. Yale University Press, New Haven, Connecticut, USA. pp. 181-200.

Cooper, D.J. 1986. Arctic-alpine tundra vegetation of the Arrigetch Creek Valley, Brooks Range, Alaska. *Phytocoenologia* 14:467-555.

Cowardin, L. W., V. Carter, F.C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Biological Service Program, U.S. Fish and Wildlife Service, FWS/OBS 79/31. Office of Biological Services, Fish and Wildlife Service, U.S. Department of Interior, Washington, D.C.

Curtis, J.T. 1959. The vegetation of Wisconsin: an ordination of plant communities. University of Wisconsin Press, Madison, Wisconsin, USA. 657 p.

Damman, A. W. H. 1979. The role of vegetation analysis in land classification. *Forestry Chronicle* 55:175-182.

Darman. R.G. 1990. Circular No. A-16: coordination of surveying, mapping, and related spatial data activities. Office of Management and Budget, Washington, D.C.

Daubenmire, R.F. 1952. Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. *Ecological Monographs* 22:301-330.

______. 1953. Classification of the Conifer Forests of eastern Washington and Northern Idaho. Northwest Science 27:17-24.

______. 1959. A canopy-coverage method of vegetation analysis. *Northwest Science* 33:43-64.

______. 1968. Plant communities: a textbook of plant synecology. Harper and Row, New York. 300 p.

______. 1978. Plant Geography, with special reference to North America. Academic Press, New York. 338 p.

Daubenmire, R.F. and J.B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Washington Agricultural Experiment Station Technical Bulletin 60, Pullman, Washington, USA.

Di Gregorio, A. And L.J.M. Jansen. 1996. FAO Land cover classification: a dichotomous, modular-hierarchical approach. Food and Agriculture Organization of the United Nations, Rome, Italy.

Domin, K. 1928. The relations of the Tatra mountain vegetation to the edaphic factors of the habitat: a synecological study. *Acta Botanica Bohemica* 6/7:133-164.

Drake, J. and D. Faber-Langendoen. 1997. An alliance-level classification of the vegetation of the Midwestern United States. A report prepared by The Nature Conservancy Midwest Conservation Science Department for the University of Idaho Cooperative Fish and Wildlife Research Unit. The Nature Conservancy Midwest Regional Office, Minneapolis, Minnesota, USA.

Driscoll, R.S., D.L. Merkel, D.L. Radloff, D.E. Snyder, and J.S. Hagihara. 1984. An ecological land classification framework for the United States. U.S. Department of Agriculture, Forest Service, Miscellaneous Publication 1439, Washington, D.C.

Ehrlich, P.R. 1997. A world of wounds: ecology and the human dilemma. Ecology Institute, Oldendorf/Luhe, Germany. 210 p.

Ellenberg, H. 1988. Vegetation ecology of Central Europe. Fourth edition. Cambridge University Press, Cambridge, Massachusetts, USA. 731 p.

Ellis, S.L., C. Fallat, N. Reece, and C. Riordan. 1977. Guide to land cover and use classification systems employed by western governmental agencies. FWS/OBS-77/05. Office of Biological Services, Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C.

Endangered Species Act. 1982. Public Law 97-304, 92 Stst. 1411, Oct. 13, 1982. USA.

EUROCONTROL and IfEN. 1998. WGS 84 implementation manual. European Organization for the Safety of Air Navigation, Brussels, Belgium, and Institute of Geodesy and Navigation, University FAF, Munich, Germany, Version 2.4. [Web resource: http://www.wgs84.com/files/wgsman24.pdf].

Eyre, F.H., editor. 1980. Forest cover types of the United States and Canada. Society of American Foresters, Washington, D.C.

Faber-Langendoen, D., editor. 2001. Plant communities of the Midwest: classification in an ecological context. Association for Biodiversity Information, Arlington, Virginia, USA. 705 p.

Faber-Langendoen, D., and P.F. Maycock. 1987. Composition and soil-environment analysis of prairies on Walpole Island, southwestern Ontario. *Canadian Journal of Botany* 65:2410-2419.

Federal Register. 1994. Coordinating geographic data acquisition and access: the National Spatial Database Infrastructure. Executive Order 12906 of April 11, Washington D.C. http://www.fgdc.gov/publications/documents/geninfo/execord.html

Ferguson, D. E., P. Morgan, and F. D. Johnson (eds.). 1989. Proceedings, Land Classifications Based on Vegetation: Applications for Resource Management. 17-19 November 1987, Moscow, Idaho. U.S. Department of Agriculture, Forest Service General Technical Report INT 257, Ogden, Utah, USA.

Fernald, M.L. 1950. Gray's Manual of Botany. American Book Company. New York, New York. 1632 p.

FGDC. 1997. Vegetation classification standard. FGDC-STD-005. Vegetation Subcommittee, Federal Geographic Data Committee. FGDC Secretariat, U.S. Geological Survey, Reston, Virginia, USA. [Web resource: http://www.fgdc.gov/standards]

Flahault, C. and C. Schröter. 1910a. Phytogeographische Nomenklatur. Berichte und Anträge 3. Third International Congress of Botany. Brussels, Belgium. pp14-22.

Flahault, C. and C. Schroter. 1910b. Rapport sur la nomenclature phytogeographique. Proc. 3rd Int. Bot. Cong., Brussels 1910, 1, 131-64.

Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. 7+ vols. New York and Oxford.

Fosberg, F.R. 1961. A classification of vegetation for general purposes. *Tropical Ecology* 2:1–28.

Franklin, J.F., C.T. Dyrness, and W.H. Moir. 1971. A reconnaissance method for forest site classification. *Shinrin Richi* 12(1):1-14.

Gabriel, H.W. and S.S. Talbot. 1984. Glossary of landscape and vegetation ecology for Alaska. Alaska Technical Report 10. Bureau of Land Management, U.S. Department of the Interior, Washington, D.C.

Gauch, H.G. 1982. Multivariate analysis in community ecology. Cambridge University Press, London, UK. 298 p.

Gleason, H. A. 1926. The individualistic concept of the plant association. *Bulletin of the Torrey Botanical Club* 53:7-26.

Grossman, D.H., K.L. Goodin, and C.L. Reuss (eds.). 1994. Rare plant communities of the coterminous United States: an initial survey. A report prepared by The Nature Conservancy for the U.S. Fish and Wildlife Service, Idaho Cooperative Fish and Wildlife Research Unit. The Nature Conservancy, Arlington, Virginia, USA.

Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P.S. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International Classification of Ecological Communities: terrestrial Vegetation of the United States. Volume I. The national vegetation classification system: development, status, and applications. The Nature Conservancy, Arlington, Virginia, USA.

Hall, G.M.J. 1992. PC-RECCE: Vegetation inventory data analysis. For. Res. Inst. Bull. 182. Christchurch, New Zealand.

Jackson, J.A. (ed). 1997. Glossary of geology, 4th Ed. American Geological Institute, Alexandria, Virginia, USA. 769p.

Jennings, M.D. 1993. Natural terrestrial cover classification: assumptions and definitions. GAP Analysis Technical Bulletin 2. U.S. Fish and Wildlife Service, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho, USA.

Jennings, M.D. 2000. Gap analysis: concepts, methods, and recent results. *Journal of Landscape Ecology* 15(1):5-20.

Jongman, R.H.G., C.J.G. ter Braak, and O.F.R. Van Tongeren. 1995. Data analysis in community and landscape ecology. Cambridge University Press, Cambridge, UK. 299p.

Kareiva, P., S. Andelman, D. Doak, B. Elderd, M. Groom, J. Hoekstra, L. Hood, F. James, J. Lamoreux, G. LeBuhn, C. McCulloch, J. Regetz, L. Savage, M. Ruckelshaus, D. Skelly, H. Wilbur, K. Zamudio. 1999. Using science in habitat conservation plans. Report from National Center for Ecological Analysis and Synthesis, Santa Barbara, California, USA. [Web resource: http://www.nceas.ucsb.edu/nceas-web/projects/97KAREI2/hcp-1999-01-14.pdf]

Kartesz, J. T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. Second edition. Volume 1. Checklist. Timber Press, Portland Oregon, USA.

Kartesz, J.T. 1999. A Synonymized Checklist and Atlas with Biological Attributes for the Vascular Flora of the United States, Canada, and Greenland. First Edition. In: Kartesz, J.T., and C.A. Meacham. Synthesis of the North American Flora, Version 1.0. [computer application] North Carolina Botanical Garden, Chapel Hill, North Carolina, USA.

Kent, M. and P. Coker. 1992. Vegetation description and analysis: a practical approach. Belhaven Press. London, UK. 363 p.

Kimmins, J.P. 1997. Forest ecology: a foundation for sustainable management. Second edition. Prentice Hall, Upper Saddle River, New Jersey, USA. 596 p.

Klinka, K. H. Qian, J. Pojar, and D.V. Meidinger. 1996. Classification of natural forest communities of coastal British Columbia, Canada. *Vegetatio* 125:149-168.

Klopatek, J.M., R.J. Olson, C.J. Emerson, and J.L. Jones. 1979. Land use conflicts with natural vegetation in the United States. *Environmental Conservation* 6:191-199.

Komárková, V. 1979. Alpine Vegetation of the Indian Peaks area, Front Range, Colorado Rocky Mountains. J. Cramer, Vaduz, Lichtenstein. 2 vol., 591p.

Krajina, V.J. 1933. Die Pflanzengesellschaften de Mlynica-Tales in den Vysoke Tatry (Hohe Tatra). Mit besonderer Berücksichtigung der ökologischen Verhältnisse. Botan. Central., Beih. Abt. II, 50:774-957; 51:1-224.

Küchler, A.W. 1988. The nature of vegetation. In: Vegetation mapping, Küchler and Zonneveld, eds., Kluwer Academic Publishers, Dordrecht, Netherlands.

Lapin, M., and B. V. Barnes. 1995. Using the landscape ecosystem approach to assess species and ecosystem diversity. Conservation Biology 9:1148-1158.

LaRoe, E.T., G.S. Garris, C.E. Puckett, P.D. Doran, and M.J. Mac (eds.). 1995. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Department of the Interior, National Biological Service, Washington, D.C.

Layser, E.F. 1974. Vegetative classification: its application to forestry in the northern Rocky Mountains. *Journal of Forestry* 72: 354-357.

Lee, H.T., W.D. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig and S. McMurray. 1998. Ecological land classification for Southern Ontario: First approximation and its application. Ontario Ministry of Natural Resources, Southcentral Science Section, Science Development and Technology Branch. SCSS Field Guide FG-02. 225 p.

Lins, K.F., and R.L. Kleckner. 1996. Land use and land cover mapping in the United States: An overview and history of the concept. In: Gap analysis: A landscape approach to biodiversity planning, Scott et. al , eds. American Society for Photogrammetry and Remote Sensing, Bethesda, Maryland, USA. pp 56-65.

Loucks, O.L. 1995. Special committee on vegetation classification: annual report. *Bulletin of the Ecological Society of America* 76:221-223.

______. 1996. 100 years after Cowles: a national classification of vegetation. *Bulletin of the Ecological Society of America* 77:75-76.

Loveland, T.R., Z. Shu, D.O. Ohlen, J.F. Brown, B.C. Reed, and L. Yang. 1999. an analysis of the IGBP global land-cover characterization process. Photogrammetric Engineering & Remote Sensing, 65(9):1021-1032.

Ludwig, J.A. and Reynolds, J.F. 1988. Statistical ecology: a primer on methods and computing. Wiley, New York. 337 p.

Mac, M.J., P.A. Opler, C.E. Puckett Haeker, and P.D. Doran, eds. 1998. Status and trends of the Nation's biological resources. 2 vols. U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia, USA.

Mack, R.N. 1986. Alien plant invasion into the Intermountain West: a case history. In: H.A. Mooney and J.A. Drake (eds.). Ecology of Biological Invasions of North America and Hawaii. Springer-Verlag, New York. pp 191-212.

McAuliffe, J. R. 1990. A rapid survey method for the estimation of density and cover in desert plant communities. *Journal of Vegetation Science* 1:653-656.

McCune, B., and M.J. Mefford. 1999. Multivariate analysis of ecological data, PC-ORD version 4.17. MjM Software, Gleneden Beach, Oregon, USA.

McCune, B., J.B. Grace, and D.L. Urban. 2002. Analysis of ecological communities. MjM Software Design, Gleneden Beach, Oregon, USA. 300p.

McIntosh, R.P. 1967. The continuum concept of vegetation. *Botanical Review* 45:130-187.

McMillan, C. 1969. Discussion. In: Systematic biology; Proceedings of an International Conference, held at the University of Michigan, Ann Arbor, June 1967. National Academy of Sciences, Washington, D.C. pp.203-206.

McNab, W.H. and P.E. Avers. 1994. Ecological subregions of the United States: section descriptions. Administrative Publication WO-WSA-5. U.S. Department of Agriculture, U.S. Forest Service, Washington, D.C.

Michener, William K., James W. Brunt, John J. Helly, Thomas B. Kirchner, Susan G. Stafford, 1997. Nongeospatial metadata for the ecological sciences. *Ecological Applications*: Vol. 7, No. 1, pp. 330–342.

Minnesota Natural Heritage Program (Minnesota Department of Natural Resources). 1993. Minnesota’s native vegetation: a key to natural communities. Version 1.5. Minnesota Department of Natural Resources Natural Heritage Program, Biological Report No. 20. St. Paul. 111 p.

Moravec, J. 1973. The determination of the minimal area of phytocenoses. *Folia Geobotanica et Phytotaxonomica* 8: 23-47.

Moravec, J. 1993. Syntaxonomic and nomenclatural treatment of Scandinavian-type associations and sociations. *Journal of Vegetation Science* 4:833-838.

Morse, L.E., L.S. Kutner, and J.T. Kartez. 1995. Potential impacts of climate change on North American flora. pp 392-395 In: E.T. LaRoe, G.S. Garris, C.E. Puckett, P.D. Doran, and M.J. Mac (eds.). Our Living Resources: a Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems. U.S. Department of the Interior, National Biological Service, Washington, D.C.

Mucina, L. 1997. Conspectus of classes of European vegetation. *Folia Geobotanica et Phytotaxonomica*. 32:117-172.

Mucina, L, J.S. Rodwell, J.H.J. Schaminee, and H. Dierschke. 1993. European vegetation survey: current state of some national programs. *Journal of Vegetation Science* 4:429-438.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley, New York.

Naeem, S., T. Chapin, Robert Costanza, Paul Ehrlich, Frank B. Golley, David Hooper, J. H. Lawton, Robert O'Neil, Harold Mooney, O. Sala, Amy Symstad, and David Tilman. 1999. Biodiversity and Ecosystem Functioning. Ecological Issues No. 4. Ecological Society of America, Washington, D.C.

Nakamura, Y. and M.M. Grandtner. 1994. A comparative study of the alpine vegetation of Eastern North America and Japan. pp. 335-347 In: A. Miyawaki, K. Iwatsuki, and M.M. Grandtner (eds.). Vegetation in Eastern North America. University of Tokyo Press, Tokyo, Japan.

Nakamura, Y., M.M. Grandtner, and N. Vilenue. 1994. Boreal and oroboreal coniferous forest of Eastern North American and Japan. Pp. 121-154 In: A. Miyawaki, K. Iwatsuki, and M.M. Grandtner (eds.). Vegetation in Eastern North America. University of Tokyo Press, Tokyo, Japan.

National Science and Technology Council. 1997. Integrating the nation's environmental monitoring and research networks and programs: a proposed framework. Committee on Environment and Natural Resources, Environmental Monitoring Team, Washington, D.C.

NatureServe. 2003. International Ecological Classification Standard: International Vegetation Classification. Central Databases, NatureServe, Arlington, Virginia, USA.

NatureServe Explorer: an online encyclopedia of life. 2002. Version 1.6. Arlington, Virginia, USA. [Web resource: http://www.natureserve.org/explorer. (Accessed January 15, 2002].

Naveh, Z. and R.H. Whittaker. 1979. Structural and floristic diversity of shrublands and woodlands in northern Israel and other Mediterranean areas. *Vegetatio* 41:171-190.

Nelson, P. W. 1985. The terrestrial natural communities of Missouri. Missouri Department of Natural Resources, Jefferson City, Missouri, USA.

Nicolson, M,. and R.P. McIntosh. 2002. H.A. Gleason and the individualistic hypothesis revisited. *Bulletin of the Ecological Society of America*, 83(2):133-142.

Noss, R.F., E.T. LaRoe III, and J.M. Scott. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. Biological Report 28, U.S. Department of the Interior, National Biological Service, Washington, D.C.

Noss, R.F. and R.L. Peters. 1995. Endangered ecosystems: a status report on America's vanishing habitat and wildlife. Defenders of Wildlife, Washington, D.C.

NRCS (U.S. Department of Agriculture, Natural Resources Conservation Service). 2001. National Soil Survey Handbook, title 430-VI, part 614.05..

Overpeck, J.T., P.J. Bartlein, and T. Bebb III. 1991. Potential magnitude of future vegetation changes in eastern North America: comparison with the past. *Science* 254:692-695.

Pearlstine, L, A. McKerrow, M. Pyne, S. Williams, and S. McNulty. 1998. Compositional groups and ecological complexes: a methodological approach to realistic GAP mapping. Gap Analysis Bulletin No. 7. National Gap Analysis Program, Moscow, Idaho, USA. [web resource: http://www.gap.uidaho.edu/Bulletins/7/CGECAMABVM.htm].

Peet, R.K. 1980. Ordination as a tool for analyzing complex data sets. *Vegetatio* 42:171-174.

______. 1981. Forest vegetation of the northern Colorado Front Range: composition and dynamics. *Vegetatio* 45:3-75.

______. 1994. Vegetation classification in contemporary ecology. Ecological Society of America Vegetation Section Newsletter 2-5, Washington D.C.

Peet, R. K., T. R. Wentworth, and P. S. White. 1998. The North Carolina Vegetation Survey protocol: a flexible, multipurpose method for recording vegetation composition and structure. *Castanea* 63:262-274.

Peinado, M., F. Alcaraz, J. Delgadillo, J.L. Aguirre, J. Alvarez, and M. de la Cruz. 1994. The coastal salt marshes of California and Baja California: phytosociological typology and zonation. *Vegetatio* 110:55-66.

Peinado, M., J.L. Aguirre, and M. de la Cruz. 1998. A phytosociological survey of the boreal forest (Vaccinio-Piceetea) In: North America. *Plant Ecology* 137:151-202.

Pfister, R. D. and S. F. Arno. 1980. Classifying forest habitat types based on potential climax vegetation. *Forest Science* 26:52-70.

Pignatti, S., E. Oberdorfer, J.H.J. Schaminee, and V. Westhoff. 1994. On the concept of vegetation class in phytosociology. *Journal of Vegetation Science* 6:143-152.

Podani, J. 2000. Introduction to the exploration of multivariate biological data. Backhuys Publishers, Leiden, Hungary. 407p.

Ponomarenko, S. and R. Alvo. 2000. Perspectives on developing a Canadian classification of ecological communities. Canadian Forest Service, Science Branch, Information Report ST-X-18E. Natural Resources Canada, Ottawa. 50 p.

Poore, M. E. D. 1962. The method of successive approximation in descriptive ecology. *Advances in Ecological Research* 1:35-68.

Pyle, R.L. 2004. Taxonomer: a relational data model for managing information relevant to taxonomic research. *PhyloInformatics* 1:1-54.

Raunkiaer, C. 1934. The life forms of plants and statistical plant geography. Clarendon, Oxford. 632 pp.

Reed, R.A., R.K. Peet, M.W. Palmer and P.S. White. 1993. Scale dependence of vegetation-environment correlations in a Piedmont woodland, North Carolina, USA. *Journal of Vegetation Science* 4: 329-340.

Rejmanek, M. 1997. Towards a simplification of phytosociological nomenclature. *Folia Geobotanica et Phytotaxonomic*a 32:419-420.

Reschke, C. 1990. Ecological communities of New York State. New York Natural Heritage Program. New York State Department of Environmental Conservation, Latham, New York, USA.

Reid, M.S., K.A. Schulz, P.J. Comer, M.H. Schindel, D.R. Culver, D.A. Sarr, and M.C. Damm. 1999. Descriptions of vegetation alliances of the coterminous western United States. The Nature Conservancy, Boulder, Colorado, USA.

Rivas-Martínez, D. Sánchez-Mata, and M. Costa. 1999. North American boreal and western temperate forest vegetation. Itinera Geobotanica 12:5-316.

Rodwell, J.S. (ed.). 1991. British plant communities. Volume I. Woodlands and scrub. Cambridge University Press, New York. 405 p.

Rodwell, J.S., S. Pignatti, L. Mucina, and J.H.J. Sohamined. 1995. European vegetation survey: update on progress. *Journal of Vegetation Science* 6:759-762.

Rodwell, J.S., J.H.J. Schamineé, L. Mucian, S. Pignatti, J. Dring and D. Moss. 2002. The diversity of European vegetation. An overview of phytosociological alliances and their relationships to EUNIS habitats. Wageningen, NL. EC-LNV. Report EC-LNV nr. 2002/054. 168 p.

Salisbury, E. J. 1940. Ecological aspects of plant taxonomy. In: Huxley, J. (ed.). The new systematics. Clarendon Press, Oxford, UK. pp.329-340.

Sawyer, J. O. and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento, California, USA.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina: third approximation. North Carolina Department of Environment, Health and Natural Resources, Division of State Parks and Recreation, Natural Heritage Program, Raleigh, North Carolina, USA.

Schaminée, J.H.J., S.M. Hennekens, and G. Thébaud. 1993. A syntaxonomical study of subalpine heathland communities in West European low mountain ranges. *Journal of Vegetation Science* 4:125-134.

Scott. J. M., F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'Erchia, T. C. Edwards Jr., J. Ulliman, and R. Wright. 1993. Gap Analysis: a geographic approach to protection of biological diversity. Wildlife Monograph 123, 1-41.

Scott, J.M., and M.D. Jennings. 1998. Large-area mapping of biodiversity. *Annals of the Missouri Botanical Garden,* 85(1):34-47.

Shiftlet, T.N. (ed.). 1994. Rangeland cover types of the United States. Society for Range Management, Denver, Colorado, USA.

Shimwell, D.W. 1971. Description and classification of vegetation. Sidgwick and Jackson, London. 322 p.

Shmida. A. 1984. Whittaker's plant diversity sampling method. *Israel Journal of Botany* 33:41-46.

Sims, R. A., W. D. Towill, K. A. Baldwin, and G. M. Wickware. 1989. Field guide to the forest ecosystem classification for northwestern Ontario. Forestry Canada, Ontario Ministry of Natural Resources, Thunder Bay, Ontario, Canada.

Smith, M.-L. 1995. Community and edaphic analysis of upland northern hardwood communities, central Vermont, USA. *Forest Ecology and Management* 72:239-245.

Sneddon, L., M. Anderson, and K. Metzler. 1994. A classification and description of terrestrial community alliances in the Nature Conservancy's Eastern region: first approximation. A report prepared by the Nature Conservancy Eastern Regional Office for the University of Idaho Cooperative Fish and Wildlife Research Unit. Nature Conservancy Eastern Regional Office, Boston, Massachusetts, USA.

Specht, R., E.M. Roe, and V.H. Boughton. 1974. Conservation of major plant communities in Australia and Papua New Guinea. *Australian Journal of Botany* Supplement 7.

Sperberg-McQueen, C.M. and H. Thompson. 2003. XML Schema, revision 1.87. W3C, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA. Available online [http://www.w3.org/XML/Schema].

Spribille, T., H.G. Stroh, and F.J. Triepke. 2001. Are habitat types compatible with floristically-derived associations. *Journal of Vegetation Science* 12:791-796.

Spribille, T. 2002. The mountain forests of British Columbia and the American Northwest: floristic patterns and syntaxonomy. *Folia Geobotanica* 37: 475-508.

SRM (Society for Range Management). 1989. Glossary of terms used in range management. Society for Range Management, Denver, Colorado, USA.

Stachurska-Swakon, A. and T. Spribille. 2002. Forest communities of the northern Whitefish Range, Rocky Mountains, Montana, U.S.A. *Folia Geobotanica* 37: 509-540.

Stohlgren, T.J., M.B. Falkner, and L.D. Schell. 1995. A modified-Whittaker nested vegetation sampling method. *Vegetatio* 117:113-121.

Tabachnik, B.G., and L.S. Fidell. 1989. Using multivariate statistics. Allyn & Bacon, Needham Heights, Massachusetts, USA. 932 p.

Taylor, B.N. 1995. Guide for the Use of the International System of Units (SI). National Institute of Standards and Technology Special Publication 811, U.S. Government Printing Office, Washington, D.C. 84p.

Thomas, J.W. (ed.). 1979. Wildlife habitats in managed forests in the Blue Mountains of Oregon and Washington. Agriculture Handbook Number 553. U.S. Department of Agriculture, Forest Service, Washington, D.C.

Tüxen, R. 1956. Die heutige naturliche potentielle Vegetation als Gegenstand der vegetationskartierung. Remagen. *Berichte zur Deutschen Landekunde* 19:200-246.

Tyrrell, L. E., G. J. Nowacki, T. R. Crow, D. S. Buckley, E. A. Nauertz, J. N. Niese, J. L. Rollinger, and J. C. Zasada. 1998. Information about old growth for selected forest type groups in the Eastern United States. Gen. Tech. Rep. NC-197. St. Paul, Minnesota: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 507p.

UNEP/FAO (United Nations Environment Programme/Food and Agriculture Organization of the United Nations). 1995. Background note on ongoing activities relating to land use and land cover classification. United Nations, Nairobi, Kenya.

UNESCO (United Nations Educational, Scientific, and Cultural Organization). 1973. International Classification and Mapping of Vegetation. Series 6. Ecology and Conservation. United Nations, Paris, France.

USDA, NRCS. 2000. The PLANTS Database, National Plant Data Center, Baton Rouge, LA, USA. (web resource: http://plants.usda.gov).

USDA, NRCS. 2002. National Soil Survey Handbook, title 430-VI. Available online [http://soils.usda.gov/technical/handbook/].

Vitousek, P.M., H. A. Mooney, J. Lubchenco, J.M. Melillo. 1997. Human domination of earth's ecosystems. *Science* 277:494-499.

Walker, M.D., D.A. Walker, and N.A. Auerbach. 1994. Plant communities of a tussock tundra landscape in the Brooks Range Foothills. *Journal of Vegetation Science* 5:843-866.

Weakley, A.S., K. Patterson, S. Landaal, M. Pyne, and M. Gallyoun. 1997. An alliance-level classification of the vegetation of the southeastern United States. A report prepared for the University of Idaho Cooperative Fish and Wildlife Research Unit by The Nature Conservancy Southeastern Regional Office, Chapel Hill, North Carolina, USA.

Weakley, A. S., K. D. Patterson, S. Landaal, M. Pyne, and others (compilers). 1998. International classification of ecological communities: terrestrial vegetation of the southeastern United States. Working draft of March 1998. The Nature Conservancy, Southeast Regional Office, Southern Conservation Science Department, Community Ecology Group, Chapel Hill, North Carolina, USA.

Weber, H.E., J. Moravec, and J.-P. Theurillat. International Code of Phytosociological Nomenclature. 3rd edition. Journal of Vegetation Science 11(5):739-768.

Wellner, C.A. 1989. Classification of habitat types in the Western United States. In: D.E. Ferguson, P. Morgan, and F.D. Johnson (eds.). Proceedings, Land Classifications Based on Vegetation: applications for Resource Management. 17-19 November 1987, Moscow, Idaho. U.S. Department of Agriculture, Forest Service General Technical Report INT 257, Ogden, Utah, USA.

Werger, M. J. A. 1973. Phytosociology of the Upper Orange River Valley, South Africa. Botanical Research Institute, Department of Agriculture and Fisheries, Pretoria, South Africa. 98 p.

Westhoff, V. and E. van der Maarel. 1973. The Braun-Blanquet approach. In: R.H. Whittaker (ed.). Handbook of Vegetation Science. Part V. Ordination and Classification of Communities. Junk, The Hague, The Netherlands. pp 617-726.

Whittaker, R.H. 1956. Vegetation of the Great Smoky mountains. *Ecological Monographs* 26:1-80.

______. 1962. Classification of natural communities. *Botanical Review* 28:1-239.

______. (ed.). 1973. Ordination and Classification of Communities. *Handbook of Vegetation Science* 5. Junk, The Hague.

______. 1973a. Approaches to classifying vegetation. In: R.H. Whittaker, ed. Ordination and Classification of Communities. *Handbook of Vegetation Science* 5:323-354. Junk, The Hague.

______. 1975. Communities and ecosystems. Second edition. MacMillan, New York.

Whittaker, R.H., W.A. Niering, and M.D. Crisp. 1979. Structure, pattern, and diversity of a mallee community in New South Wales. *Vegetatio* 39:65-76.

Whittaker, R.H. 1960. Vegetation of the Siskiyou Mountains, Oregon and California. *Ecological Monographs* 30:279-338.

Wilson, M.V., and A. Shmida. 1984. Measuring beta diversity with presence-absence data. *Journal of Ecology* 72:1055-1064.

Wilcove, D.S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperiled species in the United States: assessing the relative importance of habitat destruction, alien species, pollution, overexploitation, and disease. *Bioscience* 48:607-616.

Yorks, T.E., and S. Dabydeen. 1998. Modification of the Whittaker sampling technique to assess plant diversity in forested natural areas. *Natural Areas Journal* 18:185-189.

GLOSSARY

Alliance — A group of associations with a defined range of species composition, habitat conditions, and physiognomy, and which contains one or more of a set of diagnostic species, typically at least one of which is found in the upper most or dominant stratum of the vegetation. (This definition includes both floristic and physiognomic criteria, in keeping with the integrated physiognomic-floristic hierarchy of the NVC. It is similar to the FGDC 1997 definition: a physiognomically uniform group of Associations sharing one or more diagnostic (dominant, differential, indicator, or character) species, which, as a rule, are found in the uppermost stratum of the vegetation.)

Association — A vegetation classification unit consistent with a defined range of species composition, diagnostic species, habitat conditions, and physiognomy.

Associes — a type of vegetation unit applied in the Western US tradition, to avoid confusion with association (q.v.) as used in the Western US tradition to refer to the latest successional or climax (q.v.) stage; suggested for classification of plant communities in earlier stages of secondary succession (Daubenmire 1968).

Basal Area — the surface area of a woody stem (or stems) if cut off at a specific height (“breast height” is here defined as 1.37 meters or 4.5 feet).

Character species — a species that shows a distinct maximum concentration (quantitatively and by presence) in a well-definable vegetation types, sometimes recognized at local, regional, and absolute geographic scales (Mueller-Dombois and Ellenberg 1974, p. 178, 208; Bruelheide 2002), c.f. differential species.

Class — the first level in the NVC hierarchy (see Figure 1); based on the structure of the vegetation and determined by the relative percentage of cover and the height of the dominant, life forms (FGDC 1997). As used here for a physiognomic NVC category, the term does not correspond with "class" as used strictly in phytosociological classifications.

Classification — the grouping of similar types (in this case – vegetation types) according to criteria (in this case - physiognomic and floristic). The rules for classification must be clarified prior to delineation of the types within the classification standard. Classification methods should be clear, precise, and based upon objective criteria so that the outcome is theoretically independent of who applies the classification. (UNEP/FAO 1995, FGDC 1997).

Classification Plot Records — plot records that contain the data necessary to inform the development or revision of the floristic units within the NVC. Such plots typically contain high quality data on floristic composition and structure, and conform to the guidelines articulated in Section 5.3 (see Occurrence Plot Records; also Appendix 1).

Climax Vegetation — the final, relatively stable community at the conclusion of ecological succession that is able to reproduce itself indefinitely under existing environmental conditions (Gabriel and Talbot 1984).

Community — a group of organisms living together and linked together by their effects on one another and their responses to the environment they share (Whittaker 1975).

Community Constant (species) —a species that occurs frequently in stands of a type; synonymous with constant companion.

Constancy — the percentage of plots in a given data set that a taxon occurs in.

Cover Estimate — an estimate of the percentage of the surface of the earth (within a specified area, or plot) covered by biomass of plants of a specified group (from one species to all species, from one horizontal layer to all growth.). This can be viewed as the percentage of the sky that would be obscured by the biomass. In contrast to leaf area index, total cover cannot exceed 100%.

Cover Type — a community type defined on the basis of the plant species forming a plurality of composition and abundance (FGDC 1997; see this document Section 3.1, also see Eyre 1980).

Diagnostic Species — any species or group of species whose relative constancy or abundance differentiates one vegetation type from another (see Sections 3.1, 4.2). This is consistent with, but more narrow than, the FGDC 1997 definition "an indicator species or phytometer used to evaluate an area, or site, for some characteristic," Similarly, Curtis (1959) defined a diagnostic species as a plant of high fidelity to a particular community and one whose presence serves as a criterion of recognition of that community (Curtis

1959). In the Braun-Blanquet system, diagnostic species comprise the character and differential species used to delimit associations (Bruelheide 2000).

Differential Species — A plant species that is distinctly more widespread or successful in one of a pair of plant communities than in the other, although it may be still more successful in other communities not under discussion (Curtis 1959). This is consistent with Bruelheide's (2000) definition: a species "that shows a distinct accumulation of occurrences in one or more vegetation units", and clearly distinguishes the concept from that of a character species which should show a distinctive accumulation of occurrences in only one type.

Division — level in the FGDC physiognomic classification standard separating Earth cover into either vegetated or non-vegetated categories (FGDC 1997).

Dominance — the extent to which given taxa (or growth forms) predominate in a community because of their size, abundance, or cover. Dominance is interpreted in two different ways for NVC purposes: (1) where vegetation covers more than 25% of the area, the taxon or taxa (or growth forms) within a given stratum having the greatest amount of cover above 25% is considered dominant; and (2) where vegetation covers less than 25% of the area, the taxon or taxa (or growth forms) with the highest percent canopy cover is considered dominant. In the case of a 'tie', the upper canopy will be referred to as the dominant growth form (FGDC 1997). (Other definitions sometimes applied refer to the most common taxon of the upper-most stratum, the taxa with the greatest relative basal area, or the more successful taxon in a competitive interaction.)

Dominance Type — a class of communities defined by the dominance of one or more species, which are usually the most important ones in the uppermost or dominant layer of the community, but sometimes of a lower layer of higher coverage (Gabriel and Talbot 1984).

Dominant Species — species with the highest percent of cover, usually in the uppermost dominant layer (in other contexts dominant species can be defined in terms of biomass, density, height, coverage, etc., (Kimmins 1997; see Section 2.1.3)).

Entitation — the process by which we recognize and define entities, usually by dividing a continuously varying phenomenon into a set of discreet entities. In vegetation ecology entitation refers to the act of segmenting an area of vegetation into homogeneous entities, within which samples (plots) can be placed (see Mueller-Dombois and Ellenberg 1974), or the division of community data (usually plot data) into discrete vegetation classes.

Existing Vegetation — vegetation found at a given location at the time of observation (in contrast to potential vegetation).

Fidelity — the degree to which a species is confined in a given vegetation unit. The fidelity of a species determines whether it can be considered a differential or character species, or just a companion or accidental species (Bruelheide 2000)

Formation — a level in the NVC based on physiognomic grouping of vegetation units with broadly defined environmental and additional physiognomic factors in common. (FGDC 1997). Grossman et al. (1998) clarified this definition as "a level in the classification hierarchy below subgroup (see Figure 1) which represents vegetation types that share a definite physiognomy or structure within broadly defined environmental factors, relative landscape positions, or hydrologic regimes." Both of these definitions derive from Whittaker 1962: a "community type defined by dominance of a given growth form in the uppermost stratum of the community**,** or by a combination of dominant growth forms."

Frequency — percentage of observations within which a taxon occurs.

Group — the level in the classification hierarchy below subclass (see Figure 1) based on leaf characters and identified and named in conjunction with broadly defined macroclimatic types to provide a structural-geographic orientation (Grossman et al. 1998).

Growth form — the characteristic structural or functional type of plant. Growth form is usually consistent within a species, but may vary under extremes of environment (Mueller-Dombois 1974). Growth forms determine the visible structure or physiognomy of plant communities (Whittaker 1973a). As defined here life forms, constitute a subset of the characteristics that are combined as growth forms (see section 5.3).

Habitat Type — a collective term for all parts of the land surface supporting, or capable of supporting, a particular kind of climax plant association (Daubenmire 1978; Gabriel and Talbot 1984).

Indicator Species — a species whose presence, abundance, or vigor is considered to indicate certain site conditions (Gabriel and Talbot 1984); synonymous with diagnostic species.

Layer (vegetation) — a structural component of a community consisting of plants of approximately the same height stature (e.g., tree, shrub, and field layer), here synonymous with stratum. (Note that elsewhere "strata" are sometimes used to designate vertical layers of foliage with the foliage of a specific plant divided into more than one stratum, whereas as used here an individual plant always belongs exclusively to the one layer or stratum in which the majority of its leaf area occurs.)

Life form — plant type defined by the characteristic structural features and method of perennation, generally as defined by Raunkiaer (1934; see Beard 1973).

Metadata — information about data. This describes the content, quality, condition, and other characteristics of a given dataset. Its purpose is to provide information about a dataset or some larger data holdings to data catalogues, clearinghouses, and users. Metadata are intended to provide a capability for organizing and maintaining an institution's investment in data as well as to provide information for the application and interpretation of data received through a transfer from an external source (FGDC 1997). Recommended standards for ecological metadata have been proposed by Michener et al. (1997).

Occurrence Plot Records — plot records that contain data valuable for ecological and geographical characterization of vegetation, but which do not contain sufficient data to be used in quantitative description of an association or alliance (see Classification Plot Records; also Section 5.3, Appendix 1).

Order — the level in the NVC hierarchy under division, generally defined by dominant growth form(tree, shrub, herbaceous; FGDC 1997).

Physiognomy — the visible structure or outward appearance of a plant community as expressed by the dominant growth forms, such as their leaf appearance or deciduousness (Fosberg 1961; *c.f.*, structure).

Plant Community — a group of plant species living together and linked together by their effects on one another and their responses to the environment they share (modified from Whittaker 1975). Typically the plant species that co-occur in a plant community show a definite association or affinity with each other (Kent and Coker 1992).

Plot — in the context of vegetation classification, an area of defined size and shape that is intended for characterizing a homogenous occurrence of vegetation (c.f., relevé).

Potential Natural Vegetation — the vegetation that would become established if successional sequences were completed without interference by man or natural disturbance under the present climatic and edaphic conditions (Tüxen 1956; c.f., existing vegetation).

Range of Variation — the values of an attribute, such as species composition or environmental parameters, that fall within the upper and lower bounds determined for that attribute. The range of variation in the floristic composition of a vegetation type may, for example, be expressed in terms of its beta diversity (*cf.* Wilson and Shmida 1984, McCune et al. 2002), either along an environmental gradient or as the amount of compositional change in a multidimentional hyperspace.

Relevé — a record of vegetation intended for characterizing a stand of vegetation having uniform habitat and relatively homogeneous plant cover, and which is large enough in area to contain a large proportion of the species typically occurring in the plant community (Mueller-Dombois and Ellenberg 1974; c.f., plot).

Sampling Method — the means used to select the locations for plots. (Note that the act of recording a plot or relevé is often referred to as vegetation sampling, but this is really vegetation recording; the sampling component occurs in the selection of the specific plot to be recorded.)

Seral — a vegetation type (or component species) that is nonclimax; a species or community demonstrably susceptible to replacement by another species or community (Daubenmire 1978).

Sere — a continuous sequence of community types that occur in a successional sequence prior to reaching the climax type.

Site Type — a qualitative grouping or classification of sites by climate, soil, and habitat attributes, typically determined by the vegetation present at the site.

Stand — a spatially continuous unit of vegetation with uniform composition, structure, and environmental conditions. This term is often used to indicate a particular example of a plant community.

Stratum — in this document used synonymously with layer. Elsewhere it can indicate a layer of vegetation defined by the foliage between two horizontal planes.

Structure (vegetation) — the spatial pattern of growth forms in a plant community, especially with regard to their height, abundance, or coverage within the individual layers (Gabriel and Talbot 1984; see also, physiognomy). Elsewhere this term is used more generally to include all aspects of how communities are assembled.

Subclass — the level in the NVC classification hierarchy under class (see Figure 1) based on growth form characteristics (Grossman et al. 1998).

Subclimax — the stage plant succession immediately preceding the climax stage (Gabriel and Talbot 1984).

Subgroup — the level in the NVC classification hierarchy below group (see Figure 1) that separates “natural or seminatural” from “cultural” vegetation (planted or cultivated; Grossman et al. 1998).

Taxon-concept —When used with respect to taxonomic nomenclature, the combination of a taxon name along with a reference to a circumscribed taxonomic concept (as in “potential taxon” of Berendsohn (1995) or “assertion” of Pyle (2004)).

Vegetation — the collective plant cover of an area (FGDC 1997).

APPENDIX 1

Required and optimal attributes for classification and occurrence plot records. *Classification plots* provide data needed to develop and define classified vegetation types (associations and alliances). *Occurrence plots* document a less formal observation of a known association or alliance at a location. Required fields are those minimally needed to serve as either classification or occurrence plots. Optimal fields are those fields that, while not required, reflect best practices when recording plots.

For access to an ASCII file of each table as well as more detailed information, see http://www.vegbank.org.

1. Information that should be included on the form used to record plot data in the field. The attribute names derive from the attribute names in the VegBank plot archive (with the exception that underscore symbols have been added to improve readability).

1.1. Field form information about the plot record.

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Author Plot Code	Author's plot number/code, or the original plot number if taken from literature.	Required	Required

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Author Observation Code	Code or name that the author uses to identify this plot observation. Where a plot has only one observation, this code may equal Author Plot Code.	Required	Optimal
Placement Method	Description of the method used to determine the placement of a plot.	Optimal	Optimal
Observation Start Date	The date of the observation, or the first day if the observation spanned more than one day.	Required	Required
Observation Stop Date	The last day of the observation if the observation spanned more than one day.	Optimal	Optimal
Date Accuracy	Estimated accuracy of the observation date. Accuracy is often low for legacy data. See Table 3, Appendix 2 for a constrained vocabulary.	Required	Optimal

1.2. Field form information about the plot vegetation.

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Dominant Stratum	Identify the dominant stratum (of the six standard strata)	Optimal	Optimal
Growth Form 1	The predominant growth form.	Optimal	Optimal
Growth Form 2	The second-most predominant growth form.	Optimal	Optimal
Growth Form 3	The third-most predominant growth form	Optimal	Optimal
Growth Form 1 Cover	Total cover of the predominant growth form.	Optimal	Optimal
Growth Form 2 Cover	Total cover of the second-most predominant growth form.	Optimal	Optimal
Growth Form 3 Cover	Total cover of the third-most predominant growth form.	Optimal	Optimal
Basal Area	Total basal area of woody stems in m^2/ha	Optimal	Optimal
The following stratum variables are recorded once for each stratum recognized. While not strictly required, measurements of strata are a best practice. If strata are measured, the first three and last are required			

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Stratum Index	Indices used to represent stratum	Required only if strata are recorded	Optimal
Stratum Name	Name of stratum	Required only if strata are recorded	Optimal
Stratum Description	Description of stratum	Required only if strata are recorded	Optimal
Stratum Height	Average height to the top of the stratum in meters.	Optimal	Optimal
Stratum Base	Average height of the bottom of the stratum in meters.	Optimal	Optimal
Stratum Cover	Total cover of vegetation within the given stratum in percent.	Required only if strata are recorded	Optimal
The following apply for recording plant taxa, with at least one record per taxon, and multiple records when taxa are observed in multiple strata.			
Plant Name	Name of the taxon. For occurrence plots, only dominant taxa are required, whereas for classification plots a comprehensive list of taxa is required.	Required	Required
Plant Reference	Authority followed for taxon (could be entered by taxon, or collectively for the whole plot or as a default where not otherwise specified in the metadata).	Required	Required
Taxon Stratum Cover	Percent cover of taxon in stratum.	Optimal	Optimal
Taxon Cover	Overall cover of the taxon across all strata. For occurrence plots, only dominant taxa are required, whereas for classification plots a comprehensive list of taxa is required.	Required	Required
Taxon Inference Area	This is the area in square meters used to estimate the cover of a given taxon. Generally this should be equal to Taxon Observation Area, but at times this area may be larger or smaller for a specific taxon.	Required	Optimal
Taxon Basal Area	Total basal area of woody stems in m^2/ha for a given taxon, usually for	Optimal	Optimal

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
	those with a tree growth form.		
Taxon Stem Count	The number of stems of a given taxon, usually for those with a tree growth form.	Optimal	Optimal

1.3. Field form information about the plot location (some can be determined after a return to office, for example, with coordinate conversions).

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Latitude & Longitude	WGS84 Latitude and Longitude of the plot origin in degrees and decimals following any adjustments, conversions and postprocessing.	Required	Required
Type of Field Coordinates	Coordinates recorded in the field (latitude and longitude with datum, UTM with datum, or alternative geographic projection with units, longitude of center of projection, latitude of center of projection, False easting, False northing, X axis shift, & Y axis shift)	Required	Required
Location Accuracy	Estimated accuracy of the location of the plot. Plot origin has a 95% or greater probability of being within this many meters of the reported location.	Optimal	Required
Location Narrative	Text description that provides information useful for plot relocation.	Optimal	Optimal
Area	Total area of the plot in square meters. If many subplots, this area includes the subplots and the interstitial space.	Required	Optimal
Stand Size	Estimated size of the stand of vegetation in which the plot occurs.	Optimal	Optimal
USGS Quad	U.S. Geological Survey 7.5 minute quadrangle name.	Optimal	Optimal
Ecoregion	Bailey (1995) Ecoregion Section.	Optimal	Optimal
Place name Country	Country of plot location.	Optimal	Optimal
Place Name State/Prov.	State, province, or similar subnational jurisdiction.	Optimal	Optimal
Place Name Canton	County, township, parish, or similar local jurisdiction.	Optimal	Optimal

1.4. Field form information about the plot environment.

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Elevation	The elevation of the plot origin in meters above sea level.	Optimal	Optimal
Elevation Accuracy	The accuracy of the elevation in percentage of the elevation reported.	Optimal	Optimal
Slope Aspect	Representative azimuth of slope gradient (0-360 degrees; -1 if too flat to determine; -2 if too irregular to determine).	Optimal	Optimal
Slope Gradient	Representative inclination of slope in degrees; if too irregular to determine, = -1.	Optimal	Optimal
Topographic Position	Position of the plot on land surface (e.g., summit, shoulder, upper slope, middle slope, lower slope, toeslope, no slope, channel bed, dune swale, pond). See Table 19, Appendix 2 for a constrained vocabulary.	Optimal	Optimal
Landform	Landform type. See U.S. Department of Agriculture, Natural Resources Conservation Service, 2002. National Soil Survey Handbook, Part 629 Exhibit 1, Parts I.A & I.B. (Online at http://soils.usda.gov/technical/handbook/contents/part629p2.html#ex1) for a list of landform terms.	Optimal	Optimal
Geology	Surface geology type. See Table 18, Appendix 2 for a constrained vocabulary.	Optimal	Optimal
Hydrologic Regime	Hydrologic regime based on, frequency and duration of flooding) (Cowardin et al. 1979). See Table 8, Appendix 2 for a constrained vocabulary.	Optimal	Optimal
Soil Moisture Regime	Soil moisture regime, such as xeric, mesic, hygric, hydric. See Table 11, Appendix 2 for a constrained vocabulary.	Optimal	Optimal
Soil Drainage	Drainage of the site (generally consistent with USDA classes). See Table 10, Appendix 2 for a constrained vocabulary.	Optimal	Optimal

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Water Salinity	How saline is the water, if a flooded community. See Table 13, Appendix 2 for a constrained vocabulary.	Optimal	Optimal
Water Depth	For wetland, aquatic or marine vegetation, the water depth in m	Optimal	Optimal
Shore Distance	For aquatic or marine vegetation, the closest distance to shore in m	Optimal	Optimal
Soil Depth	Median depth to bedrock or permafrost in m (usually from averaging multiple probe readings).	Optimal	Optimal
Organic Depth	Depth of the surficial organic layer, where present, in centimeters.	Optimal	Optimal
Soil Cover: Percent Bedrock	Percent of surface that is exposed bedrock.	Optimal	Optimal
Soil Cover: Percent Rock & Gravel	Percent of surface that is exposed rock and gravel.	Optimal	Optimal
Soil Cover: Percent Dead Wood	Percent of surface that is wood.	Optimal	Optimal
Soil Cover: Percent Litter	Percent of surface that is litter.	Optimal	Optimal
Soil Cover: Percent Bare Soil	Percent of surface that is bare mineral soil.	Optimal	Optimal
Soil Cover: Percent Water	Percent of surface that is water.	Optimal	Optimal
Soil Taxon	Name of soil type.	Optimal	Optimal
Soil Taxon Source	Source of soil type.	Optimal	Optimal
Soil Cover: Percent Live Stems	Percent of surface that is occupied by live plant stems.	Optimal	Optimal
Soil Cover: Percent Nonvascular	Percent of surface that is occupied by nonvascular plants (moss, lichen, liverwort, algae).	Optimal	Optimal

1.5. Field form information about the plot habitat.

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Observation Narrative	Additional unstructured observations useful for understanding the ecological attributes and significance of the plot observations.	Optimal	Optimal
Landscape Narrative	Unstructured observations on the landscape context of the observed	Optimal	Optimal

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
	plot.		
Homogeneity	Homogeneity of the community (e.g., homogeneous, compositional trend across plot, conspicuous inclusions, irregular mosaic or pattern)? See Table 7, Appendix 2 for a constrained vocabulary.	Optimal	Optimal
Phenological Aspect	Season expression of the community (e.g., typical growing season, vernal, aestival, wet, autumnal, winter, dry, irregular ephemerals present). See Table 9, Appendix 2 for a constrained vocabulary.	Optimal	Optimal
Representativeness	Narrative description of how representative the plot is of the stand.	Optimal	Optimal
Stand Maturity	Assess maturity of stand (e.g., young, mature but even-aged, old-growth, etc.) See Table 12, Appendix 2 for a constrained vocabulary.	Optimal	Optimal
Successional Status	Description of the assumed successional status of the plot.	Optimal	Optimal
The following should be repeated once for each type of disturbance reported			
Disturbance Type	The type of disturbance being reported. Repeat this field as many times as necessary where there is more than one type of disturbance	Optimal	Optimal
Disturbance Intensity	Intensity or degree of disturbance. Values are: High, Medium, Low, None.	Optimal	Optimal
Disturbance Age	Estimated time in years since the disturbance event	Optimal	Optimal
Disturbance Extent	Percent of the plot that experienced the event	Optimal	Optimal
Disturbance Comment	Text description of details of the disturbance and its impact on the vegetation. Repeat this field as many times as necessary where there is more than one type of disturbance	Optimal	Optimal

2. Information that should be included as metadata.

2.1. Metadata about the original field project for which the plot record was collected.

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Project Name	Project name as defined by the principal investigator.	Optimal	Optimal
Project Description	Short description of the project including the original purpose for conducting the project. This can be viewed as the project abstract plus supporting metadata.	Optimal	Optimal
Start Date	Project start date.	Optimal	Optimal
Stop Date	Project stop date.	Optimal	Optimal

2.2. Metadata about the plot and the plot observation.

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Layout Narrative	Text description of and the rationale for the layout of the plot.	Optimal	Optimal
Method Narrative	Additional metadata helpful for understanding how the data were collected during the observation event.	Optimal	Optimal
Plot Type	Indicate if information is recorded from the entire plot or from subplots. If from subplots indicate how the subplots were configured: contiguous, regular, random, or haphazard (see Appendix 2, Table 2).	Required	Optimal
Taxon Observation Area	The total surface area (in square meters) used for cover estimates and for which a complete species list is provided. If subplots were used, this would be the total area of the subplots without interstitial space.	Required	Optimal
Cover Dispersion	Indication of how cover values for the total taxon list were collected; i.e., from one contiguous area or dispersed subplots (e.g., contiguous, dispersed-regular, dispersed-random)?	Required	Optimal
Original Data	Location where the hard data reside and any access instructions.	Optimal	Optimal
Effort Level	Effort spent making the observations as estimated by the party that submitted the data. Values are: very	Optimal	Optimal

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
	thorough; accurate; hurried or incomplete.		
Quality of the Floristic Observation	Subjective assessment of the quality of taxonomic resolution made by the party that submitted the plot. For example, what percent of all taxa were identified to species level; how thorough was the search? See Table 21, Appendix 2 for values and their definitions.	Optimal	Optimal
Quality of the Bryophyte Observation	Subjective estimate of the quality of taxonomic resolution made by the party that submitted the plot. See Table 21 of Appendix 2 for values and their definitions. .	Optimal	Optimal
Quality of the Lichen Observation	Subjective estimate of the quality of taxonomic resolution made by the party that submitted the plot. See Table 21 of Appendix 2 for values and their definitions.	Optimal	Optimal
Vouchers Collected	Indicate if voucher specimens were collected and, if so, where they were deposited	Optimal	Optimal

2.3. Metadata about the methods used to collect the field data. If you used a standard stratum method, it should be identified here. Vertical strata used for recording taxon cover must be defined in terms of their upper and lower limits with this information reported in table 1.2. Cover class scales must be defined in terms of their minimum, maximum, and representative cover in percent. You may either use an established, named cover scale which you report in field 3, or you document a new scale through repeated entries in fields 4-8.

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Stratum Method Name	Name of the stratum method. Any appropriate label (e.g., NVC, Braun-Blanquet, NatureServe, North Carolina Vegetation Survey #1, etc..).	Required only if strata are recorded	Optimal
Stratum Method Description	This field describes the general methods used for strata.	Required only if strata are recorded	Optimal
Cover Type	Name of the cover class method (e.g., Braun-Blanquet, Barkman, Domin, Daubenmire, North Carolina	Required	Optimal

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
	Vegetation Survey, etc.).		
Cover Code	The name or label used in the cover class scale for this specific cover class.	Required	Optimal
Cover Code Upper Limit	Upper limit, in percent, associated with the specific cover code.	Required	Optimal
Cover Code Lower Limit	This is the lower limit, in percent, associated with a specific Cover Code.	Required	Optimal
Cover Percent	A middle value (usually mean or geometric mean) between the Upper Limit and Lower Limit stored by the database for each taxon observation and used for all cover class conversions and interpretations. This is assigned by the author of the cover class schema.	Optimal	Optimal
Index Description	Description of the specific cover class. This is particularly helpful in the case that there is no numeric value that can be applied.	Optimal	Optimal

2.4. Metadata about the human sources of the field data.

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Given Name	One's first name.	Required	Required
Middle Name	One's middle name or initial, if any.	Optimal	Optimal
Surname	Name shared in common to identify the members of a family, as distinguished from each member's given name.	Required	Required
Organization Name	Name of an organization.	Optimal	Optimal
Current Name	Recursive foreign key to current name of this party.	Optimal	Optimal
Email	email address	Optimal	Optimal
Address Start Date	The first date on which the address/organization information was applied.	Required	Required
Delivery Point	Address line for the location (street name, box number, suite).	Optimal	Optimal
City	City of the location.	Optimal	Optimal
Administrative Area	State, province of the location.	Optimal	Optimal
Postal Code	Zip code or other postal code.	Optimal	Optimal

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Country	Country of the physical address.	Optimal	Optimal
The following can be repeated an indefinite number of times per person			
Role: Plot submitter	Name of the person submitting the analysis.	Required	Required
Role: Plot Primary Field Observer	Name of the person who made the field observation (e.g., PI, technician, volunteer, etc.).	Required	Required
Role: Plot Author	Name of the author of the plot record.	Required	Required
Role: Project PI	Name of the field plot inventory project's principal investigator.	Optimal	Optimal
Role: Other	Report other roles as appropriate.	Optimal	Optimal

2.5 Metadata about references for other sources of plot data. These fields are used when plot observations are taken from published literature sources.

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Authors	Name of authors if plot record is taken from published work.	Required	Required
Title	Title of publication, if plot record is taken from published work.	Required	Required
Publication Date	Date of publication, if plot record is taken from published work.	Required	Required
Edition	Edition of publication if applicable, and if plot record is taken from published work.	Required	Required
Series Name	Name of publication series, if applicable, and if plot record is taken from published work.	Required	Required
Page	Page number of publication, if plot record is taken from published work.	Required	Required
Table Cited	Table number or code, if applicable and if plot record is taken from published work.	Required	Required
Plot Cited	Original plot name, if plot record is taken from published work.	Required	Required
ISBN	International Standard Book Number (ISBN), if applicable, and if plot record is taken from published book.	Optimal	Optimal
ISSN	International Standard Serial Number, if applicable.	Optimal	Optimal

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Short Name	Provides a concise or abbreviated name that describes the resource that is being documented.	Optimal	Optimal
Citation Type	Describes the type of reference this generic type is being used to represent. Examples: book, journal article, webpage.	Required	Required
Title	The formal title given to the work by its author or publisher.	Required	Required
Title Superior	A second, higher order title where appropriate, which in the case of a reference to a chapter is the Book title, and in the case of a Conference Presentation is the Name of the Conference.	Optimal	Optimal
Pub Date	Represents the date that the reference was published.	Required	Required
Access Date	The date the reference being referenced was accessed. This is useful if the reference is could be changed after formal publication, such as websites or databases.	Required	Required
Conference Date	The date the conference was held.	Required	Required
Volume	The volume of the journal in which the article appears.	Required	Required
Issue	The issue of the journal in which the article appears.	Required	Required
Page Range	The beginning and ending pages of the journal article that is being documented.	Required	Required
Total Pages	The total number of pages in the book that is being described.	Required	Required
Publisher	The organization that physically put together the report and publishes it.	Required	Required
Publication Place	The location at which the work was published. This is usually the name of the city in which the publishing house produced the work.	Required	Required
ISBN	The ISBN, or International Standard Book Number assigned to this literature reference.	Required	Required
Edition	The edition of the generic reference type that is being described.	Required	Required

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Number Of Volumes	Number of volumes in a collection	Required	Required
Chapter Number	The chapter number of the chapter of a book that is being described.	Required	Required
Report Number	The unique identification number that has been issued by the report institution for the report being described.	Required	Required
Communication Type	The type of personal communication. Could be an email, letter, memo, transcript of conversation either hardcopy or online.	Optimal	Optimal
Degree	The name or degree level for which the thesis was completed.	Optimal	Optimal
URL	A URL (Uniform Resource Locator) from which this reference can be downloaded or additional information can be obtained.	Optimal	Optimal
DOI	A Digital Object Identifier - a digital identifier for any object of intellectual property. A DOI provides a means of persistently identifying a piece of intellectual property on a digital network and associating it with related current data.	Optimal	Optimal
Additional Info	Any information that is not characterized by the other reference metadata fields. Example: Copyright 2001, Robert Warner	Optimal	Optimal
Journal	The name of the publication in which the article was published. Example(s): Ecology, New York Times, Harper's, Canadian Journal of Botany/Revue Canadienne de Botanique, The Journal of the American Medical Association	Required	Required
ISSN	The ISSN, or International Standard Serial Number assigned to this literature reference. Example(s): ISSN 1234-5679	Required	Required
Abbreviation	Standard abbreviation or shorter name of the journal. Example(s): Can. J. Bot./Rev. Can. Bot., JAMA	Optimal	Optimal
The following can be repeated an indefinite number of times for each alternate identifier			

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
used to describe the reference.			
System	The data management system within which a plot identifier is found. This is typically a URL (Uniform Resource Locator) that indicates a data management system. All identifiers that share a system must be unique. In other words, if the same identifier is used in two locations with identical systems, then by definition the objects at which they point are in fact the same object. Example: http://metacat.somewhere.org/svc/mc/	Optimal	Optimal
Identifier	An additional, secondary identifier for this reference. The primary identifier belongs in the reference table, but additional identifiers that are used to label this reference, possibly from different data management systems, can be listed here. Example: VCR3465	Optimal	Optimal
The following can be repeated an indefinite number of times for each contributor to the reference (e.g. author, editor).			
Role Type	The role the party played with respect to the reference contribution. Some potential roles include technician, reviewer, principal investigator, and many others.	Required	Required
Order	Numerical order in which this contributor's name should be in the order of contributors, if applicable. Examples: 1 [for the first author], 2, [for the second author], etc.	Required	Required
Type	The type of Party that a given record refers to, usually a person or institution.	Required	Required
Position Name	This field is intended to be used to indicate the position occupied by a person within an institution. Position Name is needed for consistency in cases where the associated person that	Optimal	Optimal

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
	holds the role changes frequently.		
Salutation	The salutation field is used in addressing an individual with a particular title, such as Dr., Ms., Mrs., Mr., etc.	Optimal	Optimal
Given Name	The given name field is used for all names except the surname of the individual. Examples: Jo, Jo R., Jo R.W., John Robert Peter	Required	Required
Surname	The surname field is used for the last name of the individual.	Required	Required
Suffix	A suffix or suffix abbreviation that follows a name. Examples: Jr., Senior, III, etc.	Optimal	Optimal
Organization Name	The full name of the organization that is associated with the reference contribution. This field is intended to describe which institution or overall organization is associated with the resource being described.	Optimal	Optimal
Current Party	A link to the record of the current name of the party, if different from the name used in this record.	Optimal	Optimal

2.6. Metadata about plot record confidentiality and links to publications and sources.

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Confidentiality Status	Are the data to be considered confidential? 0=no, 1= 1km radius, 2=10km radius, 3=100km radius, 4=location embargo, 5=public embargo on all plot data, 6=full embargo on all plot data.	Optimal	Optimal
Confidentiality Reason	The reason for confidentiality. This field should not be open to public view. Reasons might include specific rare species, ownership, prepublication embargo, or many other reasons.	Optimal	Optimal

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Classification Publication ID	Link to a publication wherein the observation was classified.	Optimal	Optimal
Community Authority ID	Link to the reference from which information on the community concept was obtained during the classification event.	Optimal	Optimal

3. Information that should be included about each assignment of a field plot to a vegetation type in the NVC, or other party-specific classification. Assignment, per se, of a plot to a classification type is not required.

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
Classification Start Date	Start date for the application of a vegetation class to a plot observation by one or more parties.	Required	Required
Inspection	Was the classification informed by simple inspection of data (Yes/No)?	Optimal	Optimal
Table Analysis	Was the classification informed by inspection of floristic composition tables (Yes/No)?	Optimal	Optimal
Multivariate Analysis	Was the classification informed by use of multivariate numerical tools (Yes/No)?	Optimal	Optimal
Expert System	Was the classification informed by use of automated expert system (Yes/No)?	Optimal	Optimal
Classifier	Name of person who classified the plot – this should link to a person included in the human resources metadata table.	Required	Required
Interpretation Date	The date that the interpretation was made.	Required if known	Required
Interpretation Type	Categories for the interpretation (e.g., author, computer-generated, simplified for comparative analysis, correction, finer resolution).	Required if known	Required
Original Interpretation	Does this interpretation correspond to the original interpretation of the plot author, as best as can be determined. There is no requirement that the authority match the authority of the author; only that the concepts are	Required if known	Required

Attribute Name	Attribute Definition	Classification Plots	Occurrence Plots
	synonymous.		
Current Interpretation	This interpretation is the most accurate and precise interpretation currently available.	Required if known	Required
The following may be repeated for each community type associated with a plot during a classification event			
Community Name	Name of the community	Required if known	Required
Community Reference	Reference wherein the above name is defined	Required if known	Required
Classification Fit	Indicates the degree of fit with the community concept being assigned (e.g., fits concept well, fits but not typal, possible fit, just outside concept). See Table 23 of Appendix 2 for standard classification fit categories and codes.	Optimal	Optimal
Classification Confidence	Indicates the degree of confidence of the interpreter (s) in the interpretation made. This can reflect the level of familiarity with the classification or the sufficiency of information about the plot (e.g., high, moderate, low).	Optimal	Optimal

APPENDIX 2

Recommended Constrained Vocabularies. The following lists are vocabularies that should be used when recording plot information that describes a condition of the following subjects. These standardized vocabularies are used in database "picklists" and greatly facilitate standardized data types and information exchange.

<u>Table Index</u>

Appendix 2, Table 1.

Disturbance Types
Avalanche and snow
Cryoturbation
Cultivation
Erosion
Fire suppression
Fire, canopy
Fire, ground
Fire, general
Flood
Grazing, domestic stock
Grazing, native ungulates
Herbicide or chemical
Herbivory, vertebrates
Hydrologic alteration
Ice
Invertebrate caused
Mass land movement (landslides)
Mowing
Other disturbance
Plant disease
Roads and vehicular traffic
Salt spray
Tidal
Timber harvest, general
Timber harvest, clearcut
Timber harvest, selective
Trampling and trails
Wind, chronic
Wind event

Appendix 2, Table 2

Plot Observation Types	Descriptions of Plot Observation Types
Entire	Cover based on observation of an entire plot consisting of a single contiguous area of land.
Subplot-contiguous	Cover based on observation of a single contiguous area of land of less spatial extent than the entire plot.
Subplot-regular	Cover based on observation of multiple subplots arranged in a regular pattern within the overall plot.
Subplot-random	Cover based on observation of multiple randomly dispersed within the overall plot.
Subplot-haphazard	Cover based on observation of multiple subplots haphazardly arranged within the overall plot.

Appendix 2, Table 3

Accuracy of Time of Day	Descriptions of Time of Day Accuracy Categories
One minute	Time of day is accurate to within one minute
One hour	Time of day is accurate to within one hour
Quarter-day	Time of day is accurate to within one quarter-day (e.g., during morning, during afternoon)
Half day	Time of day is accurate to within one half-day (e.g., between 00:00 and 11:59, or between 12:00 and 23:59)

Appendix 2, Table 4

Accuracy of Date	Descriptions of Date Accuracy Categories
One day	Date accurate to within one day
One week	Date accurate to within one week
One month	Date accurate to within one month
Three months	Date accurate to within three months
One year	Date accurate to within one year
Three years	Date accurate to within three years
Ten years	Date accurate to within then years
Greater than ten years	Date accurate to within more than ten years

Appendix 2, Table 5 NOTE: Vegetation strata are not to be confused with life forms.

Vegetation Stratum Types	Descriptions of Vegetation Stratum Types
Tree	Includes tall trees (single-stemmed woody plants, generally more than 5 m in height or greater at maturity under optimal growing conditions). Very tall shrubs with tree-like form may also be included here, as may other life forms, such as lianas and epiphytes, and their contribution to the stratum can be further specified using the "life form" field.
Shrub	Includes shrubs (multiple-stemmed woody plants, generally less than 5 m in height at maturity under optimal growing conditions) and by shorter trees (saplings). As with the tree stratum, other life forms present in this stratum may also be included (however, herbaceous life forms should be excluded, as their stems often die back annually and do not have as consistent a height as woody life forms). Where dwarf-shrubs (i.e. shrubs < 0.5 m) form a distinct stratum (either as part of a series of strata, as in a forest, or as the top stratum of more open vegetation, such as tundra or xeric shrublands), they should be treated as a low version of the shrub stratum (or short shrub substratum). In many vegetation types, dwarf-shrubs may simply occur as one life form component of the herb stratum (see below).
Herb	Also referred to as field stratum. Includes herbs (plants without woody stems and often dying back annually), often in association with low creeping semi-shrubs, dwarf-shrubs, vines, and non-woody brambles (such as raspberries), as well as tree or shrub seedlings.
Moss	Also referred to as nonvascular, bryoid, or ground stratum. Defined entirely by mosses, lichens, liverworts, and alga. Ground-creeping vines, prostrate shrubs and herbs should be treated in the herb stratum. Where herbs are entirely absent, it is still possible to recognize this stratum if other very low woody or semi-woody life forms are present.
Floating	Includes rooted or drifting plants that float on the water surface (e.g., duckweed, water-lily).
Submerged	Includes rooted or drifting plants that by-and-large remain submerged in the water column or on the aquatic bottom (e.g., pondweed). The focus is on the overall strata arrangement of these aquatic plants. Note that emergent plants life forms in a wetland should be placed in the strata listed above (e.g., cattail or sedges would be placed in the herb stratum, whereas the duckweed would be in the floating aquatic stratum).

Appendix 2, Table 6

Growth Form Types
Alga
Aquatic herb
Bamboo
Broad-leaved deciduous shrub
Broad-leaved deciduous tree
Broad-leaved evergreen shrub
Broad-leaved evergreen tree
Bryophyte
Dwarf-shrub
Epiphyte
Evergreen sclerophyllous shrub
Evergreen sclerophyllous tree
Fern or fern allie
Forb
Graminoid
Lichen
Needle-leaved shrub
Needle-leaved tree
Palm shrub
Palm tree
Semi-shrub
Succulent forb
Succulent shrub
Succulent tree
Thorn shrub
Thorn tree
Tree fern
Vine/Liana (woody climbers or vines)

Appendix 2, Table 7

Homogeneity of Plot
Homogeneous
Compositional trend across plot
Conspicuous inclusions
Irregular or pattern mosaic

Appendix 2, Table 8

Hydrologic Regime of Plot
Semipermanently flooded
Seasonally flooded
Saturated
Seasonally saturated
Temporarily flooded
Intermittently flooded
Permanently flooded
Permanently flooded - tidal
Tidally flooded
Wind-tidally flooded
Irregularly flooded
Irregularly exposed
Upland
Unknown

Appendix 2, Table 9

Phenologic Aspect of Plot
Typical growing season
Vernal
Early wet season
Aestival
Wet season
Autumnal
Late wet season
Winter
Dry season
Irregular ephemeral phase

Appendix 2, Table 10

Soil Drainage of Plot
Excessively drained
Somewhat excessively drained
Well drained
Moderately well drained
Somewhat poorly drained
Poorly drained
Very poorly drained

Appendix 2, Table 11

Soil Moisture Regime of Plot
Very xeric
Xeric
Subxeric
Submesic
Mesic
Subhygric
Hygric
Subhydric
Hydric

Appendix 2, Table 12

Stand Maturity
Young, regenerative
Even-age, aggrading
Mature, even-age
Transition, breakup
Old growth or senescent, all-age
Uneven-age

Appendix 2, Table 13

Water Salinity	Description of Water Salinity
Saltwater	greater than 30 ppt
Brackish	0.5 to 30 ppt
Freshwater	less than 0.5 ppt

Appendix 2, Table 14

Rock Types. For definitions of these terms see Jackson 1997, or USDA, NRCS 2002.		
\`a\`a lava	hornfels	quartz-diorite
amphibolite	igneous, unspecified	quartz-monzonite
andesite	ignimbrite	quartzite
anorthosite	iron-manganese concretions	rhyolite
arenite	iron-manganese nodules	sandstone, calcareous
argillite	ironstone nodules	sandstone, glauconitic
arkose	lapilli	sandstone, unspecified
basalt	latite	schist, mica
block lava	limestone, arenaceous	schist, unspecified
breccia, non-volcanic	limestone, argillaceous	scoria
breccia, non-volcanic, acidic	limestone, cherty	sedimentary, unspecified
breccia, non-volcanic, basic	limestone, phosphatic	serpentinite
calcrete (caliche)	limestone, unspecified	shale, acid
carbonate concretions	marble	shale, calcareous
carbonate nodules	metaconglomerate	shale, clayey
carbonate rock, unspecified	metamorphic, foliated	shale, unspecified
chalk	metamorphic, unspecified	shell fragments
charcoal	metaquartzite	silica concretions
chert	metasedimentary, unspecified	siltstone, calcareous
cinders	metavolcanics	siltstone, unspecified
claystone	migmatite	slate
coal	mixed	soapstone
conglomerate, calcareous	monzonite	syenite
conglomerate, unspecified	mudstone	syenodiorite
dacite	mylonite	tachylite
diabase	obsidian	tonalite
diorite	orthoquartzite	trachyte
dolomite (dolostone)	ortstein fragments	travertine
durinodes	pahoehoe lava	tufa
duripan fragments	peridotite	tuff breccia
gabbro	petrocalcic fragments	tuff, acidic
gibbsite concretions	petroferric fragments	tuff, basic
gibbsite nodules	petrogypsic fragments	tuff, unspecified
gneiss	phyllite	tuff, welded
granite	pillow lava	ultramafic, unspecified
granodiorite	plinthite nodules	volcanic bombs
granofels	porcellanite	volcanic breccia, acidic
granulite	pumice	volcanic breccia, basic
graywacke	pyroclastic (consolidated)	volcanic breccia, unspecified
greenstone	pyroxenite	volcanic, unspecified
gypsum	quartz	wood

Appendix 2, Table 15

Placement Method of Plot
Regular
Random
Stratified random
Transect component
Representative
Capture specific feature

Appendix 2, Table 16

Plot Shape
Rectangular
Square
Circle
Transect/Strip
Plotless
Diffuse
Other

Appendix 2, Table 17

Stand Size	Descriptions of Stand Sizes
Very Extensive	greater than 1000x plot size
Extensive	greater than 100x plot size
Large	10-100x plot size
Small	3-10x plot size
Very small	1-3x plot size
Inclusion	less than 1x plot size

Appendix 2, Table 18

Surficial Geologic Material
Residual Material: Bedrock
Residual Material: Disintegrated Rock
Residual Material: Deeply Weathered Rock
Glacial Deposits: Undifferentiated glacial deposit
Glacial Deposits: Till
Glacial Deposits: Moraine
Glacial Deposits: Bedrock and till
Glacial Deposits: Glacial-fluvial deposits (outwash)
Glacial Deposits: Deltaic deposits
Alluvial Deposits: Floodplain
Alluvial Deposits: Alluvial Fan
Alluvial Deposits: Deltas
Marine and Lacustrine Deposits: Unconsolidated Sediments
Marine and Lacustrine Deposits: Coarse sediments
Marine and Lacustrine Deposits: Fine-grained sediments
Organic Deposits: Peat
Organic Deposits: Muck
Slope and Modified Deposits: Talus and scree slopes
Slope and Modified Deposits: Colluvial
Slope and Modified Deposits: Solifluction, landslide
Aeolian Deposits: Dunes
Aeolian Deposits: Aeolian sand flats and cover sands
Aeolian Deposits: Loess deposits
Aeolian Deposits: Volcanic Ash
Chemical Deposits: Evaporites and Precipitates
Other
Variable

Appendix 2, Table 19

Topographic Position	Descriptions of Topographic Positions
Interfluve	crest, summit, ridge
High slope	shoulder slope, upper slope, convex creep slope
High level	mesa, high flat
Midslope	transportational midslope, middle slope
Backslope	dipslope
Step in slope	ledge, terracette
Lowslope	lower slope, foot slope, colluvial footslope
Toeslope	alluvial toeslope
Low level	terrace, low flat
Channel wall	bank
Channel bed	narrow valley bottom, gully arroyo
Basin floor	depression

Appendix 2, Table 20

Soil Texture	Descriptors of Soils Texture Terms			
	General Descriptor	Texture Group	Texture Class	Texture Subclass
Sand	coarse-textured	Sandy soils	Sands	Sand
Coarse Sand	coarse-textured	Sandy soils	Sands	Coarse Sand
Fine Sand	coarse-textured	Sandy soils	Sands	Fine Sand
Very Fine Sand	coarse-textured	Sandy soils	Sands	Very Fine Sand
Unspecified Sand	coarse-textured	Sandy soils	Sands	unspecified
Loamy Coarse Sand	coarse-textured	Sandy soils	Loamy Sands	Loamy Coarse Sand
Loamy Sand	coarse-textured	Sandy soils	Loamy Sands	Loamy Sand
Loamy Fine Sand	coarse-textured	Sandy soils	Loamy Sands	Loamy Fine Sand
Loamy Very Fine Sand	coarse-textured	Sandy soils	Loamy Sands	Loamy Very Fine Sand
Unspecified Loamy Sands	coarse-textured	Sandy soils	Loamy Sands	unspecified
Loam	medium-textured	Loamy soils	Loam	Loam
Coarse Sandy Loam	moderately coarse-textured	Loamy soils	Sandy Loams	Coarse Sandy Loam
Sandy Loam	moderately coarse-textured	Loamy soils	Sandy Loams	Sandy Loam
Fine Sandy Loam	moderately coarse-textured	Loamy soils	Sandy Loams	Fine Sandy Loam
Very Fine Sandy Loam	medium-textured	Loamy soils	Sandy Loams	Very Fine Sandy Loam
Unspecified Sandy Loams	moderately coarse-textured to medium-textured	Loamy soils	Sandy Loams	unspecified
Silt Loam	medium-textured	Loamy soils	Silt Loam	Silt Loam
Silt	medium-textured	Loamy soils	Silt	Silt
Sandy Clay Loam	moderately fine-textured	Loamy soils	Sandy Clay Loam	Sandy Clay Loam
Clay Loam	moderately fine-textured	Loamy soils	Clay Loam	Clay Loam
Silty Clay Loam	moderately fine-textured	Loamy soils	Silty Clay Loam	Silty Clay Loam
Sandy Clay	fine-textured	Clayey soils	Sandy Clay	Sandy Clay
Silty Clay	fine-textured	Clayey soils	Silty Clay	Silty Clay
Clay	fine-textured	Clayey soils	Clay	Clay

Appendix 2, Table 21

Quality of the Floristic Observation	Descriptions of Quality of Floristic Observation Values
Highest	At least 95% of all taxa were identified to species level; search was thorough.
High	Between 85% and 95% of all taxa were identified to species level; search was thorough.
High but Incomplete	At least 85% of all taxa were identified to species level; search was not so thorough.
Moderate	Between 70% and 85% of all taxa were identified to species level; search was thorough.
Moderate but Incomplete	Between 70% and 85% of all taxa were identified to species level; search was not so thorough.
Low	Less than 70% of all taxa were identified to species level.

Appendix 2, Table 22.

Confidentiality Codes	Descriptions of Confidentiality Codes
1	Not confidential
2	Confidential, locality generalized to 1 km radius
3	Confidential, locality generalized to 10 km radius
4	Confidential, locality generalized to 100 km radius
5	Confidential, locality embargoed entirely
6	Confidential, all plot data embargoed

Appendix 2, Table 23.

Classification Fit Codes	Descriptions of Classification Fit Codes
1	Plot fits concept well
2	Plot fits, but is not typal.
3	Plot possibly fits the type.
4	Plot is just outside the concept of the type.

APPENDIX 3

An example of the description of a floristic association.

OVERVIEW:

Names:

Name: Sporobolus heterolepis - Schizachyrium scoparium - (Carex scirpoidea) / (Juniperus horizontalis) Herbaceous Association.

Name, translated: Prairie Dropseed - Little Bluestem - (Scirpus-like Sedge) / (Creeping Juniper) Herbaceous Vegetation

Common Name: Little Bluestem Alvar Grassland

Identifier: CEGL005234

Unit: ASSOCIATION

Placement in Hierarchy:

CLASS: V. Herbaceous

FORMATION: V.A.5.N.c. Medium-tall sod temperate or subpolar grassland

ALLIANCE: V.A.5.N.c.41 SPOROBOLUS HETEROLEPIS - (DESCHAMPSIA CAESPITOSA, SCHIZACHYRIUM SCOPARIUM) HERBACEOUS ALLIANCE

Summary: The little bluestem alvar grassland type is found primarily in the upper Great Lakes region of the United States and Canada, in northern Michigan and southern Ontario. These grasslands occur on very shallow, patchy soils (usually less than 20 cm deep, averaging about 6 cm deep) on flat alkaline limestone and dolostone outcrops (pavements). This community often has a characteristic soil moisture regime of alternating wet and dry periods. The vegetation is dominated by grasses and sedges, which tyically have at least 45% cover. Characteristic species of the grassland are *Sporobolus heterolepis, Schizachyrium scoparium, Juniperus horizontalis, Carex scirpoidea, Deschampsia caespitosa, Packera paupercula (= Senecio pauperculus)*, and *Carex crawei*. There is usually less than 10% cover of shrubs over 0.5 m tall; however there may be as much as 50% cover of dwarf-shrubs (under 0.5 m tall) especially *Juniperus horizontalis*. Less than 50% of the ground surface is exposed bedrock (including bedrock covered with nonvascular plants: lichens, mosses, algae).

Classification Comments: The most commonly associated alvar communities that occur with this community in a landscape mosaic are *Juniperus horizontalis - Dasiphora fruticosa ssp. floribunda / Schizachyrium scoparium - Carex richardsonii* Dwarf-shrubland (Creeping Juniper - Shrubby-cinquefoil Alvar Pavement Shrubland; CEGL005236), *Deschampsia caespitosa - (Sporobolus heterolepis, Schizachyrium scoparium) - Carex crawei - Packera paupercula* Herbaceous Vegetation (Tufted Hairgrass Wet Alvar Grassland;CEGL005110), *Tortella tortuosa - Cladonia pocillum - Placynthium* spp. Sparse Vegetation (Alvar Nonvascular Pavement;CEGL005192) and, *Thuja occidentalis - Pinus banksiana / Dasiphora fruticosa ssp. floribunda / Clinopodium arkansanum* Wooded Herbaceous Vegetation (White-cedar - Jack Pine / Shrubby-cinquefoil Alvar Savanna; CEGL005132) (Reschke et al. 1998).

Rational for nominal species: *Sporobolus heterolepis* and *Schizachyrium scoparium* are dominants. *Carex scirpoidea* and *Juniperus horizontalis* are constants (>60% constancy) in the type. *Sporobolus heterolepis*, *Carex scirpoidea* and *Deschampsia cespitosa* are differential species.

VEGETATION:

Physiognomy and structure: The vegetation is dominated by grasses and sedges, which usually have at least 45% cover. There is usually less than 10% cover of shrubs over 0.5 m tall; however there may be as much as 50% cover of dwarf-shrubs (under 0.5 m tall) especially *Juniperus horizontalis*. This dwarf-shrub is shorter than the dominant grasses, and usually is found under the canopy of grasses, so the physiognomic type here is considered a grassland (in spite of relatively high cover of dwarf-shrubs). Less than 50% of the ground surface is exposed bedrock (including bedrock covered with nonvascular plants: lichens, mosses, algae).

Table 1. Physiognomy of the Sporobolus heterolepis - Schizachyrium scoparium - (Carex scirpoidea) / (Juniperus horizontalis) Herbaceous Association; Little Bluestem Alvar Grassland, NVC identifier code CEGL005234.

Physiognomy	Average Cover	Range of Cover
Tree Cover (> 5m)	1.0	0 - 15
Tree Height (m)	0.5	0 - 9
Tall Shrub Cover (2-5 m)	0.5	0 - 3

Table 1. Physiognomy of the Sporobolus heterolepis - Schizachyrium scoparium - (Carex scirpoidea) / (Juniperus horizontalis) Herbaceous Association; Little Bluestem Alvar Grassland, NVC identifier code CEGL005234.

Physiognomy	Average Cover	Range of Cover
Tall Shrub Height (m)	0.5	0 - 3
Short Shrub Cover (0.5-2 m)	11.0	0 - 33
Short Shrub Height (m)	1.0	0 - 1.8
Vine Cover	0.0	0 - 0
Vine Height	0.0	0 - 0
Herb Cover	46.0	4 - 99
Herb Height	0.3	0-1
Nonvascular Cover	34.0	0 - 90

Floristics: Characteristic species of the grassland are *Sporobolus heterolepis, Schizachyrium scoparium, Juniperus horizontalis, Carex scirpoidea, Deschampsia caespitosa, Packera paupercula (= Senecio pauperculus)*, and *Carex crawei*. *Juniperus horizontalis* may co-dominate in some stands.

Table 2: Floristic table of the Sporobolus heterolepis - Schizachyrium scoparium - (Carex scirpoidea) / (Juniperus horizontalis) Herbaceous Association; Little Bluestem Alvar Grassland, NVC identifier code CEGL005234. For species in > 10% of stands for a total of 17 field plots. Species nomenclature is according to Gleason and Cronquist (1991).

Species by Layer	Constancy	Avg. Cover	Range of Cover, Where Present *
SHORT SHRUB LAYER (0.5-2 m)			
Juniperus communis	24	0.1	0.3 - 2
Juniperus horizontalis	71	8.0	1 - 33
Prunus pumila	29	0.5	0.3 - 4
Thuja occidentalis	12	0.1	0.3 - 0.3
HERB LAYER			
Achillea millefolium	12	0.1	0.3 - 0.3
Agropyron trachycaulum	24	0.1	0.3 - 0.3
Ambrosia artemisiifolia	18	0.1	0.3 - 0.3
Antennaria spp.	24	0.1	0.3 - 0.3
Aquilegia canadensis	18	0.1	0.3 - 0.3
Arenaria stricta	29	0.1	0.3 - 1
Aster ciliolatus	12	0.1	0.3 - 0.3
Aster laevis	47	0.5	0.3 - 2
Bromus kalmii	18	0.1	0.3 - 2
Calamagrostis canadensis	12	0.1	1 - 2
Calamintha arkansana	59	1.0	0.3 - 5

Table 2: Floristic table of the Sporobolus heterolepis - Schizachyrium scoparium - (Carex scirpoidea) / (Juniperus horizontalis) Herbaceous Association; Little Bluestem Alvar Grassland, NVC identifier code CEGL005234. For species in > 10% of stands for a total of 17 field plots. Species nomenclature is according to Gleason and Cronquist (1991).

Species by Layer	Constancy	Avg. Cover	Range of Cover, Where Present *
Campanula rotundifolia	65	0.5	0.3 - 1
Carex aurea	12	0.1	0.3 - 0.3
Carex crawei	24	2.0	0.3 - 18
Carex eburnea	24	0.5	0.3 - 4
Carex granularis	12	0.1	0.3 - 1
Carex richardsonii	12	0.1	1 - 3
Carex scirpoidea	71	4.0	0.3 - 23
Carex viridula	41	0.5	0.3 - 2
Castilleja coccinea	29	0.1	0.3 - 1
Cladium mariscoides	12	0.5	1 - 5
Comandra umbellata	53	0.1	0.3 - 1
Danthonia spicata	53	1.0	0.3 - 5
Deschampsia cespitosa	47	1.0	0.3 - 5
Eleocharis compressa	29	0.5	0.3 - 3
Eleocharis elliptica	12	0.5	0.3 - 5
Fragaria virginiana	29	0.1	0.3 - 1
Geum triflorum	18	0.1	0.3 - 0.3
Hedyotis longifolia	18	0.5	0.3 - 5
Hypericum kalmianum	41	0.1	0.3 - 0.3
Hypericum perforatum	29	0.1	0.3 - 0.3
Muhlenbergia glomerata	12	0.1	1 - 2
Panicum spp.	35	1.0	0.3 - 5
Poa compressa	47	5.0	0.3 - 55
Polygala senega	12	0.1	0.3 - 1
Potentilla fruticosa	71	2.0	0.3 - 8
Prunella vulgaris	24	0.1	0.3 - 0.3
Rhamnus alnifolia	12	0.1	0.3 - 2
Rhus aromatica	18	0.2	0.3 - 3
Saxifraga virginiensis	12	0.1	0.3 - 0.3
Schizachyrium scoparium	71	8.0	0.3 - 38
Scirpus cespitosus	12	2.0	1 - 25
Senecio pauperculus	88	2.0	0.3 - 23
Sisyrinchium mucronatum	18	0.1	0.3 - 1
Solidago juncea	12	0.1	0.3 - 0.3
Solidago ohioensis	12	1.0	0.3 - 16
Solidago ptarmicoides	76	0.5	0.3 - 3
Solidago spp.	18	0.1	0.3 - 0.3
Sporobolus heterolepis	53	12.0	0.3 - 76
Sporobolus neglectus/vaginiflorus	24	2.0	0.3 - 25

Table 2: Floristic table of the Sporobolus heterolepis - Schizachyrium scoparium - (Carex scirpoidea) / (Juniperus horizontalis) Herbaceous Association; Little Bluestem Alvar Grassland, NVC identifier code CEGL005234. For species in > 10% of stands for a total of 17 field plots. Species nomenclature is according to Gleason and Cronquist (1991).

Species by Layer	Constancy	Avg. Cover	Range of Cover, Where Present *
Zigadenus elegans var. glaucus	29	0.1	0.3 - 2
MOSS LAYER			
Gloeocapsa /rock surface algae	47	12.0	5 - 60
Nostoc commune	41	2.0	0.3 - 18
Trentepohlia spp	29	0.1	0.3 - 0.3
Ditrichum flexicaule	24	0.1	0.3 - 3
Pseudocalliergon turgescens	18	1.0	0.3 - 15
Schistidium rivulare	24	0.5	0.3 - 10
Tortella spp.	41	3.0	0.3 - 29
Tortella tortuosa	12	0.5	0.3 - 10
Cladina rangiferina	18	0.1	0.3 - 0.3
Cladina spp.	12	0.1	0.3 - 0.3
Cladonia pyxidata	29	0.1	0.3 - 1
Cladonia spp.	18	0.1	0.3 - 2
Peltigera spp. (P. rufescens?)	12	0.1	0.3 - 0.3
Placynthium nigrum	24	0.2	0.3 - 2
Xanthoparmelia spp.	12	0.1	0.3 - 0.3

* Each species may not be present in every plot; the range of values is derived only from plots where the species has been found.

Dynamics: Not documented.

Environment: These grasslands occur on very shallow, patchy soils (usually less than 20 cm deep, averaging about 6 cm deep) on flat limestone and dolostone outcrops (pavements). Soils are loams high in organic matter. This community often has a characteristic soil moisture regime of alternating wet and dry periods; they can have wet, saturated soils in spring and fall, combined with summer drought in most years. In large patches over 20 ha (50 acres) this grassland often occurs as a small-scale matrix, with smaller patches of other alvar communities occurring within the larger patch of little bluestem alvar grassland, forming a landscape mosaic (Reschke et al. 1998).

Table 3. Physical environment of the Sporobolus heterolepis - Schizachyrium scoparium - (Carex scirpoidea) / (Juniperus horizontalis) Herbaceous Association; Little Bluestem Alvar Grassland, NVC identifier code CEGL005234.

Continuous Variables	Average	Range
Elevation (m)	186.0	178-209
Slope Gradient (degrees)	0.5	0 - 3
Organic Horizon Depth (cm)	1.0	0 - 8
Average Field pH	7.8	7.3 - 9
Soil Depth (cm)	4.0	1 - 9
Exposed Bedrock (%)	18.0	0 - 75
Large Rock, Surficial (% > 10 cm)	7.0	0 - 35
Small Rock, Surficial (% 0.2 - 2 cm)	10.0	0 - 72
Sand, Surficial (%)	0.0	0 - 0
Bare Soil, Surficial (%)	0.5	0 - 5
Litter (%)	2.0	0 - 12
Down Wood (% > 1 cm dbh)	0.1	0 - 1
Water (%)	0.1	0 - 1
Categorical Variables	**Category**	**Number of Plots (%)**
Slope Aspect	Flat	7 (41)
Slope Aspect	South	6 (35)
Slope Aspect	Northeast	2 (12)
Slope Aspect	West	1 (6)
Slope Aspect	North	1 (6)
Topographic Position	High, level	5 (28)
Topographic Position	Low, level	4 (24)
Topographic Position	Midslope	2(12)
Topographic Position	Other	4 (24)
Topographic Position	No Value	2 (12)
Soil Moisture	Periodically Inundated	7 (41)
Soil Moisture	Moist	4 (24)
Soil Moisture	Somewhat Moist	3 (17)
Soil Moisture	Dry	1 (6)
Soil Moisture	Extremely Dry	1 (6)
Soil Moisture	No Value	1 (6)

DISTRIBUTION:

Range: The little bluestem alvar grassland type is found primarily in the upper Great Lakes region of the United States and Canada, in northern Michigan, and in Ontario on

Manitoulin Island and vicinity, on the Bruce Peninsula, and at a few sites further east in the Carden Plain and Burnt Lands.

Nations: CA US

States/Provinces: Michigan, Ontario

USFS Ecoregions: 212H:CC, 212Pc:CCC

PLOT SAMPLING AND ANALYSIS:

Location of archived plot data: Spreadsheet files with compiled vegetation data from plots and structural types are available from The Nature Conservancy's Great Lakes Program Office or from the state or provincial Heritage Programs. Original field forms are filed at state/provincial Heritage Programs. Plot data access forthcoming (2004) at www.vegbank.org.

Factors affecting data consistency: See “Methods,” below.

The number and size of plots: Vegetation data were collected using 10 x 10 m relevé plots placed haphazardly within subjectively defined stands.

Methods used to analyze field data and identify type:

From Reschke et al. (1998): Field data collected by collaborators in Michigan, Ontario, and New York were compiled by the Heritage program staff in each jurisdiction, and provided to Carol Reschke (inventory and research coordinator for the Alvar Initiative). With assistance from a contractor (Karen Dietz), field data on vegetation, environment, and evidence of ecological processes from alvar sites were entered into spreadsheets. Spreadsheets were edited to combine a few ambiguous taxa (e.g. *Sporobolus neglectus* and *S. vaginiflorus* look similar and can only be positively distinguished when they are flowering in early fall), incorporate consistent nomenclature (Kartesz 1994), delete duplicates, and delete species that occurred in only one or a few samples. Corresponding data on the environment and evidence of ecological processes were compiled in two additional spreadsheets. The plot data set consisted of data from 85 sample plots; there were 240 taxa of vascular and nonvascular taxa included in the initial data set.

The plot data set included a great deal of structural detail. If a tree species was present in different vegetation strata, then it was recorded as a separate taxon for each layer in which it occurred; for example, *Thuja occidentalis* might be recorded as a tree (over 5 m tall), a tall shrub (2 to 5 m tall), and a short shrub (05 to 2 m tall). The full data set of 85 samples by 240 taxa was analyzed using PC-ORD v 3.0 (McCune and Mefford 1995). Vegetation data on percent cover were relativized for each sample and then transformed with an arcsine - square root transformation. This standardization is recommended for percentage data (McCune and Mefford 1995).

Two kinds of classification and two kinds of ordination procedures were applied to the full data set. Classification procedures used were: 1) cluster analysis with group average (or UPGMA) group linkage method and Sørenson's distance measure, and 2) TWINSPAN with the default settings. The two ordination procedures used were 1) Bray-Curtis ordination with Sørenson's distance and variance-regression endpoint selection, and 2) non-metric multidimensional scaling (NMS) using Sørenson's distance and the coordinates from the Bray-Curtis ordination as a starting configuration.

Environmental data recorded for each plot and data on evidence of ecological processes were used as overlays in ordination graphs to interpret ordination patterns and relationships among samples.

The classification dendrograms and ordination graphs were presented to a core group of ecologists to discuss the results. Participants in the data analysis discussions were: Wasyl Bakowsky, Don Faber-Langendoen, Judith Jones, Pat Comer, Don Cuddy, Bruce Gilman, Dennis Albert, and Carol Reschke. The two classifications were compared to see how they grouped plots, and ordinations were consulted to check and confirm groupings of plots suggested by the classification program. At the end of the first meeting to discuss the data analysis, collaborating ecologists agreed on eight alvar community types, and suggested another four or five that had been observed in field surveys but were not represented in the plot data set. The group also recommended some refinements to the data analysis.

Following the recommendations of the ecology group, the plot data were modified in two ways. For nonvascular plants, the first data set included data on individual species or genera, as well as taxa representing simple growth forms. Since only a few collaborators could identify nonvascular plants in the field, we had agreed to describe the nonvascular plants in plots by their growth form and collect a specimen if the species had at least 5% cover in the plot. If nonvascular species were identified by the surveyor, or from the collected specimen, the species were included in the data set. This may have biased the results, because the plots sampled by investigators who knew the nonvascular plants had a greater potential diversity than plots in which only a few growth forms were identified. Therefore, all data on nonvascular taxa were lumped into nine growth form categories: foliose algae (e.g. *Nostoc*), rock surface algae, microbial crusts, turf or cushion mosses, weft mosses, thalloid bryophytes, crustose lichens, foliose lichens, and fruticose lichens. The second modification involved lumping the different structural growth forms of woody taxa into a single taxon; for example, trees, tall shrubs and short shrubs forms of *Thuja occidentalis* were lumped into a single taxon.

These modifications reduced the data set to 85 plots and 199 taxa, and even fewer taxa with the woody growth forms lumped. The analyses were run again using the procedures described above with the modified data sets. Lumping the nonvascular plants improved the classification and ordination results (yielding more clearly defined groups), but lumping the growth forms of tree species was actually detrimental to the results. The final classification that we used was produced from an analysis of the data set with nonvascular plants lumped into nine growth forms, and multiple growth forms of tree species kept separate.

CONFIDENCE LEVEL:

Confidence Rank: High.

CITATIONS:

Synonymy:

Dry – Fresh Little Bluestem Open Alvar Meadow Type = (Lee et al. 1998).

References:

Gleason, H.A. and A. Cronquist. 1991. Manual of vascular of plants of northeastern United States and adjacent Canada, 2nd edition. The New York Botanical Garden, Bronx, NY, USA. 910 p.

Kartesz, J. T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. Second edition. Volume 1--Checklist. Timber Press, Portland, OR. 622 p.

Lee, H., W. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig, and S. McMurray. 1998. Ecological land classification for southern Ontario: First approximation and its application. Ontario Ministry of Natural Resources, Southcentral Science Section, Science Development and Transfer Branch. SCSS Field Guide FG-02.

McCune, B., and M.J. Mefford. 1995. Multivariate analysis of ecological data, PC-ORD version 3.0. MjM Software, Gleneden Beach, Oregon, USA.

Reschke, C., R. Reid, J. Jones, T. Feeney, and H. Potter, on behalf of the Alvar Working Group. 1998. Conserving Great Lakes Alvars. Final Technical Report of the International Alvar Conservation Initiative. December 1998. The Nature Conservancy, Great Lakes Program, Chicago, IL. 119 pp. plus 4 appendices.

Author of Description: C. Reschke

APPENDIX 4

Field Plot Data Exchange Schema.

Introduction

Most of the associations and alliances in North America have not yet been described numerically and little is formally known about their ecological characteristics, either in general or individually. A major reason for the lack of knowledge about associations and alliances is that field plot data for them has not generally been available. To date, the only information compiled systematically about alliances in the United States is the set of alliance descriptions developed by NatureServe (2002, 2003). Although this is the best available information, few descriptions are linked with field plot data and fewer are linked with field plot data that can be accessed and reexamined. To describe associations and alliances and to investigate their ecological characteristics, either a massive amount of new field plots must be collected or existing data must somehow be used.

The only way that enough field data can be developed to for this purpose is to combine data from multiple sources. To facilitate this, VegBank (www.vegbank.org) has been established to archive, integrate, and disseminate the field plot data that will be needed to achieve the NVC goal of quantitative field based and peer reviewed descriptions of associations and alliances.

At the heart of this endeavor is the technical capability to read and integrate digital files containing field plot data. The most appropriate technology for this is XML, and the operable tool for this purpose is a XML schema (see Sperberg-McQueen and Thompson, 2003). The NVC XML Schema defines the structure, content, and semantics of plot data that have been originally generated by many different workers. Legacy data formatted to this schema can be queried and combined. The NVC XML Schema is the fundamental means of formatting and transferring vegetation field plot data.

The NVC XML Schema Version 1.0 contains approximately 6,700 lines of code. It can be accessed online at: [http://vegbank.org/vegdocs/xml/vegbank-xml-index.html].

TABLES

Table 1. A crosswalk of strata categories (left column) with common growth form categories (all other columns).

Stratum	Growth Form								
	Trees				Shrubs		Herbs		Cryptogams
	Seedling	Sapling	Pole	Mature	Tall	Medium	Low Shrub	Herb	Ground
Tree			x	x	(x)				
Shrub		x			x	x			
Field	x						x	x	
Moss									x
Floating								x	
Submerged								x	

Table 2. A process for estimating canopy cover of a single stratum from the cover values of individual species occurring in that strata. The same calculation may be applied to canopy cover values of growth forms (i.e., sapling, tall shrub, etc.) recorded from a given stratum . In this example the canopy cover of the shrub stratum is estimated to be 64%.

Species (j) occurring in the shrub strata (i)	Actual cover in %	Step 1: $\left(1 - \frac{\% \text{cov } j}{100}\right)$	Step 2 $1 - \prod_{j=1}^{n} (Step1)$	Step 3 $Step2 * 100$
Acer glabrum	15	0.85		
Spiraea douglasii	40	0.6		
Vaccinium scoparium	30	0.7	1 - 0.357 = 0.643	0.643 * 100 = 64.3
$\prod$ (i.e., the product of a * b * c)		0.357		

Table 3. Recommended growth forms to be used when describing vegetation structure (see also Whittaker 1975:359, and Table 1.2 of Appendix 1). Not to be confused with vegetation strata.

Tree	Trees (larger woody plants, mostly well above 5 m tall)
	Needle-leaved tree (mainly conifers – pine, spruce, larch, redwood, etc.)
	Broad-leaved deciduous tree (leaves shed in the temperate zone winter, or in the tropical dry season)
	Broad-leaved evergreen tree (many tropical and subtropical trees, mostly with medium-sized leaves)
	Thorn tree (armed with spines, in many cases with compound, deciduous leaves, often reduced in size)
	Evergreen sclerophyllous tree (with smaller, tough, evergreen leaves)
	Succulent tree (primarily cacti and succulent euphorbs)
	Palm tree (rosette trees, unbranched with a crown of large leaves)
	Tree fern (rosette trees, unbranched with a crown of large leaves)
	Bamboo (arborescent grasses with woody-like stems)
	Other tree
Shrub	Shrubs (smaller woody plants, mostly below 5 m tall)
	Needle-leaved shrub (mainly conifers – juniper, yew, etc.)
	Broad-leaved deciduous shrub (leaves shed in the temperate zone winter, or in the tropical dry season)
	Broad-leaved evergreen shrub (many tropical and temperate shrubs, mostly with medium to small-sized leaves)
	Thorn shrub (armed with spines, in many cases with compound, deciduous leaves, often reduced in size)
	Evergreen sclerophyllous shrub (with smaller, tough, evergreen leaves)
	Palm shrub (rosette shrubs, unbranched with a short crown of leaves)
	Dwarf-shrub (low shrubs spreading near the ground surface, less than 50 cm high)
	Semi-shrub (suffrutescent, i.e., with the upper parts of the stems and branches dying back in unfavorable seasons)
	Succulent shrub (cacti, certain euphorbias, etc.)
	Other shrub
Herbaceous	Herbs (plants without perennial aboveground woody stems)
	Forb (herbs other than ferns and graminoids)
	Graminoid (grasses, sedges, and other grass like plants)
	Fern (pteridophytes –ferns, clubmosses, horsetails, etc.)
	Succulent forb
	Aquatic herb (floating & submergent)
	Other herbaceous
Nonvascular	Moss
	Liverwort/hornwort
	Lichen
	Alga

Other	Epiphyte (plants growing wholly above the ground surface on other plants) Vine/liana (woody climbers or vines) Other/unknown (null) – Not assessed Aquatic floating Aquatic submerged

Table 4. Comparison of commonly used cover-abundance scales in the United States. Agencies and authors are abbreviated as: BB=Braun-Blanquet (1928); NC=North Carolina Vegetation Survey (Peet et al. 1998); K=Domin sensu Krajina (1933); DAUB=Daubenmire (1959); FS (Db)=Forest Service, modified Daubenmire (1959) scale; PA=Pfister and Arno (1980); NZ=New Zealand LandCare (Allen 1992, Hall 1992); BDS=Barkman et al. (1964); D=Domin (1928); FS (eco) = Hann et al. (1988), Keane et al. (1990) for the U.S. Forest Service ECODATA software). Break points shown in the Cover-abundance column reflect the major break points of the Braun-Blanquet scale, which is considered the minimum standard for cover classes. Among the available cover class systems, the NC and K cover class systems can be unambiguously collapsed to the B-B standard, and the DAUB, FS, PA and NZ scales are for all practical purposes collapsible into the B-B scale without damage to data integrity. The D, BDS, WHTF are somewhat discordant with the B-B standard and should be avoided except when required for incorporation of legacy data.

Cover-abundance	BB	NC	K	DAUB	FS(Db)	PA	NZ	BDS	D	FS(eco)
Present but not in plot	( )†					+				
Single individual	r	1	+	1	T	T	1	-	+	1
Sporadic or few	+	1	1	1	T	T	1	-	1	1
0 - 1%	1‡	2	2	1	T	T	1	-	2	1
1 - 2%	1	3	3	1	1	1	2	-	3	3
2 - 3%	1	4	3	1	1	1	2	0	3	3
3 - 5%	1	4	3	1	1	1	2	0	4	3
5 - 6.25%	2	5	4	2	2	2	3	1	4	10
6.25 – 10%	2	5	4	2	2	2	3	1	4	10
10 – 12.5%	2	6	5	2	2	2	3	1	5	10
12.5 – 15%	2	6	5	2	2	2	3	1	5	10
15 – 25%	2	6	5	2	2	2	3	2	5	20
25 – 30%	3	7	6	3	3	3	4	3	6	30
30 – 33%	3	7	6	3	3	3	4	3	6	30
33 – 35%	3	7	7	3	3	3	4	3	7	30
35 – 45%	3	7	7	3	3	3	4	4	7	40
45 – 50%	3	7	7	3	3	3	4	5	7	50
50 – 55%	4	8	8	4	4	4	5	5	8	50
55 – 65%	4	8	8	4	4	4	5	6	8	60
65 – 75%	4	8	8	4	4	4	5	7	8	70
75 – 85%	5	9	9	5	5	5	6	8	9	80
85 – 90%	5	9	9	5	5	5	6	9	9	90
90 – 95%	5	9	9	5	5	5	6	9	10	90
95 – 100%	5	10	10	6	6	6	6	10	10	98

† Species present in the stand but not in the plot are usually added in parentheses to the species list.

‡ This is a cover/abundance scale; if numerous individuals of a taxon collectively contribute less than 5% cover, then the taxon can be assigned a value of 1 or, if very sparse, a "+."

Table 5. Summary of vegetation layer, or strata, data from field plots for a given type.

Layer	Height Class	Average % Cover	Minimum % Cover	Maximum % Cover
Tree				
Shrub				
Herb				
Moss				
Floating Aquatic				
Submerged Aquatic				

Table 6. A stand table of floristic composition for each stratum. Strata are defined on page 41.

Species Name	Stratum	1, Dominant 2, Characteristic 3. Constant	Constancy	Av. % Cover	Min. % Cover	Max. % Cover
Species 1						
Species 2						
Species 3						
Species *n*						

Table 7. Constancy classes.

Constancy Classes	Relative (%) Constancy
I	1-20
II	>20-40
III	>40-60
IV	>60-80
V	>80-100

FIGURES

Figure 1. Categories and examples of the National Vegetation Classification, showing the levels from class to association.

Figure 2. An illustration of strata showing growth forms of individual plants.

Figure 3. Schematic diagram of the peer review process.

Figure 4. Flow of information through the process for formal recognition of an association or alliance.

Figure 1. Categories and examples of the National Vegetation Classification, showing the levels from Class to Association. The FGDC (1997) standard also includes two higher levels above Class: Division and Order.

Physiognomic Categories

Category . . . .Example

Class . . . .Open Tree Canopy

Subclass . . . .Evergreen Open Tree Canopy

Group . . . . .Temperate or Subpolar Needle-leaved Evergreen Open Tree Canopy

Subgroup . . . .Natural/Seminatural

Formation . . . . Rounded-crowned temperate or subpolar needle-leaved evergreen open tree canopy.

Floristic Categories

Alliance . . . .*Juniperus occidentalis* Woodland Alliance

Association . . . . *Juniperus occidentalis /Artemesia tridentata* Association

Figure 2. An illustration of strata showing growth forms of individual plants as may be found in a plot (the ground stratum is not delineated). Height is shown in meters. The field stratum is between 0 and 0.5 m; the shrub stratum is from 0.5 to 3.5 m; and the tree stratum is from 3.5 to 12 m. Assignment of individual plants to a stratum is based on height and growth form as follows: A. A plant having an herbaceous growth form. Although projecting vertically into the shrub stratum it is excluded from being recorded as part of the shrub stratum canopy cover since its stems die and regrow each year. B. A plant having a dwarf shrub growth form is recorded as part of the field stratum. If desired, a separate dwarf-shrub substratum can be recognized. C. A moss; recorded as part of the ground stratum. D. A plant having a tree growth form but at a sapling stage of life. This individual is recorded as part of the shrub stratum canopy. E. A plant having a tree growth form but at a seedling stage of life. This plant is recorded as part of the field stratum canopy. F. Mature trees, recorded as part of the tree stratum. G. A sapling, as in D. H. A plant having a shrub growth form; recorded as part of the shrub stratum canopy cover. I. A plant having an herb growth form and projecting into the shrub stratum; excluded from being recorded as part of the shrub stratum canopy (as in A).

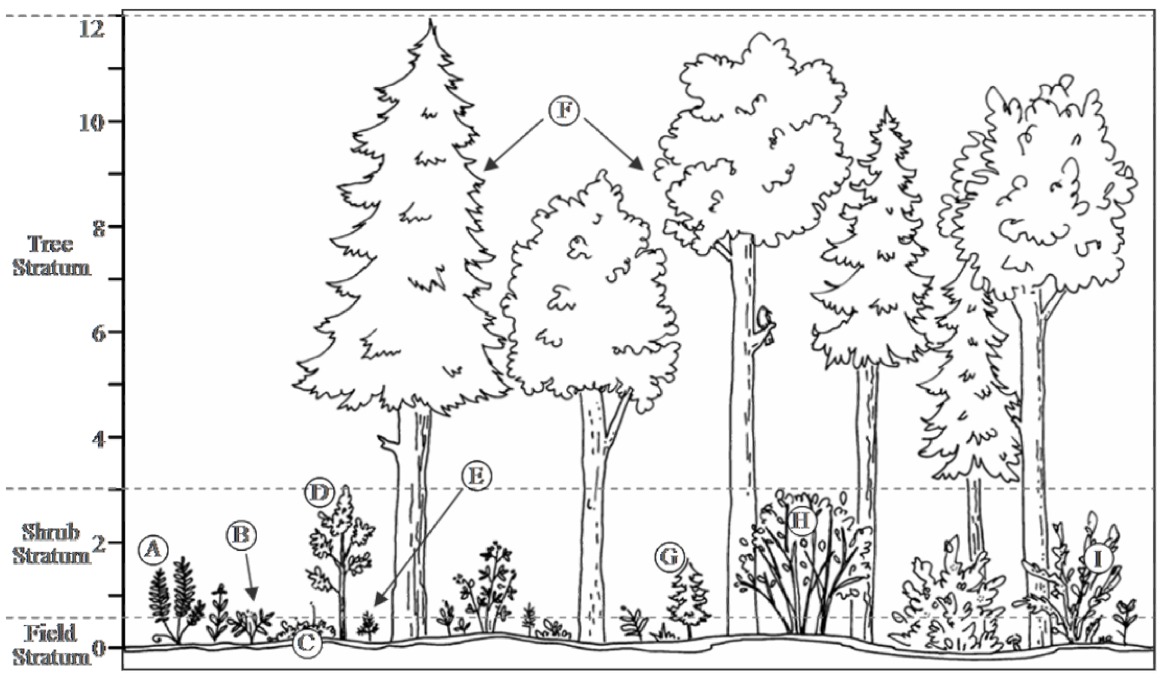


Figure 3. Schematic diagram of the peer-review process.

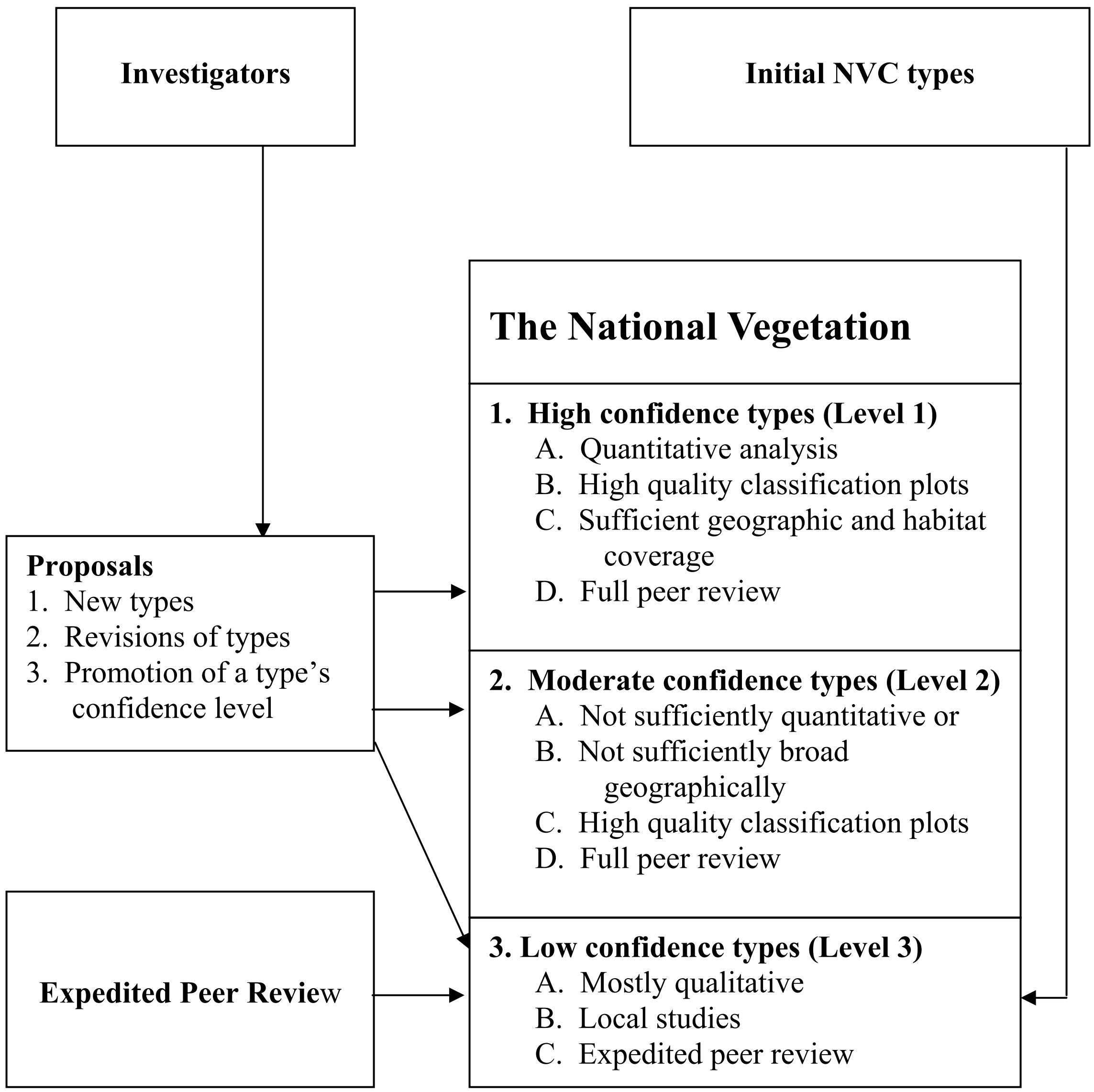
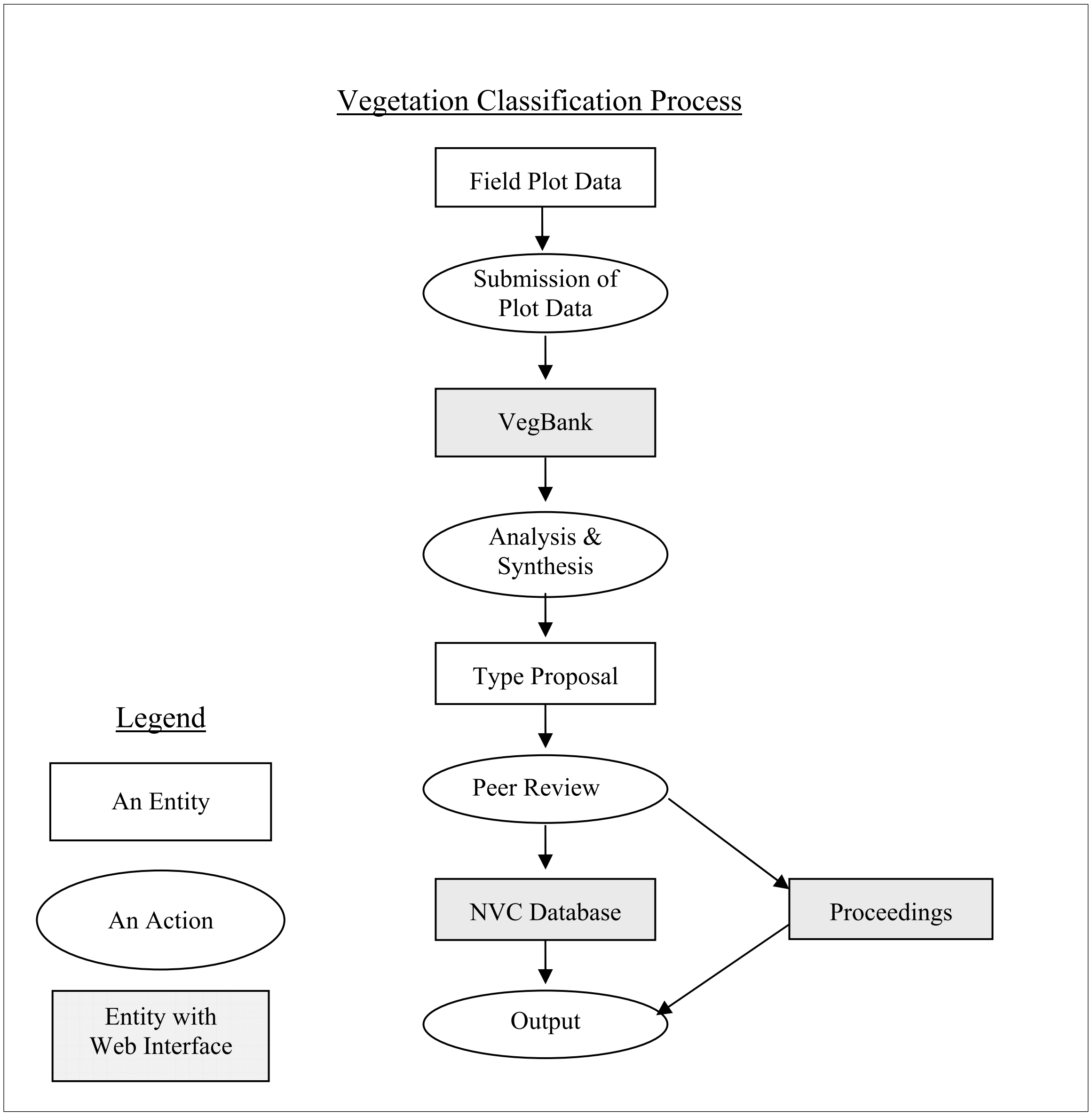


Figure 4. Flow of information through the process for formal recognition of an association or alliance. Beginning at the top, field plot data are collected, plot data are submitted to the plots database (VegBank), data are analyzed, and a proposal describing a type is submitted for review. If accepted by reviewers, the type description is classified under the NVC, the monograph is published, and the description made available.



TEXT BOXES

Text Box 1. Guiding principles of the FGDC National Vegetation Classification Standard (FGDC 1997).

Text Box 2. Required topical sections for monographic description of alliances and associations.

Text Box 3. Examples of Association and Alliance names.

Text Box 1. Guiding principles of the FGDC Vegetation Classification Standard (FGDC 1997).

- The classification is applicable over extensive areas.
- The vegetation classification standard compatible, wherever possible, with other Earth cover/land cover classification standards.
- The classification will avoid developing conflicting concepts and methods through cooperative development with the widest possible range of individuals and institutions.
- Application of the classification must be repeatable and consistent.
- When possible, the classification standard will use common terminology (i.e., terms should be understandable, and jargon should be avoided).
- For classification and mapping purposes, the classification categories were designed to be mutually exclusive and additive to 100% of an area when mapped within any of the classification's hierarchical levels (Division, Order, Class, Subclass, Subgroup, Formation, Alliance, or Association). Guidelines have been developed for those instances where placement of a floristic unit into a single physiognomic classification category is not clear. Additional guidelines will be developed as other such instances occur.
- The classification standard will be dynamic, allowing for refinement as additional information becomes available.
- The NVCS is of existing, not potential, vegetation and is based upon vegetation condition at the optimal time during the growing season. The vegetation types are defined on the basis of inherent attributes and characteristics of the vegetation structure, growth form, and cover.
- The NVCS is hierarchical (i.e., aggregatable) to contain a small number of generalized categories at the higher level and an increasingly large number of more detailed categories at the lower levels. The categories are intended to be useful at a range of scales (UNEP/FAO 1995, Di Gregorio and Jansen 1996).
- The upper levels of the NVCS are based primarily on the physiognomy (life form, cover, structure, leaf type) of the vegetation (not individual species). The life forms (e.g., herb, shrub, or tree) in the dominant or uppermost stratum will predominate in the classification of the vegetation type. Climate and other environmental variables are used to help organize the standard, but physiognomy is the driving factor.
- The lower levels of the NVCS are based on actual floristic (vegetation) composition. The data used to describe Alliance and Association types must be collected in the field using standard and documented sampling methods. The Alliance and Association units are derived from these field data. These floristically-based classes will be nested under the physiognomic classes of the hierarchy.

Text Box 2. Required topical sections for monographic description of alliances and associations.

OVERVIEW
1. Proposed names of the type (Latin, translated, common).
2. Floristic unit (alliance or association).
3. Placement in hierarchy.
4. A brief description of the overall type concept.
5. Classification comments.
6. Rationale for nominal species.

VEGETATION
7. Physiognomy and structure.
8. Floristics.
9. Dynamics.

ENVIRONMENT
10. Environment description.

DISTRIBUTION
11. A description of the range/distribution.
12. A list of U.S. states and Canadian provinces where the type occurs or may occur.
13. A list of any nations outside the U.S. and Canada where the type occurs or may occur.

PLOT SAMPLING AND ANALYSIS
14. Plots used to define the type.
15. Location of archived plot data.
16. actors affecting data consistency.
17. The number and size of plots.
18. Methods used to analyze field data and identify the type.
    a. Details of the methods used to analyze field data.
    b. Criteria for defining the type.

CONFIDENCE LEVEL
19. Overall confidence level for the type (see Section 7).

CITATIONS
20. Synonymy
21. Full citations for any sources
22. Author of Description

DISCUSSION
23. Possible sub-association or -alliance types or variants, if appropriate, should be discussed here along with other narrative information.

Text Box 3. Examples of association and alliance names.

Examples of association names:

Schizachyrium scoparium - (Aristida spp.) Herbaceous Vegetation

Abies lasiocarpa / Vaccinium scoparium Forest

Metopium toxiferum - Eugenia foetida - Krugiodendron ferreum - Swietenia mahagoni / Capparis flexuosa Forest

Rhododendron carolinianum Shrubland

Quercus macrocarpa - (*Quercus alba* - *Quercus velutina*) / *Andropogon gerardii* Wooded Herbaceous Vegetation

Examples of alliance names:

Pseudotsuga menziesii Forest Alliance

Fagus grandifolia - Magnolia grandiflora Forest Alliance

Pinus virginiana - Quercus (coccinea, prinus) Forest Alliance

Juniperus virginiana - (Fraxinus americana, Ostrya virginiana) Woodland Alliance

Pinus palustris / Quercus spp. Woodland Alliance

Artemisia tridentata ssp. *wyomingensis* Shrubland Alliance

Andropogon gerardii - (Calamagrostis canadensis, Panicum virgatum) Herbaceous Alliance