



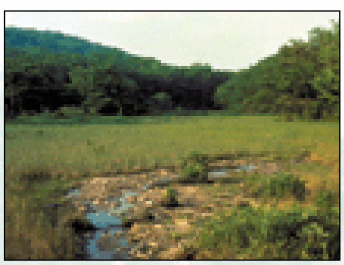

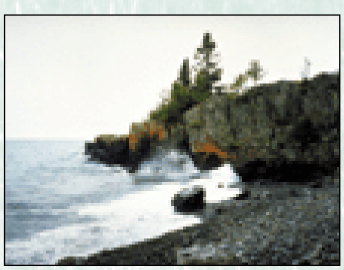

International Classification
of Ecological Communities:

TERRESTRIAL VEGETATION of the UNITED STATES

VOLUME I

The National Vegetation Classification System: Development, Status, and Applications

The Nature Conservancy

This work was accomplished through a partnership with ecologists from the following Natural Heritage Programs and Conservation Data Centers

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Alabama Natural Heritage Program
Alaska Natural Heritage Program
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Atlantic Canada Conservation Centre
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Tennessee Valley Authority Regional Natural Heritage
Texas Conservation Data Center
Utah Natural Heritage Program
Vermont Nongame and Natural Heritage Program
Virginia Division of Natural Heritage
Washington Natural Heritage Program
West Virginia Natural Heritage Program
Wisconsin Natural Heritage Program
Wyoming Natural Diversity Database

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VOLUME I

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D. H. Grossman, D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. Patterson, M. Pyne, M. Reid, and L. Sneddon

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Photographs on the front cover, from top to bottom:

1. Forest: *Thuja plicata / Athyrium filix-femina*, northern Idaho. The Nature Conservancy, Western Conservation Science.

2. Woodland: *Juniperis monosperma* Alliance, northern Arizona. The Nature Conservancy, Western Conservation Science.

3. Shrubland: *Rhizophora mangle / Eleocharis cellulosa* (grading into *Eleocharis cellulosa* Herbaceous Vegetation), Everglades National Park, Florida. Photograph by Jim Snyder.

4. Dwarf Shrubland: *Vaccinium* (*angustifolium, myrtilloides, pallidum*) High Allegheny Plateau/ Central Appalachian, Dolly Sods, West Virginia. Photograph by W. Beals.

5. Herbaceous Vegetation: *Cladium mariscoides - Sanguisorba canadensis / Sphagnum subsecundum*, Bluff Mountain Preserve, North Carolina. Photograph by Alan S. Weakley.

6. Nonvascular Vegetation: *Racomitrium lanuginosum* Montane Bog, Kanaele Bog, Hawaii. Photograph by Win Anderson.

7. Sparse Vegetation: Cobble-Gravel Shore, north shore of Lake Superior, Minnesota. Photograph by Don Faber-Langendoen.

Background photograph: Seasonally Flooded Tropical or Subtropical Seasonal Evergreen Forest Formation, south of Fakahatchee Strand State Preserve, Florida. Photograph by Jim Snyder.

Back Cover: Map of vegetation types, Scotts Bluff National Monument, Nebraska. Published courtesy of the USGS-NPS Mapping Program.

Contents

FIGURES AND TABLES

List of Figures

List of Tables

Acknowledgments

The development of this classification system represents a team effort. Whereas primary leadership, continuity, and maintenance have been provided by the science programs at The Nature Conservancy, the classification of vegetation types across the United States is based in large part on decades of field efforts by the ecologists across the network of state Heritage Programs. Numerous Conservancy and Heritage scientists have made important contributions to the development of the classification system. The list includes all of the Senior Ecology Group within the Conservancy and many past members of this Group. We would particularly like to acknowledge Dorothy Allard, Mark Bryer, Kim Chapman, Lisa Engelking, Bob Jenkins, Tom Rawinski, Rick Schneider, and Jack White. We would also like to acknowledge Kat Maybury for the editorial and coordination roles that she performed to bring this volume to completion.

Work on this classification has been strongly supported by many federal programs at the national and regional level. The U.S. Forest Service and the U.S. Department of Interior Gap Analysis Program have consistently provided a high level of involvement and support for the development of the classification system and descriptions of types. The National Park Service's Vegetation Mapping Program has furthered the development and documentation of the classification itself, along with standards for its application to vegetation mapping. The use of this classification across these programs and partnerships has culminated in the refinement of this vegetation classification and information system and its adoption as a standard by the Federal Geographic Data Committee (FGDC 1997). The subsequent development of the Ecological Society of America Vegetation Classification Panel has been instrumental for the implementation of a broader documentation and review process.

In summary, the development of this classification framework and the emerging list of vegetation types across the U.S. represents an extensive collaborative effort with a diverse set of partners. This classification system is new to this country, and without such broad collaboration it would not have been possible.

Preface

The committees of the Nature Conservancy have the task of assembling information on a country-wide basis and coordinating the activities between states. Some of their immediate tasks are as follows: "A study and enumeration of the vegetation and biotic types of the United States and Canada." A number of studies of this sort have been made for limited regions and for certain categories such as forest types and range types. No one has ever undertaken to compile this information for the whole country..... Estimated cost $5,000.

Nature Conservation News. Annual Report of The Nature Conservancy, 1952.

The mission of The Nature Conservancy, an international non-profit conservation organization, is to conserve species and natural communities through the protection of the lands and waters that they need to survive. The Conservancy's approach to conservation relies on the consistent and systematic accumulation, management, and analysis of scientific information on the "elements of biological diversity"—specifically the status and location of plants, animals, and ecological communities. This information is collected and managed in partnership with an international network of cooperating Natural Heritage Programs and Conservation Data Centers. The information is then used to help guide the Conservancy's land acquisition and stewardship activities and to assist others in identifying priorities for biodiversity conservation.

From the beginning the Conservancy emphasized the need to protect ecological communities, or "biotic types," as illustrated by the quote from the 1952 Annual Report of The Nature Conservancy, above. Until recently these ecological communities were classified at the state or regional level by the Conservancy and the Natural Heritage Programs in North America, and these classifications helped direct conservation priorities on a state-by-state basis. Although these classifications have proved useful for many purposes (including conservation planning, description of managed areas, and understanding of species habitats), they did not support the identification of regional and national ecological units nor the associated setting of regional conservation priorities. Many conservationists identified the need to move from a national conservation strategy focused primarily on endangered species to a more comprehensive approach based on ecological communities (with more specifically targeted actions on rare species protection). A standardized national classification of ecological communities would be the basis for implementing such a strategy.

To meet these objectives, the Conservancy, in conjunction with the Natural Heritage Programs, undertook the development of a scientifically sound, consistent, and flexible classification system based on vegetation. A team of Conservancy and Heritage ecologists has now completed the first draft of a standardized national vegetation classification system for the United States. Although this classification system was initially developed to support the conservation and management objectives of the Conservancy and the network of Natural Heritage Programs, its utility has attracted a broader range of users in federal and state agencies, academic institutions, and other conservation organizations, as well as interest from international partners. The identification of vegetation types at the finest level of the classification hierarchy is far from complete, and there are numerous steps that must be implemented to ensure the continued development and improvement of the classification system. It is our objective to introduce the emerging system; provide information on its background, structure, and development; highlight some of the applications; and point out key areas that still need to be developed. We have written this report to inform resource managers, scientists, and conservationists of what has been accomplished so far, to elicit feedback, and to solicit an expanded set of partners.

A classification of ecological communities or ecosystems using vegetation has both advantages and limitations. Vegetation is dynamic, and type definitions often require a high degree of variability. However, vegetation is readily measured for both inventory and monitoring purposes, it can be tracked efficiently at multiple scales, and it is a strong, if complex, indicator of the ecological function of natural systems. A national classification of vegetation can serve as an important component of a larger strategy to understand and conserve these natural systems. We are excited about its development and look forward to its application both here in the U.S. and, in cooperation with other international groups, in other countries.

The work that is detailed in these two volumes could not have been done without the Conservancy's willingness to support this effort over many years. We hope that this product will serve to further the work of understanding and conserving ecological systems in the United States and internationally.

I

Introduction

The Need for a Standard Classification of Ecological Communities

Attempts to understand the natural world have been directed at different biological and ecological levels, from genes and species to communities and ecosystems. Efforts to conserve biological diversity can be focused at each of these levels as well. Conservationists have often emphasized communities—assemblages of species that co-occur in defined areas at certain times and that have the potential to interact with one another (Whittaker 1962, Reschke 1990, McPeek and Miller 1996). By describing, tracking, and preserving these ecological communities, they are able to protect a complex suite of interactions not easily identified and protected through other means.

The Nature Conservancy (TNC) and the Natural Heritage Network[1] have recognized ecological communities as important elements of conservation for many years, and the best occurrences of these communities (as well as rare and imperiled species) have formed the basis for protection decisions throughout the Conservancy's history. The Conservancy recently reconfirmed the importance of using ecological communities as a key component in developing conservation strategies within an ecoregional context (TNC 1996).

Ecological communities constitute unique sets of natural interactions among species, provide numerous important ecosystem functions (Costanza et al. 1997, Daily et al. 1997), and create part of the context for species evolution. In addition, by protecting ecological communities, many species not specifically targeted for conservation are protected as well. As such, communities become extremely important conservation targets in areas where species patterns and ecological processes are poorly understood. Communities also provide an important tool for systematically characterizing the current condition of ecosystems and landscapes. Finally, change over time is often more efficiently monitored in communities than in component species. Changes may be detected by monitoring composition (changes in species abundance, proportions of endemics or exotics), structure (old growth characteristics, canopy features), and function (productivity, herbivory, patch dynamics, and nutrient cycling) (Noss 1990, Max et al. 1996).

Until recently, however, there has been no accepted standard for national or international community classification. Community protection proceeded on a state-by-state or agency-by-agency basis, based on independently developed classifications. For the Conservancy and others, these classifications worked effectively for the conservation of important areas within states or jurisdictions, but from a national and international perspective, the lack of a standard system resulted in unnecessarily redundant protection of a few types and inadequate protection of many others.

A common currency of ecological community types is clearly of fundamental importance to the work of the Conservancy. Similarly, it is a critical tool for federal and state agencies that are responsible for the conservation and management of biological diversity. In the absence of a common classification, the results of many inventory and monitoring programs, such as those conducted in national forests and parks, state forests and parks, or fish and wildlife refuges,

[1] The Natural Heritage Network is an informal designation of state and other programs that work cooperatively to collect and manage information on rare species and natural communities.

cannot be integrated. As recently as 1995, Noss et al. concluded that a basic question—to what extent the natural ecosystems in the United States had been reduced in area or degraded in quality due to human activities—could only be answered "by a relatively crude approach because a systematic approach to understanding these systems at a national scale was not yet available."

The management implications of inconsistent classifications have also become more apparent. Over the past few years, most federal resource management and land use agencies have redefined their missions to address an "ecosystem approach to management." The meaning of ecosystem management and what this approach will accomplish are articulated by each agency in relation to its mission. Variation in the definition of ecosystems among the agencies has led, in some cases, to considerably different interpretations of ecological units. A standard community classification system provides a consistent basis for the characterization of the biological components of different ecosystem units across the physical and administrative landscape. Thus, a standard classification system contributes to the formation of more precisely defined and less variable ecosystem units. It also allows for the comparison of units that are defined and managed by different land management agencies within and among regions.

A standardized classification system also provides a valuable structure for framing and answering important scientific inquiries about vegetation patterns and environmental processes. Such inquiries include (1) the comparison of ecological community richness and variability in different parts of the world, (2) the determination of the geographic distributions of specific vegetation types, (3) the elucidation of relationships between particular communities and environmental patterns or ecological processes across the landscape, and (4) the development of mechanistic models that can explain the patterns and dynamics of ecological communities, including responses to management and natural disturbance regimes.

Thus, the relevance of a national vegetation classification system is becoming clear to many organizations involved in conservation, natural resource planning and management, and vegetation inventory, monitoring, and mapping. In summary, the development of a standard national community classification is regarded as a major step toward enhancing our ability to understand, protect, and manage the natural resources of the United States (National Research Council 1993, Orians 1993, Noss et al. 1995, TNC 1996).

Recognizing the need for a national and international classification of ecological communities, the Conservancy, in conjunction with the Natural Heritage Network, undertook the development of a scientifically sound, consistent, and flexible classification system. Early on, the Conservancy identified the need for a separate classification of each major ecological system (terrestrial, freshwater, marine, and subterranean), as each would require the application of different concepts and variables. The immediate needs of existing land-based conservation programs dictated that the classification of the terrestrial system[2] be developed first. A vegetation-based classification approach was chosen, designed to be used at a variety of scales appropriate for conservation planning, resource management, and long-term monitoring of ecological communities and ecosystems.

A team of Conservancy and Heritage ecologists has now completed the hierarchical framework for the first standardized terrestrial vegetation classification system and has identified over 4,100 vegetation types at the finest level of the classification hierarchy, the association. These are presented in Volume II of this document (Anderson et al. 1998). Identification of all vegetation types—even within the United States—is far from complete, and there are numerous steps that must be taken to ensure the continued development and refinement of the classification.

Although the Conservancy initially

[2] As used here, "terrestrial system" includes all wetland systems with rooted vascular plants.

developed the vegetation classification system to support its own conservation and management objectives and those of the Natural Heritage Network, the availability of a standardized classification has attracted a broad range of users, including federal and state agencies, academic institutions, and other conservation organizations. The Federal Geographic Data Committee (FGDC) has accepted this framework as an information and classification standard to be used by all federal agencies (FGDC 1997). The Ecological Society of America has begun to work with the Conservancy and federal agencies to develop standards for future refinements of the classification (Loucks 1996). These institutions are increasingly important partners in the overall development and maintenance of the standards and the classification system.

This report documents the development of the U.S. National Vegetation Classification (USNVC) System, emphasizing the key issues and requirements of such a system in relation to previous approaches to classification. The report reviews the current structure of the classification system and the standards that were used to develop, name, and describe the vegetation types. It summarizes the status of classifications, descriptions, conservation ranks, and overall distribution patterns for the vegetation types and provides a discussion of data gaps. The report also describes the data management systems and standards that have been implemented to ensure currency and consistency of information across the Conservancy and the Natural Heritage Programs. In addition, it includes some discussion of USNVC applications for conservation assessment and planning; vegetation mapping, inventory, and monitoring; resource management; regional planning; ecosystem management; and research associated with understanding vegetation patterns. Finally, the future directions envisioned for the USNVC system are discussed, including the need for continuing and expanding partnerships with the FGDC and individual federal agencies, the network of state Natural Heritage Programs, and the Ecological Society of America.

II

Introduction

Developing a Classification Approach: Key Issues

Two principal focuses of community ecology are the manner in which species aggregations are distributed across natural landscapes and the ways in which these "communities" are influenced by interactions between species and the environment. Descriptions of the composition, structure, and function of these communities form a core body of knowledge for understanding ecological systems. This is particularly true of vegetation, the dominant and most accessible component of terrestrial ecological communities.

The role of a classification system is to provide a set of criteria that bring a certain degree of order to ecological community patterns. Because of the variable and dynamic nature of plant communities, ecologists have often debated the value and practicality of classifying them. Classification systems have been developed that address a wide variety of spatial scales and purposes. Syntheses of the literature and the schools of vegetation classification have been admirably accomplished by a number of authors (Whittaker 1962, Shimwell 1971, Westhoff and van der Maarel 1973, Whittaker 1973, Mueller-Dombois and Ellenberg 1974); these reviews have helped clarify some of the issues and led to something of a rapprochement among vegetation scientists in both methodology and concept (Whittaker 1978, Gauch 1982, Austin 1985, 1991). The history and the various schools of vegetation classification will be reviewed here only to provide a context for the key issues and decisions guiding the development of the USNVC. A discussion of the ways in which the USNVC addresses these key issues is provided in Section III.

II.A. Vegetation or Multi-factor Classifications

Classifications of ecological systems can be based on a variety of factors (e.g., vegetation, soils, landforms) that are used either singly or jointly. Single factor classification systems, such as those based on vegetation, are generally easier to develop, since less information is required, characteristics are less complex, and they can be tailored to specific objectives. Multi-factor classification systems are often more comprehensive and suited to a wider variety of needs. They are often very complex and require a great deal of information and analysis.

Vegetation is often chosen as the basis for a single-factor system for classifying terrestrial ecological systems because it generally integrates the ecological processes operating on a site or landscape more measurably than any other factor or set of factors (Mueller-Dombois and Ellenberg 1974, Kimmins 1997). Because patterns of vegetation and co-occurring plant species are easily measured, they have received far more attention than those of other components, such as fauna. Vegetation is a critical component of energy flow in ecosystems and provides habitat for many organisms in an ecological community. In addition, vegetation is often used to infer soil and climate patterns. For these reasons, a classification of terrestrial ecological communities based on vegetation can serve to describe many (though not all) facets of biological and ecological patterns across the landscape.

Multi-factor classification systems are often chosen over single-factor systems because they integrate a larger number of ecological factors, both abiotic and biotic, to identify ecological units. These systems often create a regionalized set of ecological units that are used to guide management, especially to predict how ecological systems will respond to different management and disturbance scenarios at a variety of scales. Some examples of multi-factor classifications, and a brief look at their utility relative to vegetation classification, follow.

1. The ***natural community classification*** *developed by the Illinois Natural Areas Inventory (White and Madany 1978)*

This is a practical system that allows locally characteristic features, such as vegetation physiognomy, species composition, soil moisture, substrate, soil reaction, or topographic position, to be used to identify the community types. Many states throughout the eastern United States have developed natural community classifications with a focus on conservation application (e.g., Nelson 1985, Reschke 1990, Schafale and Weakley 1990). The system has been used with great success for conservation and inventory at the local and state level, but its lack of uniformity led to limited applicability at a regional or national scale.

2. The ***wetland classification system*** *of Cowardin et al. (1979), which forms the basis for the National Wetlands Inventory Classification and Mapping Program across the United States*

In this system, the hierarchical levels are defined by water body types (e.g., marine, riverine, palustrine), substrate materials, flooding regimes, and vegetation life forms. The lowest unit of the classification, the Dominance Type, which is named for the dominant plant or animal forms, is unstructured and must be developed by the user (some recent studies have begun to refine Dominance Type using total floristic composition [Hansen et al. 1995]. One advantage of the Cowardin system is that it can be mapped using aerial photography and ground-truthing. Limitations are that not all features of the system can be observed from aerial photography, and some features, such as flooding, are very dynamic and not consistently observable. In addition, because the development of the user-defined types has not been coordinated, they are (by definition) not comparable among users.

3. The U.S. Forest Service's ***ecological land unit classification*** *for the United States (Bailey 1976, 1995, Keys et al. 1996) and the world (Bailey 1989a, b)*

This classification uses a combination of climate, physiography, landform, soils, and potential natural vegetation to derive units that express a shared ecological potential, irrespective of existing land use and vegetation. Ecological units are classified at multiple spatial scales in a hierarchical arrangement, with consistent "driving variables" identified at each scale. Subdividing regions into distinct units provides a more permanent framework for (1) integrating resource management and planning, (2) conserving biodiversity, and (3) comparing differences in composition, structure, interactions, and productivity of the biological elements among units (Albert 1995). This approach provides a test of site potential and the key ecological variables that structure a spatially defined system. An ecological classification can highlight the ecological variability present in a landscape (Lapin and Barnes 1995), and the natural and disturbed vegetation that could occur in a landscape unit. However, in order to describe the current condition and ongoing dynamics of the biotic components of the system, an assessment of the current vegetation pattern is required.

4. ***Land cover and land use classifications****, such as those developed from satellite imagery and intended primarily for land management or resource planning*

These emphasize conspicuous features of the land surface that can easily be mapped, including vegetation or any other natural or cultural features (Witmer 1978). They can often provide accurate, up-to-date information on the status of land cover. However, the classification or map units are often dependent on the mapping technology, leading to inconsistencies from one effort to the next.

II.B. Vegetation Pattern and the Continuum Concept

The "continuum concept," developed by Gleason (1926), Curtis (1959), Whittaker (1956, 1962), and others, is based on the "individualistic hypothesis" of species distributions, which stated that species have distinct, independent responses to the environment. As a result, the continuum concept emphasizes that species assemblages tend to change more or less gradually across environmental and geographical gradients, with no definite demarcation lines. In contrast, the "community unit concept" of Clements (1916) and Daubenmire (1966) held that communities are "integrated wholes," such that repeatable combinations of species consistently occur together, and all communities are successionally directed to stable endpoints ("climax" communities).

Vigorous debate has occurred about the "continuum concept" and the "community unit concept (Daubenmire 1966, Cottam and McIntosh 1966, Whittaker 1973, Westhoff and van der Maarel 1973), but there is now some consensus that the continuum concept offers a more realistic view of vegetation pattern (Austin 1985, McIntosh 1993). There is also a recognition that species found in a certain area are structured to some degree by interactions with each other and their environment such that certain combinations of species do recur (Austin and Smith 1989, Roughgarden 1989, Wilson 1991, 1994). Studies also indicate that species' distributions may be due to a variety of factors in addition to responses to environmental gradients; these include species interactions, disturbances, and past history (Allen and Starr 1982). Thus, species do not have distributions that are simply "individualistic"; nor are there "discrete," "organismal" assemblages of species (Roughgarden 1989, Moravec 1992, Jackson 1994, Jablonski and Sepkoski 1996).

This viewpoint—one that is perhaps intermediate between the "community unit concept" and the "continuum concept"—has been widely used in guiding the classification of vegetation. This is the "systematic unit concept" typified in the Braun-Blanquet approach (Moravec 1992). In the words of Kimmins (1997), this approach "recognizes the reality of continuous species distributions, but emphasizes interactions between species that lead to *relative* discontinuities between assemblages of species" (also see Mueller-Dombois and Ellenberg 1974). Thus, although there is continuous variation in species composition along an environmental gradient, in some places the level of compositional change is low (within a vegetation type), whereas in other places the level of compositional change is high (transitional areas between vegetation types).

Despite some perceived tension between the continuum concept and classification, classification can be done without the assumption that natural plant communities are discrete groupings of plant species. Classification only requires the assumption that it is reasonable to separate a continuum of variation in vegetation composition and structure into a series of somewhat arbitrary classes (Whittaker 1975, Kimmins 1997). Floristic and physiognomic uniformity or homogeneity have been widely accepted as useful criteria to *define* these classes, but this fact need not restrict the classification from evaluating many segments along multiple continua of variation (Whittaker 1962, Mueller-Dombois and Ellenberg 1974, Whittaker 1978).

In using the continuum concept in classification, several features of communities may be stated, following Mueller-Dombois and Ellenberg (1974):

- Similar species combinations recur from stand to stand.
- No two stands (or sampling units) are exactly alike.
- Species assemblages change more or less continuously if one samples a geographically widespread community throughout its range.

It may be added that similarity depends on the spatial and temporal scale of analysis and requires some agreement on the definitions of a stand (Allen and Starr 1982, Austin 1991).

II.C. Natural versus Cultural Vegetation

Vegetation—the plant life of an area—can range from cultivated to natural. The extremes of "natural" (vegetation which appears to be unmodified by human activities) and "cultural" (vegetation which is planted or actively maintained by humans such as annual croplands, orchards, and vineyards) are relatively self-evident. Most existing vegetation falls between these extremes, having been subjected to a variety of disturbance types and intensities. This has led to varying degrees of alteration in both species composition and vegetation structure across the landscape. Imposing a clear line between natural and cultural vegetation is problematic and somewhat arbitrary, yet it is a conceptual distinction with important implications.

Judgments about naturalness must consider the context of ongoing dynamic changes in natural vegetation over thousands of years. Historic, anthropogenic disturbances that have altered native ecological communities over long periods of time often affect perceptions about naturalness. For example, many consider pre-European settlement vegetation to be the appropriate baseline for naturalness in North America. This uses a historic—and certainly human-influenced—condition as the definition of natural vegetation. In Europe, where much of the landscape has been heavily human-influenced for longer periods of time, a distinction between natural and cultural vegetation is even more difficult to make. For this reason, most European vegetation ecologists fully describe all existing vegetation short of arable crops (Ellenberg 1985, Rodwell 1991).

Decisions about where to draw the line between natural and cultural vegetation will also be influenced by the objectives of the classification. When the conservation of native species and ecological processes is of primary concern, the definition of "natural" has tended to emphasize communities where native species predominate (van der Maarel and Klötzli 1996).

II.D. Existing Natural versus Potential Natural Vegetation

Vegetation classification systems may be based on either existing or potential natural vegetation (PNV). Classifications based on existing vegetation categorize types with little reference to any future potential or developmental context. These vegetation types are derived from the current expression of floristic composition and structural variation. The types can then be used to hypothesize or interpret processes based on ecological knowledge or models.

In contrast, classifications emphasizing PNV are based on projected (hypothesized) mature or stable endpoints of vegetation development. In the words of Tüxen (1956, in Mueller-Dombois and Ellenberg 1974), potential vegetation is "the vegetation structure that would become established if all successional sequences were completed without interference by man under the present climatic and edaphic conditions (including those created by man)." Sampling within this context is directed towards stands hypothesized to be representative of mature or "climax" communities. Climax communities are judged to be relatively stable; that is, the assemblage of species tends to persist for a relatively long period of time.

Since natural disturbances have a profound influence on the character and composition of vegetation (White 1979), efforts to identify climax vegetation have led to extensive debates over the role of these natural disturbances in establishing and maintaining vegetation patterns. The role of natural disturbances, coupled with a diverse set of physical site factors, led many ecologists to prefer a "poly-climax" view of vegetational dynamics (Whittaker 1953, 1956, 1975). In this view, vegetation can be described as being in an early-, mid-, or late-seral stage with respect to various kinds of disturbances, but each of these stages may be more or less persistent, depending on many factors. For practical reasons, persistence is often judged over time periods measured in decades (Mueller-Dombois and Ellenberg 1974).

In a classification based on existing vegetation, each of the seral stages may be classified separately, depending on its floristic/physiognomic characteristics and degree of persistence. Succession is treated in terms of a series of changes in floristically distinguishable plant communities (Moravec 1992). A PNV classification emphasizes only the later stages. In landscapes where there is little natural or climax vegetation, a PNV classification may bear little resemblance to existing vegetation conditions. For example, stands managed with fire regimes reflective of historic processes would not be at climax with respect to site factors. These stands would be classified differently by existing versus PNV classifications. Conversely, in a landscape where the vegetation is considered to be relatively natural *and* climax (or late seral), a PNV classification may be very similar to an existing vegetation classification.

Vegetation types classified using PNV concepts are limited by the current knowledge of vegetation-site relationships and the ability of the observer to infer these relationships (Cook 1995). However, they represent a first approximation or hypothesis that is important to developing a better understanding of these relationships. PNV concepts can be helpful in projecting the type of vegetation expected under a certain set of ecological factors. In addition, sampling stands that are similar with respect to successional stage or absence of disturbance may bring a certain clarity to some of the ecological processes that maintain these stands.

Both existing and PNV classification systems have been widely developed. One of the better known applications of the PNV approach is that of Küchler (1964, 1985), who produced a joint classification and map of the potential natural vegetation of the United States at scales of 1:3,168,000 and 1:7,500,000. Küchler focused on mature (potential) types; therefore, some widespread existing types, such as those dominated by trembling aspen (*Populus tremuloides*) or longleaf pine (*Pinus palustris*), are not portrayed (Ware et al. 1993). Küchler's maps are among the few comprehensive United States vegetation maps available, and they have been widely used to describe ecological regions and determine conservation priorities (Klopatek et al. 1979, Crumpacker et al. 1988, Martin et al. 1993). The Braun-Blanquet system is a widely applied classification system for existing vegetation (e.g., Ellenberg 1985, Rodwell 1991), as are the many dominance-based systems, such as the Society of American Foresters (SAF) cover type classification (Eyre 1980).

II.E. Physiognomic versus Floristic Characters

Most vegetation classification systems, whether based on potential natural or existing vegetation, can be divided into those that rely predominantly on physiognomic characters, those that rely predominantly on floristic characters, or those that use some combination of the two. In general, physiognomic systems have been used for coarse-scale interpretations of vegetation patterns and floristic systems for both fine- and coarse-scale interpretations.

II.E.1.
Physiognomic Systems

Physiognomy can refer to both the structure (height and spacing) and growth form (gross morphology and growth aspect) of the predominant species and to leaf characters (seasonality, shape, phenology, duration, size, and texture) of the dominant or component plants. These features provide a fast, efficient way to categorize vegetation. They can often be linked to remote sensing signatures and are useful for initial reconnaissance and stratification of areas requiring survey. Physiognomic features are easily recognized in the field and can be used with little knowledge of the flora. In some parts of the world, especially in the tropics, the ability to complete a more detailed characterization of the vegetation may not be scientifically or practically feasible because of the floristic complexity of these areas (Adam 1994). Physiognomic systems allow generalizations about the vegetation at broad geographical scales (Fosberg 1961, Beard 1973, Whittaker 1975) and can provide indirect information about gross environmental conditions—particularly climate—to which the particular physiognomy may be an adaptation (Holdridge 1947, Whittaker 1975, Howard and Mitchell 1985, Walter 1985). For example, broad-leaved evergreen trees tend to be found in tropical climates, whereas needle-leaved evergreen trees tend to be found in boreal or montane climates. Similarly, tree crowns are often rounded to flat-topped in the tropics and conical-shaped in the boreal zone (Terborgh 1985).

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 (or the uppermost closed stratum) of the community, or by a combination of dominant growth forms" (Whittaker 1962). In practice, formations are often defined by varied, conventionally accepted combinations of growth-form dominance *and* characteristics of the environment, e.g., "cold-deciduous alluvial forests," "evergreen subdesert shrublands," and "alpine meadows."

An example of a world-wide physiognomic classification system is that developed by UNESCO (1973), based on the work of Brockman-Jerosch and Rübel (1912), Rübel (1930), and Fosberg (1961). This classification was developed to provide a comprehensive framework for the preparation of vegetation maps at a scale of 1:1,000,000 or coarser. A hierarchical system of physiognomy and structure and some geographical and environmental factors were used to define the vegetation types.

II.E.2.
Floristic Systems

Floristic classifications utilize species composition or species groups, rather than physiognomic patterns of the dominant species, to define vegetation types. Patterns of succession, disturbance, history (including paleoecology), and natural communities are better assessed through floristic composition than physiognomy (Glenn-Lewin and van der Maarel 1992). Floristic classifications vary as to whether they emphasize dominant or overstory species of a stand (e.g., dominance types or SAF cover types [Whittaker 1978, Eyre 1980]), the ground layer species (e.g., forest site types or ecological species groups [Kimmins 1997, Host and Pregitzer 1991]), or the entire plant community. The most systematic vegetation classifications that have been developed are those that emphasize the entire plant community. Two such systems have been widely established—that of the Zürich-Montpellier or Braun-Blanquet system and the association/habitat type system of Daubenmire. Each of these systems uses a basic floristic unit called the association, defined as "a plant community type of definite floristic composition, uniform habitat conditions and uniform physiognomy" (Flahault and Shroter [1910] in Moravec 1992).

Braun-Blanquet established a floristic-diagnostic approach to the floristic classification of existing vegetation, emphasizing the systematic character of plant associations (see Braun-Blanquet 1928, Becking 1957, Whittaker 1962, Shimwell 1971, Mueller-Dombois and Ellenberg 1974, Westhoff and van der Maarel 1973). Braun-Blanquet (1921, in Moravec 1993) defined the association as "a plant community characterized by definite floristic and sociological (organizational) features which shows, by the presence of character-species (exclusive, selective, and preferential), a certain independence." Plant associations that shared diagnostic species were grouped into higher floristic units called alliances, orders, and classes (see Pignatti et al. 1995). Character species were based on the concept of fidelity: the degree to which a species is limited to a definite association (or to other floristic types higher or lower in the hierarchical taxonomy). Character species and others of high constancy (i.e., those present in at least 60% of the stands), along with ecologic and geographic considerations, helped to define an association. The use of character species worked best within a regional context, but the degree of fidelity of a species to an association tended to break down at larger scales (Becking 1957, Whittaker 1962).

The second widespread floristic classification approach is that of the association/habitat type classification system (Daubenmire 1952, Pfister and Arno 1980, Kotar et al. 1988). This system, based on detailed ground surveys, focuses on sampling late-successional, minimally disturbed vegetation over a full range of environments. Relationships between associations and soils or landform factors are evaluated during and after the classification process, but these ecological factors are not used to define the vegetation units (Komarkova 1983). The emphasis is on determining associations that represent ecologically equivalent sites (Kotar et al. 1988), and each resulting habitat type encompasses all the successional variants judged to be on these equivalent sites. The habitat type system groups associations into series determined by the shared late-seral dominants among a group of associations. An advantage of this system is that it provides a vegetation-based method for evaluating site potential and guiding forest conservation and management. Because of its emphasis on late-seral or climax associations, maps of habitat types are essentially equivalent to PNV maps, but the habitat type system provides a window into the ecological relationships associated with vegetation patterns.

Floristic methods reveal local and regional patterns of vegetation and are typically more detailed than physiognomic methods. Floristically-based systems rely on intensive field sampling, detailed knowledge of the flora, and careful tabular or quantitative analysis of stand data to determine the diagnostic species groups.

II.E.3. Physiognomic-Floristic Systems

Many approaches to classification have combined physiognomic and floristic systems. The rationale for these combined systems has developed over many years (e.g., Rübel 1930, Whittaker 1962, Westhoff 1967, Webb et al. 1970, Beard 1973, Werger and Sprangers 1982, Borhidi 1991). These studies have found a good fit between floristic and physiognomic classifications of the same vegetation. Underlying a physiognomic classification is the idea that each specific life form reflects a strategy that has been selected under ecological pressures, and that the composition of life forms in a vegetation type is governed by these strategies (Raunkier 1937, Walter 1973, Whittaker 1975, Stearns 1976). Since physiognomic attributes are borne by individual species, recognition of a physiognomic assemblage depends on the co-occurrence of species in a given area (Bourgeron and Engelking 1994). These co-occurring species can be classified further by floristic methods.

In the United States, Driscoll et al. (1984) recommended the development of a joint system using the physiognomic units of UNESCO (1973) and the floristic units of habitat types. An example of this has recently been provided by Dick-Peddie (1993) for New Mexico. Vankat (1990) developed a physiognomic-dominance type classification for forest types in North America. Strong et al. (1990) in Canada also proposed a combined physiognomic-floristic approach. In addition, Specht et al. (1974) used the joint approach to develop a conservation evaluation for Australian plant communities.

Not all vegetation is easily classified using a joint physiognomic-floristic approach. For example, researchers in the South African fynbos found a poor match between a structural classification and a floristic classification of the vegetation, in part because of the rapid structural changes following fires with little corresponding floristic change (McDonald et al. 1996). Physiognomic criteria may also require a separation among stands that are otherwise part of the same floristic unit (see Gillison 1994, especially Figure 8.1). Similarly, Austin and Margules (1986), in commenting on an Australian classification by Specht et al. (1974), point out that the "arbitrary class limits for continuous structural variables creates artificial pigeon-hole categories which may separate vegetation which is floristically identical." Because of this, it is important to evaluate and reevaluate the types of physiognomic and floristic criteria used to ensure the most effective correspondence between them. The most effective physiognomic-floristic classifications will be those which at the outset seek to maximize the contribution of both criteria.

II.F. Identification of Vegetation Units

Classification of vegetation begins with field observations of similar assemblages of plants that repeat across the landscape and appear to be correlated with similar environmental settings. The vegetation cover can then be divided into stands of plant communities—areas judged to be relatively homogeneous with respect to vegetation and environmental features. Gradually or abruptly, these stands may shift—both spatially and temporally—to stands of different composition and/or structure, depending on many factors. Of interest is the degree to which groups of species have shared distributions under some conditions in certain locations and at particular scales. A classification establishes criteria that allows one to generalize from these observations of individual stands to a set of shared characteristics that define an abstract type (Mueller-Dombois and Ellenberg 1974). A fundamental challenge in the process of classifying vegetation is deciding how to consistently group similar stands together to define vegetation units. This may be done through a variety of methods from careful qualitative assessment of field observations and data to rigorous quantitative analysis of stand data. The appropriate method depends largely on the objectives of the classification and the availability of data.

II.F.1. Delineating Stands of Vegetation (Entitation)

Plant communities are typically documented through the selection and analysis of representative stands. Entitation, or the delimitation of stands of plant communities in the field, is an important step because it places initial bounds on the concept of the vegetation type being described and establishes guidelines for field sampling. Decisions about where boundaries are drawn around stands in the field will vary considerably depending on the objectives of the classification. One might draw different boundaries around the same stand if all unique assemblages, certain successional stages, the dominant strata, or all strata were intended to be represented by the classification. Because of the continuous nature of vegetation change, the variable rates of this change per unit area, and the lack of any fundamental vegetation unit, there are few existing rules concerning the "right" scale of entitation.

II.F.2. Identifying Vegetation Types: Quantitative Approaches

Extensive research efforts conducted in the past provide a wealth of information that can support the development of a U.S. national classification. The stand data from these studies vary in completeness from partial species lists to detailed quantitative data on vegetation and ecological factors. Much of the data and any existing classifications can be used to identify national vegetation units—provided that the standards are consistent. In fact, existing data sets and classifications generally present some limitations for direct application to the development of a national classification. Collection and analysis of additional stand data across the range of a type is often needed. There are numerous methods available for analyzing stand data in order to develop the classification of national vegetation types. Three methods—ordination, cluster analysis, and tabular analysis—are commonly used, often in a complementary fashion (Mueller-Dombois and Ellenberg 1974, Gauch 1982, Digby and Kempton 1987, Jongman et al. 1987). Though these methods differ in their statistical approach, all arrange samples by similarity in species composition. While these methods have not changed the essentially subjective nature of classification decisions, they have helped to improve the consistency of these decisions.

Decisions about when to stop splitting the variability of vegetation are dictated, in part, by the desired degree of similarity among stands. For the recognition of associations, Mueller-Dombois and Ellenberg (1974) suggest, as a rule of thumb, that stands with an index of similarity of between 25 and 50% be part of the same association. The subject of "stopping rules" is a complex one, and a variety of complicated criteria are often applied. The nature of the vegetation itself strongly influences decisions about where to draw conceptual boundaries between vegetation types. Important considerations may include species richness, variability, degree of anthropogenic alteration, and the homogeneity of the vegetation.

The intended use of the classification should be reflected by the level of analysis. A classification developed for conservation purposes must provide a list of vegetation types that can be recognized in the field by trained ecologists. Detailed vegetation patterns demonstrated through quantitative techniques can help ecologists understand the variability of a given type, but these detailed patterns may not necessarily identify practical units for conservation.

II.F.3. Identifying Vegetation Types: Qualitative Approach

While quantitative analysis of stand data from across the range of a type is desirable, data from existing studies often do not meet the requirements for quantitative analysis or do not span the perceived geographic range of a type. Although these data are not as rigorous or comprehensive as could be desired, they can still be used to support the rangewide classification of vegetation types. The best way to use this rich resource of existing data is to have expert opinion inform a qualitative assessment of them. Whittaker (1962) suggested one qualitative approach to identifying vegetation units across regions by using a careful selection of dominant species. Where plot data are available, dominance types can be further subdivided using diagnostic species (Whittaker 1962). Studies by Vankat (1990) using existing data and by Monk et al. (1990) from original data illustrate the application of this method.

II.G. Classification and Mapping

Conservation and management of vegetation resources is more practical when the classification types can be mapped from aerial photography, satellite imagery, and ground survey. The relationship between vegetation classification and vegetation mapping, however, is extremely complex. The ability to map vegetation accurately depends upon the imagery to be used, the minimum mapping unit desired, the scale of the classification, the amount of ground survey possible, and the availability of ancillary data sets. The scale and resolution at which mapping is both useful and practical is determined by the intended use of the map, the intrinsic characteristics of the vegetation, and the resources available for the effort.

Usually mapping efforts begin with an analysis of remotely-sensed imagery. Imagery analysis requires the development of decision rules used to assign consistent vegetation labels to the spectral signatures visible on the imagery. These decision rules are best developed jointly by photo-interpreters and ecologists familiar with the vegetation and its landscape context. Such a collaborative effort allows for the integration of spectral and ecological information to achieve the best representation of the vegetation types at the desirable scale.

The type of imagery (e.g., color, infrared, black and white, digital, single or multiple band, etc.) as well as the scale, resolution, and timing of the imagery all determine how accurately the vegetation can be mapped. Even with the best available imagery, not all important vegetation distinctions are discernible through interpretation of the imagery alone. The environmental conditions or diagnostic species that distinguish closely related types are often not discernible on imagery. When available technology cannot support the desired resolution of classification, imagery analysis can often be supplemented with integration of ancillary data (hydrology, soils, etc.) and ground survey.

When it is impossible to discern important characteristics of the vegetation with an acceptable level of accuracy, vegetation may be mapped at a coarser level of classification. Hierarchical classification systems often make it possible to identify a coarser vegetation level appropriate to the practicalities of a mapping project. Hierarchical classifications that include physiognomic levels lend themselves more readily to mapping, since these criteria are more often detectable from remote-sensing imagery. For example, although a wetland black spruce (*Picea mariana)* stand is distinguishable from a wetland white cedar (*Thuja occidentalis*) stand on the ground, it may only be possible to recognize each as a "wetland conifer" stand through the analysis of available imagery.

When mapping at a coarse level of classification is not desirable, but fine-level vegetation types are difficult to discern, it may be necessary to aggregate vegetation types into single mapping units. For example, seasonally flooded loblolly pine-dominated (*Pinus taeda*) types are often mixed with upland loblolly pine-dominated types, but it is difficult to distinguish them using imagery. In such cases a mapping unit which combines both closely related types must be defined. More often, aggregated map units will represent ecologically linked types that have very different structures and/or compositions. For example, Coastal Plain pondshores in the eastern United States typically have three zones distinguished by vegetation types with very different structures and compositions: a shrub zone (least wet), a seasonally flooded herbaceous zone, and a semipermanently flooded or aquatic zone. These zones are often mapped as a single unit due to their dynamic nature, fine scale of occurrence, and consistent co-occurrence on the landscape.

Vegetation mapping is often a localized exercise to discern consistent signatures from the available imagery using the best available local or regional classifications. The resulting maps may have high utility at the local level, but often do not portray broader patterns of vegetation distribution on a regional or national scale. The application of a consistent national classification may present local mapping challenges, but the resulting products will support assessment at the local, regional, and national levels.

III

The U.S. National Vegetation Classification

Guiding Principles of the U.S. National Vegetation Classification

The USNVC has been constructed from the efforts of many ecologists whose work preceded that of the Conservancy. It is an attempt to integrate the features of existing systems that best fit the needs of the Conservancy and its partners. Six key decisions were made regarding the issues that were discussed in Section II. The classification

- *is vegetation-based*
- *uses a systematic approach to classifying a continuum*
- *emphasizes natural vegetation*
- *emphasizes existing vegetation*
- *uses a combined physiognomic-floristic hierarchy*
- *identifies vegetation units based on both qualitative and quantitative data at a scale that is practical for conservation*
- *is appropriate for mapping at multiple scales*

These decisions are discussed in greater detail below.

III.A. Base the Classification on Vegetation

A pivotal decision made by Conservancy ecologists was to develop a terrestrial classification system that was based primarily on vegetation. Several factors were key to this decision. First, the mission of the Conservancy is to protect biodiversity. A classification that emphasizes the biotic component of ecological systems was seen as most directly relevant to this mission. Second, vegetation is a readily measured component of ecological systems. Ease of measurement is important to ongoing surveys of the status of biodiversity being conducted on the ground and through analysis of aerial photography and satellite imagery, as well as to monitoring and restoration efforts. Third, building such a system was more practical than building a complex multi-factor system.

A vegetation-based classification is valuable in itself because it describes an important biotic component of ecological systems. The Conservancy has a strong interest in linking its vegetation-based approach to ecological land classifications such as ECOMAP (Avers et al. 1994) and that of Bailey (1995). These classifications provide a series of hypotheses about the ecological variables that structure a system and represent the ecological variability present in a landscape, irrespective of the disturbances to the vegetation (Lapin and Barnes 1995). In addition, vegetation-based descriptions of the landscape will benefit from an integration with assessments of landscape processes (Bourgeron et al. 1994, Chen et al. 1996).

III.B. Use a Systematic Approach to Classifying a Vegetation Continuum

The USNVC recognizes that the underlying pattern of vegetation is more or less that of a continuum. However, continuum theory does not preclude recognizing the degree to which species form repeating groups in ecologically similar habitats. Thus, the USNVC categorizes continuously varying, multi-dimensional species assemblages in a reasoned, systematic, but somewhat arbitrary way. Such categories or types are an important tool for organizing information and communicating the needs of conservation and management (Shimwell 1971, McIntosh 1993).

A plant community type in any classification system can be characterized based on specified criteria for homogeneity, but individual stands can present great variability in species composition and structure. To accommodate some of this variability, the USNVC is ecologically realistic: it does not require too rigid a system of diagnostic species or physiognomic structure. It relies on units that are flexibly designed with respect to concordant species patterns, but which are explicit in their descriptions of the major dominants and characteristic species of the types and the full range of the type's variability.

The USNVC represents a simplification of natural complexity and a consequent loss of information, as does any classification. Thus, the classification will be only one component of efforts to describe and understand the multi-dimensional, continuous pattern of vegetation. However, when a systematic sampling of vegetation is undertaken across a region, the classification of that pattern can be a powerful stimulus to the conservation, management, and restoration of vegetation (Daubenmire 1952, Curtis 1959, Shimwell 1971, Rodwell 1991).

III

III.C. Apply the Classification to Natural Vegetation

The Conservancy's focus is on the classification of natural vegetation for conservation applications. Whereas the USNVC framework can be used to classify all vegetation, only the more natural types are systematically classified and described by the Conservancy and the Natural Heritage Network. Within the context of the USNVC, "natural vegetation" is broadly defined to include types that occur spontaneously without regular management, maintenance, or planting, and that generally have a strong component of native species. For the purposes of conservation, however, it is useful to further divide these natural and semi-natural types into natural/near natural and semi-natural/altered categories (see Figure 1 on page 16 and Appendix E on page 123). Natural/near natural vegetation refers to plant communities that appear to be unmodified, or only marginally impacted, by human activities. Where anthropogenic impacts are apparent, the resulting physiognomic and floristic patterns have a clear, naturally maintained analogue. For example, a native grassland stand that has been invaded by native shrubs due to fire suppression may be considered a near-natural type when it resembles natural stands where fire was less frequent[3]. Semi-natural/altered vegetation may be defined as plant communities where the species composition or structure of the vegetation has been sufficiently altered by anthropogenic

[3] The effects of human influences on natural/near-natural vegetation can partly be evaluated by the Conservancy using a ranking system that rates the individual stands with respect to their naturalness. The ranking system reduces the need to classify human impacts per se on natural/near-natural vegetation, treating these impacts instead as part of the variability of a type. Only where such impacts cause a considerable departure from the floristic and physiognomic characteristics of the type are the stands classified as semi-natural/altered or planted/cultivated types.

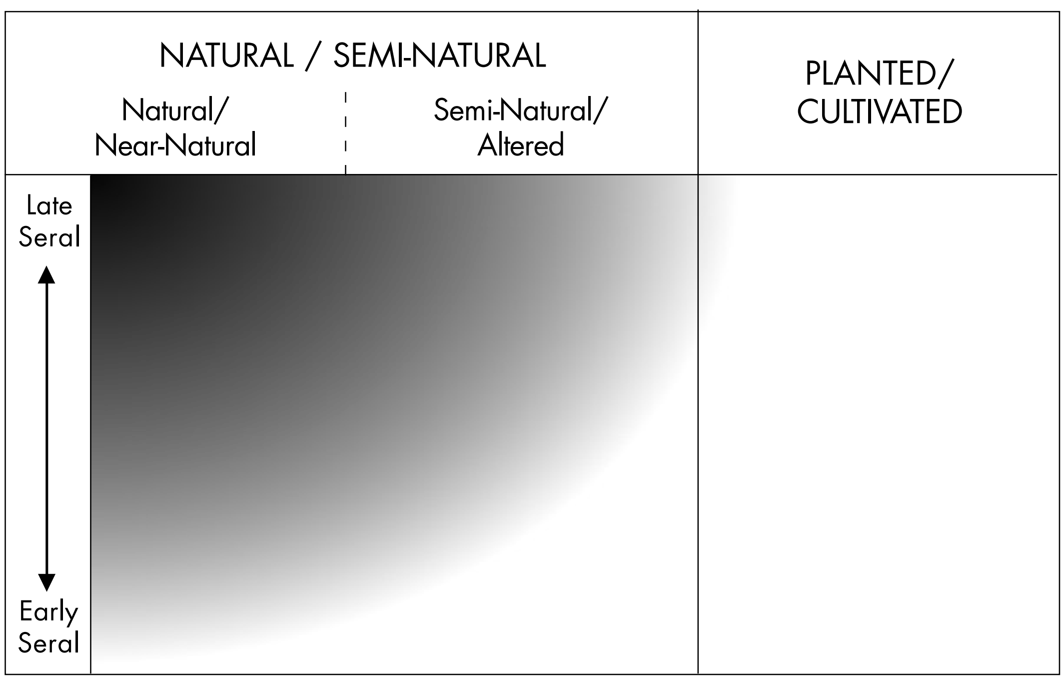
disturbance such that no clear natural analogue is known. This type of vegetation may be dominated by either native or exotic species. One example is an old field community that originated on abandoned farmland and is dominated by native species, but the species assemblage is never found in natural/near-natural stands. A second example is a stand of Melaleuca or cajeput-tree (*Melaleuca quinquenervia*), an aggressive exotic species that occurs without human maintenance or management and has become a major part of the Everglades landscape in south Florida.

Planted/cultivated vegetation includes types such as orchards, pastures, and vineyards. Semi-natural/altered and planted/cultivated vegetation types have not been classified or described to any great extent by the Conservancy, but further development of these types will undoubtedly be useful to, and pursued by, other organizations and agencies.

III.D. Apply the Classification to Existing Vegetation

The focus of the USNVC is on existing, rather than potential, vegetation. In the Conservancy's conservation strategy, it is assumed that effective conservation of all existing natural community types will ensure the conservation of a high percentage of all species, both plant and animal. Therefore, identification of all existing natural types, rather than only those that are late-seral

FIGURE 1. Vegetation Being Classified by the Conservancy and Natural Heritage Programs



Shading illustrates vegetation being classified by the Conservancy and Heritage Programs. All types of vegetation—natural and cultural—may be classified with the USNVC system, but the Conservancy and Heritage Program efforts have been primarily focused on mid- to late-seral, natural/near-natural vegetation. Less natural and earlier seral vegetation are also sometimes classified (typically on an as-needed basis for use in various applications). Often these classifications are at a coarser level of the hierarchy and are less comprehensive than those focused on more natural, late-seral types.

or potential, is a necessary component of the Conservancy's approach to biodiversity conservation. While the USNVC framework is comprehensive with regard to existing vegetation—encompassing the spectrum from natural to cultivated—the Conservancy's efforts have focused on the best existing occurrences of natural types, both naturally disturbed (early- and mid-seral) and naturally *un*disturbed (late-seral) types.

In addition to its usefulness for conservation purposes, the classification of existing, rather than potential, vegetation makes fewer assumptions about process or vegetation dynamics and allows the taxonomy to be grounded in what is directly observable and measurable. When the sampling and description of types includes environmental factors, an emphasis on existing vegetation allows the greatest latitude in subsequent data interpretation. Classification of existing natural vegetation also allows interpretation of vegetation patterns in the context of ecological units and processes at multiple scales. Therefore, the focus on existing vegetation can support a wide number of uses in addition to the identification of conservation sites. These include inventory and monitoring of the current status of vegetation, mapping of the landscape, and development of dynamic ecological models (including models of succession and response to management).

III.E. Use a Physiognomic-Floristic Approach

The USNVC uses both physiognomic and total floristic composition criteria, allowing for most of the advantages of both approaches. The formation concept guides the development of physiognomic types (Whittaker 1962, 1975), and the association concept guides the development of floristic units (Moravec 1993).

The USNVC has a hierarchical taxonomic structure with physiognomic criteria used at the coarsest levels of the hierarchy and floristic criteria used at the finest. This ordered structure allows flexibility in emphasis from essentially physiognomic to essentially floristic descriptions and provides a unifying framework within which to relate national and international physiognomic systems to local and regional floristic systems. Structuring the classification in a hierarchical fashion allows it to be used at different taxonomic scales, depending on the amount of information and resolution needed. This approach also facilitates the organization and tracking of information.

The current USNVC represents an initial attempt at melding floristic and physiognomic approaches; the floristic levels are at least partially *constrained* by the upper levels. Such a statement may imply an overly rigid classification, with floristically very similar stands being artificially separated solely by physiognomic criteria. However, the USNVC accounts for the inherent variability of vegetation by placing the *abstract* floristic type within a single physiognomic class, explicitly noting that individual stands will express physiognomic variation clustering around this average expression.

In certain cases, structurally different stands of very similar species composition are placed in different formations, in recognition that these structural differences have a particular significance. These "variants" may or may not warrant recognition as separate associations based on pure floristics, but such distinctions are both a trade-off for retaining the utility of the physiognomic upper levels and a recognition that structural patterns can have important ecological meaning beyond those indicated by floristics alone. Ongoing review of both the physiognomic and floristic criteria chosen will be needed to ensure maximal value of both these criteria. Because the USNVC has primarily been developed using a "top down" approach (i.e., by partially constraining floristic types to pre-defined physiognomic categories), an overall reexamination of the physiognomic criteria used is especially needed to ensure that they provide the most useful and "unforced" bases for further classification.

III.F. Identify Types Using a Pragmatic Approach

The USNVC was specifically developed for conservation purposes. Conservancy ecologists have used both qualitative and quantitative analysis of existing and newly collected field data to develop a list of vegetation types that could be used to efficiently inform conservation decision making.

III.F.1. Delineating Stands

As stated previously, the process of entitating stands is strongly influenced by the classification approach to be employed. Because the USNVC employs a physiognomic-floristic approach, stands are chosen based on homogeneity of floristics, physiognomy, and habitat.

III.F.2. Identifying Vegetation Types

The finest level of the USNVC, the association, is intended to be the basic unit of inventory for biodiversity assessment. Associations are defined as mutually exclusive, with definite conceptual boundaries. Each association is designed to be clearly recognizable by trained ecologists. Each occurrence or stand of an association is similar enough in composition, structure, and habitat that it can be compared, contrasted and ultimately ranked against other occurrences of its type for conservation purposes. Yet a reasonable range of variation within a type is accepted, so that the number of types does not become so great that types can no longer be effectively described, tracked, and managed.

The status of expert knowledge and existing data dictates that the development of USNVC types be an iterative, qualitative, and quantitative process that will require successive approximation and refinement over time. Thus far, in the absence of complete floristic data sets, many alliances and associations have been defined using a thorough qualitative analysis based on available information on the dominant species, characteristic species (those that are typical or indicative of a habitat or have a particular geographic distribution), and environmental variables. Wherever existing classifications that rely on concepts similar to that of the formation and the association are available, their types are provisionally included in the USNVC. Expert local and regional ecological opinion is widely used to assist in this process.

To date, no explicit quantitative or qualitative formula has been applied in the formal recognition of USNVC associations. The lack of total floristic data in many cases precludes the standard use of an index of similarity or other mathematical measure; in some cases criteria other than floristic composition (e.g., structure) necessarily dictate the preliminary recognition of associations.

Quantitative analysis of stand data collected for vegetation types across their perceived range is increasingly used to define types in the USNVC (see Section V.B.1.d.). As this practice becomes increasingly widespread, objectivity and repeatability in classification will improve. To achieve this long-term goal, the Conservancy has implemented a set of guidelines for standardized vegetation data collection and has provided general guidance on data analysis (see Section V.B.1.). The refinement of the USNVC will depend on further implementation of standard protocols for analysis of original and existing data sets.

III.G. Facilitate Mapping Applications

The use of physiognomic criteria to define the upper levels of the USNVC hierarchy makes it a practical tool for mapping applications. It is often possible to identify a certain level of the vegetation hierarchy that is appropriate to the scale and resolution of mapping for a particular project. However, USNVC classification units are independent of their scale and ability to be mapped.

For a map at any given scale, some vegetation types can be mapped directly. Many other vegetation types will not be mappable due to the resolution of the imagery and the spatial pattern of the vegetation. As such, map units can be constructed for several associations that are unrelated in the hierarchy but occur as repeating units on the ground. For example, a pine barrens community in New Jersey may contain several distinct associations that often occur together. A map unit created for this area may encompass all of these associations, and thus will not have direct correspondence to a single vegetation type. However, the vegetation pattern of the unit can be described by noting the typical associations that occur within each map unit.

The relationship between vegetation classification and mapping is complex. The USNVC, as a standardized classification system, provides consistent objectives for vegetation mapping. Maps attributed with standardized USNVC types can directly contribute to a standardized information base that is needed for regional, national, and international assessments and planning.

IV

The U.S. National Vegetation Classification

The Structure of the U.S. National Vegetation Classification

The fundamental issues and decisions discussed in Sections II and III provide the context for the development of USNVC. This section discusses the overall structure of the classification framework in more detail. This structure is applicable worldwide; however, the focus of this section is on its application to vegetation within the United States.

IV

IV.A. System Level

The top division of the classification hierarchy separates terrestrial vegetated communities (terrestrial system) from those of deep-water habitats (freshwater aquatic and marine systems) and subterranean habitats (subterranean system). The terrestrial system as defined includes all terrestrial vegetation and all wetland and shallow water vegetation with rooted vascular plants. In relation to Cowardin et al. (1979), this system includes the terrestrial system and those portions of the palustrine, lacustrine, riverine, estuarine, and marine systems that have rooted vegetation.

IV.B. Hierarchical Structure of the Terrestrial System

The terrestrial classification system has seven hierarchical levels. This structure allows the classification to be applied at the appropriate level for the amount of information available and the needed resolution. Five levels (formation class, formation subclass, formation group, formation subgroup, and formation) are based on physiognomic characteristics, and two levels (alliance and association) are derived from species composition (floristics) (see Figure 2, below, and Table 1 at the end of this chapter).

IV.B.1. Physiognomic Levels

The upper levels of the classification framework are a modification of the UNESCO World Physiognomic Classification of Vegetation (1973). This system was chosen for the following reasons:

- It is the existing product of an international group of experts. As such, it is more readily acceptable than a new, local, or single-authored system. It is global in scope, and parts or variants of the framework are presently being used by different United States and international agencies.
- It was constructed to be ecologically meaningful.
- It is a hierarchical system that was designed for classification and mapping at multiple scales, though generally at a scale of 1:1,000,000 or coarser.
- The structure of the framework is somewhat flexible and open-ended; units can be added as needed.

FIGURE 2. Hierarchical Vegetation Classification System for the Terrestrial Ecological Communities

SYSTEM: TERRESTRIAL		
physiognomic levels	FORMATION CLASS FORMATION SUBCLASS FORMATION GROUP FORMATION SUBGROUP FORMATION	
floristic levels		ALLIANCE ASSOCIATION

Several limitations of the UNESCO hierarchy were addressed to meet the objectives for the upper physiognomic levels of the USNVC. A more systematic framework, i.e., the more consistent application of criteria to define each level of the hierarchy, was implemented. For example, in the UNESCO system, different criteria are used to distinguish formation subclasses depending on which formation class is being subdivided. In the USNVC, however, predominant leaf phenology is the single criterion used to define formation subclasses in the Forest, Woodland, Shrubland, and Dwarf-Shrubland Formation Classes. In addition, to ensure a more consistent application of the criteria, supporting information was developed to explain the criteria used (see the descriptions of the USNVC physiognomic levels presented below). Finally, the Conservancy adapted the UNESCO formation level, based on modifications suggested by Driscoll et al. (1984), to make the system more practical for finer scale applications. For example, wetland vegetation was included in the UNESCO classification only when it occurred over large areas, such as extensive woodland bogs. Finer-scale wetland vegetation types, such as sedge meadows and seepage fens, were not recognized, though these are typically physiognomically distinct from adjacent wetland and upland vegetation. USNVC formations allow recognition of these types.

Compatibility with other systems was also a consideration in the development of the physiognomic levels. The "subclass level" of UNESCO was modified, and a new formation subgroup was added to support the Federal Geographic Data Committee's need to classify managed and cultural vegetation (FGDC 1997). Hydrological modifiers based on Cowardin et al. (1979) were also added at the formation level, since they have been used extensively to map wetlands across the United States. Each physiognomic level is described in more detail below.

Formation Class

The formation class (hereinafter called "class") is based on the structure of the vegetation. These types are determined by the relative percentage of cover and the height of the dominant, uppermost life forms, whether they are trees, shrubs, dwarf-shrubs, herbaceous plants, or nonvascular plants. This level has seven mutually exclusive classes:

FOREST: Trees with their crowns overlapping (generally forming 60-100% cover).

WOODLAND: Open stands of trees with crowns not usually touching (generally forming 25-60% cover). Canopy tree cover may be less than 25% in cases where it exceeds shrub, dwarf-shrub, herb, and nonvascular cover, respectively.

SHRUBLAND: Shrubs generally greater than 0.5 m tall with individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees generally less than 25% cover). Shrub cover may be less than 25% where it exceeds tree, dwarf-shrub, herb, and nonvascular cover, respectively. Vegetation dominated by woody vines is generally treated in this class.

DWARF-SHRUBLAND: Low-growing shrubs usually under 0.5 m tall. Individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees and tall shrubs generally less than 25% cover). Dwarf-shrub cover may be less than 25% where it exceeds tree, shrub, herb, and nonvascular cover, respectively

HERBACEOUS: Herbs (graminoids, forbs, and ferns) dominant (generally forming at least 25% cover; trees, shrubs, and dwarf-shrubs generally with less than 25% cover). Herb cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and nonvascular cover, respectively.

NONVASCULAR: Nonvascular cover (bryophytes, non-crustose lichens, and algae) dominant (generally forming at least 25% cover). Nonvascular cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and herb cover, respectively.

SPARSE VEGETATION: Abiotic substrate features dominant. Vegetation is scattered to nearly absent and generally restricted to areas of concentrated resources (total vegetation cover is typically less than 25% and greater than 0%).

Types within the Nonvascular and Sparse Vegetation Classes have not been well developed. Sparse Vegetation types are primarily based on substrate features, rather than vegetation. As more information is gathered, these types will be increasingly defined by their vegetation characteristics.

Formation Subclass

The formation subclass (hereinafter called "subclass") is based upon growth-form characteristics. Predominant leaf phenology (i.e., evergreen, deciduous, or mixed evergreen-deciduous) is the character that divides the Forest, Woodland, Shrubland, and Dwarf-Shrubland Classes into subclasses. Persistence and growth form (perennial or annual; and graminoid, forb, or hydromorphic) divide the Herbaceous Class into subclasses. The relative dominance of lichens, mosses, and algae divides the Nonvascular Class. Subclasses (and lower hierarchical levels) of the Sparse Vegetation Class are defined primarily by substrate features. To provide more meaningful and readily observable divisions, particle sizes of the substrate (e.g., consolidated rocks, gravel/cobble) divide the Sparse Vegetation Class at the subclass level.

Formation Group

The formation group (hereinafter called "group") defines vegetation units based on leaf characters, such as broad-leaf, needle-leaf, microphyllous, and xeromorphic. These units are identified and named in conjunction with broadly defined macroclimatic types (tropical or subtropical, temperate or subpolar, winter-rain, drought-deciduous, cold-deciduous) to provide a structural-geographic orientation, but the ecological climate terms do not usually define the groups per se. The presence of woody strata is used with climate to separate groups in the Herbaceous and Nonvascular Classes (e.g., herbaceous with a sparse tree layer is separated from herbaceous with a sparse shrub layer). Sparse Vegetation groups are separated by major topographic position types or landforms (e.g., cliffs versus flat pavement, talus versus rock flats).

Formation Subgroup

The formation subgroup (hereinafter called "subgroup") level divides each group into either a Natural/Semi-natural or a Cultural Subgroup, providing a consistent dichotomy between natural vegetation (broadly defined to include natural, semi-natural, and modified vegetation) and cultural or planted/cultivated vegetation. This level does not exist in the UNESCO (1973) classification; it was introduced to the USNVC to facilitate the inventory, classification, and mapping of all vegetation types across the natural and cultural landscape. Its placement at the subgroup level allows for the development of culturally distinct formations (e.g., orchards and vineyards) within the overall hierarchy.

Formation

The formation represents vegetation types that share a definite physiognomy or structure within broadly defined environmental factors, relative landscape positions, or hydrologic regimes. Structural factors such as crown shape and lifeform of the dominant stratum are used in addition to the physiognomic characters already specified at the higher levels. Hydrologic modifiers, adapted from Cowardin et al. (1979), are used for wetlands.

IV.B.2.
Floristic Levels

The lowest two levels of the hierarchy—the alliance and the association—are based on floristics; both levels are developed from the dominant or diagnostic species. In the absence of detailed floristic information, the emphasis is placed solely on dominant species. When floristic tables are available, alliances and associations are still primarily defined by dominant species, but additional diagnostic species may be considered as well (see Moravec 1993).

Alliance

Within a formation, the alliance is a physiognomically uniform group of plant associations (see *Association* below) sharing one or more dominant or diagnostic species, which as a rule are found in the uppermost stratum of the vegetation (see Mueller-Dombois and Ellenberg 1974).

For forested communities, the alliance is roughly equivalent to the Society of American Foresters' "cover type" (Eyre 1980), which was developed to describe the forest types of North America. However, the alliance is generally finer in detail than these cover types, which are characterized by a dominant tree species that extends over large geographic areas and varied environmental conditions. Alliances also apply to all non-forest vegetation types.

The alliance is also similar to the "series," a concept developed within the habitat type system to group habitat types that share the same dominant species under climax conditions. Alliances, however, are grouped by the dominant or diagnostic species for *all existing* vegetation types, whereas series are generally restricted to vegetation types occurring at the end of succession, with all early- to mid-successional types grouped into the series they presumably become at climax (see Pfister and Arno 1980).

Nomenclature for Alliances

The names of dominant and diagnostic species are the foundation of the alliance names. At least one species from the dominant and/or uppermost stratum is included. In rare cases where the combination of species in the upper and lower strata is strongly diagnostic, species from other strata are included in the name. Species occurring in the same stratum are separated by a hyphen (-), and those occurring in a different strata are separated by a slash (/). Species occurring in the uppermost stratum are listed first, followed successively by those in lower strata. In physiognomic types where there is a dominant herbaceous layer with a scattered woody layer, alliance names can be based on species found in the herbaceous layer and/or the woody layer, whichever is more diagnostic of the type.

Species less consistently found in all associations of the alliance may be placed in parentheses, and these parenthetical names are generally listed alphabetically. In cases where a particular genus is dominant or diagnostic, but the presence of individual species of the genus may vary among associations, only the specific epithets are placed in parentheses.

Nomenclature for vascular plant species follows a nationally standardized list (Kartesz 1994), with very few exceptions. Nomenclature for nonvascular plants follows Anderson (1990), Anderson et al. (1990), Egan (1987, 1989, 1990), Esslinger and Egan (1995), and Stotler and Crandall-Stotler (1977).

The lowest possible number of species is used for an alliance name. A maximum of four species is currently allowed.

Alliance names include the class (e.g.,

"Forest," "Woodland," "Herbaceous") in which they are classified, followed by the word "alliance." Use of the word "alliance" in the name distinguishes these types from associations. Exceptions are types within the Sparse Vegetation Class, which are not based on floristics; these do not include the word "alliance" in the name.

For all wetland alliances, the formation hydrologic modifier—which indicates the hydrologic regime in which the alliance is found—is also included in the name (e.g., *Acer saccharinum* Temporarily Flooded Forest Alliance). Alliances may be assumed to be upland types when the name lacks a hydrologic modifier.

Modifiers descriptive of the height of the vegetation or of environmental conditions are used sparingly, primarily in cases where the species composition of the alliance is incompletely understood and the alliance name would not otherwise be unique (e.g., *Picea sitchensis* **Giant** Forest Alliance, *Quercus alba* **Montane** Forest Alliance). These modifiers are "placeholders" only; they will eventually be replaced by diagnostic species name(s).

Alliance names generally do not include infraspecific taxa unless such taxa are particularly diagnostic.

A genus name followed by the abbreviation "spp." is used to indicate that the alliance contains numerous mixed species of that genus *or* that the species are unknown.

Examples of alliance names:

Pseudotsuga menziesii Forest Alliance
Fagus grandifolia - Magnolia grandiflora Forest Alliance
Pinus virginiana - Quercus (coccinea, prinus) Forest Alliance
Pinus rigida Woodland 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
Cobble/Gravel Shore Sparse Vegetation

Association

The association is the finest level of the hierarchy, and the basic unit for vegetation classification in North America. It is defined as "a plant community type of definite floristic composition, uniform habitat conditions, and uniform physiognomy" (see Flahault and Schroter 1910).

Associations may occur at variable spatial scales. The variation is driven by the steepness of the environmental gradients and patterning of disturbance processes across the landscape. For example, many upland eastern forests and western grassland associations occur naturally in patches of thousands or even tens of thousands of acres, whereas some herbaceous associations of seasonally flooded wetlands may occupy a few acres or less. In addition, the same association can occur at different scales under different environmental and disturbance conditions. Uniformity of physiognomy and habitat conditions may include patterned fine-scale heterogeneity (e.g., shrub savanna).[4] "Habitat" refers to the combination of environmental (site) conditions and ecological processes (such as disturbances) influencing the community.

Nomenclature for Associations

As with alliances, the names of dominant and diagnostic species are the foundation of the association names. Species occurring in the same stratum are separated by a hyphen (-), and those occurring in different strata are separated by a slash (/). Species occurring in the uppermost strata are listed first, followed successively by those in lower strata. Within the same stratum,

[4] The association may also consist of a complex of plant communities when those communities co-occur and constitute a functioning ecological unit (e.g., hummock and hollow vegetation in patterned peatland). Such cases are exceptional in the USNVC.

the order of species names generally reflects decreasing levels of dominance, constancy, or indicator value. In physiognomic types where there is a dominant herbaceous layer with a scattered woody layer, association names can be based on species found in the herbaceous layer and/or the woody layer, whichever is more diagnostic of the type.

Species less consistently found in all occurrences of the association are placed in parentheses. In cases where a particular genus is dominant or diagnostic, but individual species of the genus may vary among occurrences, only the specific epithets are placed in parentheses.

Nomenclature for vascular plant species follows the nationally standardized list of Kartesz (1994), with very few exceptions. Nomenclature for nonvascular plants follows Anderson (1990), Anderson et al. (1990), Egan (1987, 1989, 1990), Esslinger and Egan (1995), and Stotler and Crandall-Stotler (1977).

The lowest possible number of species is used in an association name. The use of up to six species may be necessary to define types with very diverse vegetation, relatively even dominance, and variable total composition.

Association names include the class in which they are classified. The word "vegetation" follows "herbaceous" and "nonvascular" for types in those classes.

In cases where diagnostic species are unknown or in question, a more general term is currently allowed as a "placeholder" (e.g., *Pinus banksiana* - (*Quercus ellipsoidalis*) / *Schizachyrium scoparium* - Prairie Forbs Wooded Herbaceous Vegetation). 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

IV

TABLE 1. The USNVC's Physiognomic-floristic Hierarchy for Terrestrial Vegetation

LEVEL	PRIMARY BASIS FOR CLASSIFICATION	EXAMPLE
Class	Growth form and structure of vegetation	Woodland
Subclass	Growth form characteristics, e.g., leaf phenology	Deciduous Woodland
Group	Leaf types, corresponding to climate	Cold-deciduous Woodland
Subgroup	Relative human impact (natural/semi-natural, or cultural)	Natural/Semi-natural
Formation	Additional physiognomic and environmental factors, including hydrology	Temporarily Flooded Cold-deciduous Woodland
Alliance	Dominant/diagnostic species of uppermost or dominant stratum	*Populus deltoides* Temporarily Flooded Woodland Alliance
Association	Additional dominant/diagnostic species from any strata	*Populus deltoides* - (*Salix amygdaloides*) / *Salix exigua* Woodland

Table 1 provides a summary and an example of the terrestrial classification hierarchy.

reasons of standardization and brevity, however, this is kept to a minimum. Examples are: *Quercus alba / Carex pensylvanica - Carex ouachitana* Dwarf Forest, *Cephalanthus occidentalis / Carex* spp. Northern Shrubland.

When confidence in the circumscription of the association is low, especially in cases where the association represents a large, heterogeneous group of stands that is unlikely to remain one association following analysis of additional data, the association name is followed by the term "[Provisional]".

Examples of association names:

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
Schizachyrium scoparium - (*Aristida* spp.) Herbaceous Vegetation

IV

V

The U.S. National Vegetation Classification

Development of the U.S. National Vegetation Classification and Its Relationship to Other Classification Systems

Section V.A. presents a brief history of the development of the USNVC system. An overview of the processes involved in developing specific vegetation types within the system is presented in Section V.B. Section V.C. describes the relationship of the USNVC to other important classification systems.

V.A. History of the Development of the USNVC System

Ecological communities have been used by the Conservancy and the Natural Heritage Programs for many years to help prioritize conservation action. The USNVC system has been developed by the Conservancy incrementally over the past twenty years to increase the effectiveness of this approach. Ecologists in state Heritage Programs began by collecting community information and developing state-level community classifications without reference to national standards. Thousands of published references and unpublished data sets (e.g., quantitative data, qualitative data, agency "gray literature," and Heritage Program element occurrence data) were reviewed and analyzed to develop these state classifications. Some of the state classifications are based strictly on vegetation, while others take a natural community approach and incorporate environmental parameters (e.g., geologic substrate, soils, hydrology), landscape pattern, and physiographic information into the classification. The classifications vary from state to state in spatial scale and in the recognized level of temporal variation. Regardless of their approach, each state classification summarizes a wealth of state-level information and reflects ecological units that are recognized and widely endorsed by local experts (e.g., White and Madany 1978, Baker 1984, Nelson 1985, Reschke 1990, Schafale and Weakley 1990). These units became the building blocks for the identification and classification of vegetation alliances and associations in the USNVC that are listed in Volume II of this report (Anderson et al. 1998).

With the spread of Natural Heritage and Conservancy programs across all states, it became increasingly evident that the application of multiple, unrelated state classifications to determine regional and national conservation priorities was potentially detrimental to achieving the Conservancy's mission. In the early 1980s, the Conservancy began in earnest to complete the task of developing a consistent national set of standards for the classification of ecological communities. A team of regional and national ecologists reviewed classification theory and practice and began to synthesize the state classifications within each of the four Conservancy Conservation Science Regions (see Table 2).

In the Conservancy's West Region, most of the state classifications were based on vegetation and were strongly influenced by the habitat type approach. The initial regional classification retained the habitat type approach to organize the identified state floristic units into series and associations. These floristic units were arranged under the Driscoll et al. (1984) hierarchy (Baker 1984). In the Midwest, East, and Southeast Regions, there was little tradition of floristically-based classifications as vegetation

V

TABLE 2. The Nature Conservancy Conservation Science Regions

East	Southeast	Midwest	West
Connecticut	Alabama	Illinois	Alaska
Delaware	Arkansas	Indiana	Arizona
Maine	Florida	Iowa	California
Maryland	Georgia	Kansas	Colorado
Massachusetts	Kentucky	Michigan	Hawaii
New Hampshire	Louisiana	Minnesota	Idaho
New Jersey	Mississippi	Missouri	Montana
New York	North Carolina	Nebraska	Nevada
Pennsylvania	Oklahoma	North Dakota	New Mexico
Rhode Island	South Carolina	Ohio	Oregon
Vermont	Tennessee	South Dakota	Utah
Virginia	Texas	Wisconsin	Washington
West Virginia			Wyoming

classifications were not broadly accepted as useful in conservation and resource management applications. As a result, each of these regions used different natural community classification approaches to synthesize existing state classifications into regional classifications (see Chapman 1988, Allard 1990).

The Conservancy decided in the early 1990s that the natural community approaches were locally relevant but would not meet national and international objectives of consistency and compatibility. A team of Conservancy ecologists agreed upon a national framework for classifying terrestrial ecological communities based primarily on the structure and composition of existing vegetation. The UNESCO classification (1973) became the basis for the upper physiognomic levels of the hierarchy (see Section IV.B.), and the vegetation alliance and association were selected as the basis for the detailed floristic levels.

The decision to proceed with a physiognomic-floristic hierarchical approach set the course for the implementation of the present USNVC system. The UNESCO physiognomic-ecological framework was revised to be more consistent in the application of variables at each hierarchical level and to incorporate additional ecological parameters (see Section IV.B.). At that time, the floristic levels were structured only in concept; the alliance level was largely undeveloped, and few associations had been defined. Efforts were concentrated on the development of these floristic levels. Conservancy ecologists began to develop subsets of the national classification for each of the four regions. Ecologists in the West Region used the extensive existing literature on habitat types in their work with state Natural Heritage Programs (Bourgeron and Engelking 1994). Ecologists in the Midwest Region evaluated a combination of dominance types and natural communities from state classifications to approximate floristic associations (Faber-Langendoen 1993). Ecologists in the Southeast Region used a similar approach, but they relied more heavily on expert opinion where published information was lacking. Ecologists in the East Region established more floristically-based alliance units and sorted state Natural Heritage types by these (Sneddon et al. 1994). *De novo* classification from original plot data was also completed on an as-needed, mostly project-driven basis. These efforts formed the beginnings of a draft national classification. Regional ecologists then worked together to standardize the units across regions, leading to a series of revisions and refinements in all levels of the hierarchy (Faber-Langendoen and

Midwest state Heritage Program ecologists 1996, Sneddon et al. 1996, Weakley et al. 1997*a*, *b*), and the first draft of a national set of vegetation types (presented in Volume II of this report, Anderson et al. 1998).

Throughout the development of the USNVC, partnerships with federal agencies have been instrumental. The first national list of rare and threatened ecological communities was researched and documented for a report supported by the U.S. Fish and Wildlife Service (Grossman et al. 1994). The development of the national list of vegetation alliances and their description is being strongly supported by the Gap Analysis Program, which employs this hierarchical level as the standard for vegetation mapping on a state-by-state basis (see Bourgeron and Engelking 1994, Sneddon et al. 1994, Drake and Faber-Langendoen 1997, Weakley et al. 1997*b*). A biodiversity assessment across all thirteen states in the Great Plains, funded by the U.S. Environmental Protection Agency, helped to standardize the associations between the Midwest, Southeast, and West Regions (Schneider et al. 1997). The U.S. Forest Service is providing ongoing support to the Southeast Region to revise all levels of the classification hierarchy and to document the vegetation on National Forests. The U.S. Forest Service is also supporting efforts in the other regions to develop portions of the classification hierarchy. On a national scale, the U.S. Forest Service supports the development and documentation of Conservation Ranks for rare types. The physiognomic levels of the classification hierarchy were thoroughly examined and revised for the development of a federal standard for vegetation classification and information (FGDC 1997). These federal agencies, as well as the U.S. Department of Energy, the U.S. Department of Defense, the National Park Service, the Tennessee Valley Authority, and others, have also provided funding at more regional, local, or project-specific scales. This support has been important in the development and application of the USNVC in many portions of the country.

The classification that emerges from all of these efforts is continuously under review by Heritage ecologists as well as by academic and government agency experts. Classification revisions and additions and new descriptive information are periodically incorporated from these reviews. The classification has been made available to an increasingly wider audience of users and reviewers, and successive iterations of the classification system have resulted in a dynamic product that is increasingly consistent, accurate, and detailed. Special attention has been directed to reviewing and reconciling the classification of alliances and associations that occur across multiple regions. In addition to this review and refinement of types, the classification standards themselves are continuously refined with additional information, experience, and expertise.

V.B. Development of the USNVC Types

The identification of vegetation types involves an iterative process of information gathering and decision making. Vegetation types in the upper (physiognomic) levels of the classification hierarchy were not developed through a structured data-driven analysis; they were defined primarily by a review of existing classifications that emphasize vegetation structure, lifeform, height, leaf characteristics, and general geographic and environmental descriptors. The lowest (floristic) levels, on the other hand, were typically determined through both qualitative and quantitative analysis of standard vegetation samples, typically plots.

Where data sets of sufficient quality and completeness existed, associations were developed through quantitative and qualitative analysis of the stand tables (e.g., Drake and Faber-Langendoen 1994, Bourgeron et al. 1995). Although such analyses can provide a robust approach to classification, many existing data sets are not sufficiently complete to support this level of analysis. Most data sets do not span the geographic range of a related set of vegetation types.

There is considerable variation in the amount of community information available on a state-by-state and region-by-region basis. Even in cases where data are geographically well distributed, the species lists are incomplete, with some only listing a few dominant taxa for each sample. These state and regional differences are reflected in the degree of classification development in the USNVC.

In the absence of complete floristic data sets, most alliances and associations have been defined on the basis of thorough qualitative assessments of available data on the dominant species, diagnostic species, and environmental variables. Analyses of thousands of published references and unpublished data sets describing vegetation community types provided the foundation for much of the USNVC. Most USNVC types were identified, substantiated, and described through the review of this literature by Conservancy regional ecologists and state Natural Heritage Program ecologists. Acceptance of types defined in the existing literature into the USNVC required an ongoing process of evaluation since these types were based on many different approaches to analysis, and on analyses performed on a diversity of data sets. They were described for many different purposes and thus were based on different assumptions and criteria. Many published types were not associated with sufficient documentation to allow confident assessment.

Regardless of their methodological origins, associations included in the USNVC are continuously evaluated by regional ecology teams to ensure that the classification concept is being consistently applied. The types of data and analysis procedures used are documented, as is the level of classification confidence associated with each type. The level of confidence is based on the quality and type of data used in the analysis, as well as the extent to which the entire (or potential) range of the association was considered.

V.B.1
The Process of Identifying Plant Associations

As is obvious from the preceding discussion, there was no single process used for the identification of all current USNVC types. Processes had to vary among and within regions and from type to type, depending on data and other resource factors. The following is a generalized overview of the steps taken to classify many associations in the USNVC. Specific examples of how these processes were applied in the identification of types are presented in Section V.B.2.

V.B.1.a. Planning

In any classification approach, the first step is the clarification of the overall purpose and scope of the classification. Classification studies can be divided into three general types. The most common entails the classification of all vegetation associations within a designated geographic area (Type 1). This could be a state, a particular ecological setting within a region (e.g., a riparian corridor), or a conservation or resource management area (e.g., a National Park, National Forest, or Conservancy Preserve). The second type of classification study is the development or refinement of classification units across a closely related group of vegetation types (Type 2). An example is the evaluation and refinement of western high elevation spruce-fir forest associations through the incorporation of new data from a previously uninventoried subregion. Type 2 studies, unlike Type 1, directly refine the classification of closely related vegetation types within a specific section of the classification hierarchy. The third type of classification study involves the analysis of relationships between the vegetation and an inferred set of environmental conditions or gradients (Type 3). Type 3 examples include studies that correlate shifts in vegetation composition to elevation gradients, geologic substrates, and hydrological regimes.

All three approaches to vegetation classification provided valuable data and analyses for the development of the USNVC. Type 2 studies provided the most robust classification through the direct, rangewide analyses of the types. Type 1 and Type 3 studies produced the local data sets and classifications that have been used to develop interim USNVC types.

TABLE 3. Utility Categories for Existing Data Sets in Vegetation Classification

Category	Description
I	Data set is sufficiently robust for quantitative and qualitative classification purposes. The data conform to acceptable field methods, contain sufficient structural and compositional vegetation information, use current taxonomy, and contain sufficient site and locality information.
II	Data set is sufficiently complete for qualitative classification and assessment. The data conform to acceptable field methods but do not contain sufficient structural and compositional information to support quantitative analysis. Some site and locality information is available.
III	Data set cannot be used for the development of the classification but may contain sufficient information to supplement the description of previously classified vegetation associations.
IV	Data set was not found to be useful at any level.

V

V.B.1.b. Data Review and Needs Assessment

This next phase in the classification process—data review and needs assessment—included an assessment of the extent and quality of vegetation information in the form of raw plot and polygon data, vegetation descriptions and maps, and other vegetation data that could support the development of the classification.

A considerable portion of the current USNVC has been based on previously existing data sets. Assessment of the quality of such data sets was necessary prior to using them for qualitative and quantitative analyses. Table 3 identifies categories that were typically assigned to data sets so that they could be used appropriately for vegetation classification.

The result of this data review and needs assessment phase was the identification of the additional vegetation data required to complete the specific objectives of the classification study.

V.B.1.c. Data Collection

A strategy for the development of data is necessary to achieve the objectives of virtually any classification effort. This strategy will be based upon factors such as the extent and quality of existing data and classification systems and the availability and quality of imagery. In situations where field efforts are necessary, standardized inventory and sampling protocols are essential to ensure that the data can be fully analyzed. In the USNVC and similar classification systems, sampling standards were particularly important to ensure that plot placement followed rules of uniform habitat conditions and floristic and physiognomic homogeneity, and that critical data fields were completed. An important consideration was the need for both overstory and understory data. The development of a physiognomic and floristic classification required floristic data for each major stratum so that structural or physiognomic patterns could be detected. The sampling standards that have been used to develop the USNVC (Bourgeron et al. 1992, Sneddon 1993, Faber-Langendoen 1995) are briefly discussed below. Appendix A presents a standard field form used for data collection.

Community-based sampling was used to refine the USNVC for a targeted group of taxonomically related communities across their range of distribution (i.e., to develop Type 2 classifications). In this type of sampling, data collection was focused on a particular group of related communities (such as an alliance) and a detailed set of criteria for site inclusion were determined a priori. For example, sampling "fens" across New England might be restricted to communities that (1) are dominated by graminoids or shrubs, (2) occur in areas with similar ecological settings (e.g., shallow to deep peat areas influenced by contact with basic groundwater), and (3) contain at least some members of a larger set of characteristic species. In practice, selection criteria were usually refined as more was learned about the vegetation group. Depending on the number of occurrences, the sampling approach ranged from complete inventory of all occurrences of rare communities to stratified and stratified random approaches for more common types with wider geographic and environmental distributions.

Site-based sampling was used in the USNVC to identify and classify the communities within a fixed geographic area (i.e., to develop Type 1 classifications). Site-based sampling often involved stratifying the area of interest into units that reflected important environmental and topographic gradients (e.g., slope, aspect, elevation, moisture regime, soil type) (Gillison and Brewer 1985, Austin and Heyligers 1989). Transects that contained strong environmental gradients in a region were selected in order to optimize the amount of information gained in proportion to the time and effort spent on the vegetation survey (Austin and Heyligers 1989). Once the major environmental gradients were identified, they were partitioned into a matrix of environmental cells that contained unique combinations of the various segments found along each of these gradients (e.g., high elevation-wet-undisturbed; low elevation-dry-disturbed). Aerial photo analysis was often used to further partition the cells into areas of homogenous vegetation. A subset of the cells that represented the entire range of environmental variation and the apparent vegetation at the site was then selected for sampling. (This type of sampling also directly supports the development of Type 3 studies.)

Once sample sites were located, plots were subjectively placed in areas of homogenous vegetation. Because the objective of sampling was the characterization of vegetation associations, placement of plots such that they included discordant floristic composition or environmental conditions was avoided. Within homogeneous vegetation, random and restricted random schemes were used to locate the plots within a site. This stratified sampling of representative types is an efficient approach to identifying and characterizing vegetation types through quantitative analysis (Kent and Coker 1992).

Field sampling methodology was usually based on the collection of plot/relevé samples (Mueller-Dombois and Ellenberg 1974) of appropriate size and shape to capture the structural and compositional variation of the vegetation that was being classified. The plot size and shape varied with the type and pattern of community occurrences. For example, square plots (20m x 20m = 400m^2) were appropriate for certain shrubland communities, whereas rectangular plots (10m x 100m or 20m x 50m = 1000m^2) were more appropriate for some riparian forested communities. Within the plot, standardized types of data were collected to identify and characterize the abundance of all plant species and the structure of the vegetation. In addition, a standard set of environmental data was collected to characterize the moisture regime, soil parameters (type, depth, organic content and pH), bedrock type, topographic setting, aspect, slope (percent and position), geographic location, and other characteristics of the immediate environment.

A subset of existing and new data was then selected for analysis based on the immediate objectives of the classification. Type 1 classifications required data sets that covered all vegetation types within a specified geographic area. Type 2 classifications required data sets restricted to a specific physiognomic group (such as an alliance), generally across a selected geographic and environmental range. Type 3 classifications were completed on data sets that characterized the vegetation across specific environmental conditions or gradients within a relatively restricted geographic area.

Existing and new data were assessed for completeness and consistency. When combining data sets from various sources, smoothing or transforming to a common set of information fields and detail was often necessary to ensure consistency. The data were then centralized in a standardized database management system to facilitate management, analyses, and other applications (data management systems are discussed in Section VII.). In most cases, limitations associated with the data were documented.

V.B.1.d. Data Analysis

Ideally, classification is based on the analysis of high quality, consistent data from stands spanning the full geographic and environmental range of related vegetation. This level of thoroughness and consistency is fundamental to the replicable and robust classification of USNVC types. However, most existing vegetation data were gathered by a range of investigators with different objectives and various methodologies. The resulting data were incomplete or of lower quality than the ideal. In order to make the most of the large but uneven set of available information, Conservancy ecologists working to develop and improve the USNVC have used a variety of analysis techniques based on the amount and quality of data available. In the absence of complete sets of quantitative data, qualitative assessments of vegetation across its range can be more robust than quantitative analyses based on incomplete and unrepresentative data sets. In practice, Conservancy ecologists have usually used a combination of quantitative analyses of existing data that represent a subset of the range, with qualitative interpretation and extrapolation to larger areas. The application of rigorous quantitative analyses as the sole basis for classification has been the exception in the USNVC; limitations on the quantity and quality of existing data have necessitated a more pragmatic approach.

Approximately 20% of the current USNVC associations were identified with the benefit of a sufficient amount of quantitative plot data, collected across the presumed geographical and environmental range of the vegetation of interest. Many of these analyses were carried out by non-Conservancy ecologists and were later evaluated from the published literature and incorporated into the USNVC. In cases where Conservancy objectives required a more rigorous quantitative approach than was then available, this type of study was completed by Conservancy ecologists. Examples include Bourgeron et al. (1995), who completed a classification of vegetation on the Gray Ranch of southern New Mexico to determine the ecoregional representativeness of this site and identify specific priorities for conservation action, and Drake and Faber-Langendoen (1994), who classified the Wisconsin pine barrens communities and assessed their relative importance for conservation.

Other, unpublished quantitatively-based classifications have been completed by Conservancy ecologists for tallgrass prairies, oak barrens, pitch pine barrens, long leaf pine savannas, coastal plain ponds, northeastern and midwestern fens, and ponderosa pine forests. In addition, the Conservancy has worked with others, including federal agencies, to compile and/or analyze plot data for vegetation within a state or region. Examples include the Columbia River Basin in the Pacific Northwest (ICBEMP 1995), the Shawnee National Forest in Illinois (TNC 1995), and the development of a complete digital version, and subsequent classification, of Curtis's plot data (Umbanhowar 1990) for the state of Wisconsin (Drake and Faber-Langendoen 1994).

About 60% of the types included in the current USNVC were classified with the benefit of some quantitative analyses, but the existing data did not represent adequate geographical and environmental coverage across the predicted range of the communities. Examples include the vegetation classifications of the Boundary Waters Canoe Area Wilderness of the Superior National Forest in Minnesota (Grigal and Ohmann 1975), the tallgrass prairies of Iowa (White and Glenn-Lewin 1984), the forest types of the Black Hills of South Dakota (Hoffman and Alexander 1987), and the high elevation rock outcrops of the southern Appalachians (Wiser et al. 1996). These studies resulted in the robust identification of local vegetation types, but their adoption into the USNVC required a broader assessment across ecological regions. This was completed through both an extensive analysis of the published and unpublished literature describing vegetation within the regions of interest and a structured review process with regional experts.

Fewer than 20% of the associations presently included in the USNVC were identified or described solely through the analysis of qualitative data. These vegetation types have been documented in the literature and are widely recognized by regional experts, but useful quantitative data were not available for classification. Thus, they were classified solely through qualitative review of the descriptive literature and through a rigorous review by experienced regional and local ecologists. Many of these types will eventually require further inventory and analysis to increase the level of confidence associated with the classification.

Regardless of the analysis approach used, a structured peer review by experienced regional and local ecologists has been, and will remain, a cornerstone of the classification process. Such review is invaluable for interpreting both qualitative and quantitative data.

The overall level of confidence in the classification of each USNVC type was included in the description of the type (see Section VI.A.2.). The confidence level was reported on a scale of 1 to 3 (1 representing the greatest confidence). This reflects the level of completeness of the data sets used, the level of quantitative and qualitative analyses that were completed to identify the type, and the level of peer review. Text that explicitly describes these factors is a goal for future descriptions, so that users will be better able to understand the classified entity. This will also help the broader user group to target additional inventory, analysis, and review.

Quantitative approaches have played an increasingly important role in the identification and refinement of vegetation types. A brief discussion of standard analysis approaches that have been used to identify USNVC types is presented in Box 1. These approaches were used by Conservancy ecologists in two ways: (1) as standards by which to evaluate analyses done by others and (2) as important tools to identify USNVC types directly.

V.B.1.e. Review and Placement in the Classification Hierarchy

The final steps in the USNVC classification process were to review the results of the analyses, and depending on the type of study conducted (Type 1, 2, or 3), determine how to place the types within the classification hierarchy. In general, initial iterations of USNVC types were derived from compiling more localized Type 1 and Type 3 classifications. Many early state classifications were produced by Heritage Program ecologists, who compared and compiled these local classifications. Much of the USNVC development process then resulted from the assessment and compilation of these state classifications into first iterations of regional classifications, which in turn were compared and integrated into the national classification. In this process, all types were reviewed in relation to similar types across their potential range of geographic and environmental distribution. Thus, Type 2 classifications (those involving the definition of types in relation to similar types across their potential range of distribution), were often completed in the process of aggregating Type 1 and Type 3 classifications. These efforts generally resulted in the refinement of the classification within specific sections of the USNVC hierarchy. Taxonomic areas identified as "weak" were targeted for additional inventory and data analysis.

BOX 1

Quantitative Analysis Methods for Vegetation Classification

Many methods have been developed to search for pattern and order in vegetation data and to group sets of vegetation samples into classes based on similarity in floristic composition. All these methods are similar in that they sort and resort the data with slight variations in procedure and sequence. Although different quantitative methods can suggest contrasting results, there is no unique solution or single correct classification of any data. Choice of a method and interpretation of results are determined in large part by the particular needs and objectives of a project. The strength of an analysis will always depend upon consistent data quality and the range and dispersion of samples. In developing a physiognomic-floristic classification, there is also a need for floristic data that are recorded by major strata and for the analysis to be conducted on all strata, rather than being limited to only one. This will ensure that the relationship between structure and composition can be assessed in the analysis and subsequent characterization of the types. There needs to be sufficient redundancy in the samples for a set of analytical procedures to accurately detect statistical trends. Finally, the results from all quantitative analyses must be interpreted with a good understanding of the local ecology and of the strengths and limitations of the data.

Standard approaches to quantitative classification usually include removing outliers from the data set, assessing stand similarity through ordination and cluster analyses, and explaining the emerging patterns of vegetation through correlation and regression to environmental gradients. Tabular analyses are often employed to identify stand similarity and diagnostic species. These approaches are discussed in greater detail below.

V

1. Identify and remove outliers from the data set

Outliers in the data set are identified and removed from the analysis. These outliers represent vegetation that significantly varies either compositionally or structurally from the rest of the data and requires analysis with a different set of data. Inclusion of these samples would obscure patterns in the remaining data and lead to interpretations that are less ecologically meaningful. Cluster analysis evaluates the floristic similarity of the samples and, through an iterative statistical process, aggregates samples that have the most similar composition into clusters. Exploratory analysis with agglomerative clustering techniques aids in the identification of these outliers. Numerous quantitative programs (e.g., SAS [SAS Institute, Inc. 1996], CLUSTAN [Wishart 1987], PC-ORD [McCune 1993]) are available to implement this type of analysis.

2. Summarize data in major groups: ordination and cluster analysis

The remaining data are analyzed with multivariate techniques to discern patterns of similarity between the samples. *Ordination* techniques arrange vegetation samples in relation to each other through similarity measures of species composition. These procedures summarize the variability in a complex multidimensional data matrix in a limited number of axes. Although the ordination methods can reveal groups of similar composition, they primarily show patterns of continuous variation across the entire data set. *Cluster analyses* differ from ordinations by grouping sets of floristically similar vegetation samples through iterative, plot-by-plot comparisons.

Indirect ordination methods (e.g., DCA, NMDS) are used in preference to direct methods (such as direct gradient analysis). Indirect ordination arranges the samples based on vegetation similarity and can be implemented using many existing analysis packages (e.g., CANOCO [ter Braak 1990],

(continued next page)

SAS [SAS Institute, Inc. 1996], DECODA [Minchin 1994], DECORANA [Hill 1979], PC-ORD [McCune 1993]). The results from the ordination are used to generate coordinate diagrams that portray the relative similarity between the samples. Symbols are used to depict different vegetation sampling units, and the distances between sampling units represent the degree of floristic similarity. Coordinate diagrams typically represent the first two axes of the ordination that display most of the variation in the data set. Plotting a third axis is often useful in revealing three-dimensional patterns in the ordination space.

Cluster analyses are typically performed at this point. Clustering is completed through the application of different fusion strategies (e.g., minimum variance clustering, centroid clustering, nearest neighbor clustering) and measures of dissimilarity (e.g., Euclidean distance, Sorenson's index, relative Euclidean distance). The choice of strategies and measures depends on the nature of the data set. The distance matrix that results from the cluster analysis is depicted as a dendrogram, which represents floristic similarity through the fusion between samples and groups of samples.

The complementary use of ordination and cluster analyses allows the development of discrete classification units based on objective measures of compositional similarity and the examination of how these units relate to each other and the environment. TWINSPAN (Hill 1979) is one commonly used program that combines divisive clustering and ordination through reciprocal averaging (RA) or correspondence analysis (CA). These two techniques approach the data in very different ways, and the comparison of analytical results assists in the identification of vegetation associations.

When data sets are very large and the results are complex, the data are often subset environmentally, structurally, or floristically. Additional ordination and cluster analyses are performed on the subsets. This progressive fragmentation and analysis reduces the dimensionality and underlying complexities within the data set and often reveals additional compositional patterns (Peet 1980). Groupings revealed in the ordination diagrams are compared with groups recognized in the cluster analysis.

3. Explore vegetation-environment relationships to assist with data interpretation

The introduction of environmental data into the vegetation analyses is often used to aid in the clarification of the factors underlying vegetation gradients. Exploration of these vegetation-environment relationships is generally completed through direct gradient analysis techniques (CCA, DCCA), multiple factor analysis, correlation analysis, or regression. Compositional gradients extracted by the ordination are regressed or correlated with key site variables (e.g., elevation, soil chemistry, slope, aspect, hydrology, landform). The association of environmental factors with compositional patterns provides a valuable independent product to assist with the final data interpretation for classification.

4. Perform tabular analysis

Before these computer-assisted analytical programs became widely available, classification was completed manually through the comparison and ordering of plots using tabular techniques. This has proven to be a powerful intuitive analytical method to subset and group plots based upon floristic affinities and similarity and to identify diagnostic and indicator species for each group. Some statistical packages generate the output synthesis tables that are used to group samples and summarize species information of each grouping. The summary reports on dominant and diagnostic species for each grouping, along with information on percentage constancy and average coverage (preferably by strata), are very useful in naming and characterizing each vegetation type.

The newly identified plant associations were then placed within the appropriate alliance, formation, and upper levels of the classification hierarchy. In general, the placement of floristic types in the USNVC physiognomic hierarchy was very straightforward, with types being grouped into the most representative physiognomic units. However, some vegetation types exhibited a broad range of inter- and intra-stand variability and could have been placed under multiple formations or higher physiognomic units. In most such cases, the general rule followed was that a floristic type should be placed under the physiognomic levels that best represent the *average expression* of that vegetation type. Whenever a newly identified alliance or association was not adequately encompassed under existing formations, a new formation was proposed for inclusion in the USNVC.

Regardless of the approach used to classify within the hierarchy, type descriptions (see Section VI.A.2.) were completed to document the degree of physiognomic (and floristic) variation that is encompassed within the concept of the association.

Alliance types were identified through the grouping of associations that were within the same formation that shared dominant diagnostic species in the primary strata. Where the classification of associations was not well developed, the alliances were classified by the dominant and co-dominant species in the uppermost dominant vegetation strata.

V.B.2.
Identification of Types in the USNVC: Examples

Broad disparities in existing data and classification systems, and in available time and resources, required that a variety of processes be employed to identify initial USNVC types. The examples presented below are illustrative of the range of methods that have been used for the identification of USNVC types.

Integrating Pre-existing Classification Systems

1. *Integrating a state Natural Heritage Program classification: Hawaii*

In order to identify priority sites for conservation, the Hawaii Natural Heritage Program took the lead in the late 1980s in developing the first state-wide classification of natural communities. The classification was developed to provide a consistent descriptive base for existing native and naturalized vegetation in Hawaii. It was the result of a collaborative effort by over twenty-five ecologists and biologists active in the Hawaiian Islands. The Hawaii Natural Heritage Program classification is based on physiognomy, elevation, moisture, and dominant canopy species. Principal community types are based on elevation, moisture, and physiognomy (e.g., Coastal Wet Forests, Montane Dry Grasslands), and unique plant communities within the principal community types are named based on dominant or co-dominant species. The system has been used by the Heritage Program in all its work with government agencies, and it has become widely understood and applied across the state. The classification was published in the *Manual of the Flowering Plants of Hawai`i* (Wagner et al. 1990), and it is the basis for the terrestrial ecosystems standard for the *Atlas of Hawai`i* (Pratt and Gon *in press*).

The types identified by the Hawaii Natural Heritage Program were examined in light of USNVC criteria, and it was decided that they were generally recognizable as types under those criteria and would provide an extremely useful preliminary classification of USNVC types. Many of these types were adopted directly into the NVC via placement in the hierarchy and modest "translation" to meet structural nomenclatural standards (e.g., the addition of a dwarf-shrubland physiognomic category not originally in the Hawaii Natural Heritage Program system). Future collaborative work between the Hawaii Natural Heritage Program and the Conservancy will result in additional modifications to the two classifications.

2. *Adopting plant associations identified from habitat type studies: western United States*

A tremendous amount of vegetation classification work has been completed in the western United States (e.g., Daubenmire and Daubenmire 1968, Pfister et al. 1977, Mueggler and Stewart 1980, Steele et al. 1981, Mauk and Henderson 1984, DeVelice et al. 1986, Hess and Alexander 1986, Cooper et al. 1987, Daubenmire 1970, Hironaka et al. 1983, Tisdale 1986, Mueggler 1988, Padgett et al. 1989). Much of this work followed the approach developed by Daubenmire (1952) and Daubenmire and Daubenmire (1968), in which habitat types are identified as the basic classification units, and plant associations are the late successional or climax vegetation types for which the habitat types are named. As a result of these extensive classification efforts, many plant associations have been identified for the west in both published and unpublished reports, which often provide comprehensive stand and summary data. TNC and Heritage ecologists reviewed the data provided in these reports and classifications on a subregional basis. In order for a plant association to be included in the USNVC, references associated with it had to provide location information, a description of methods, plant species lists, and quantitative measures of plant species abundance. The plant associations identified by each study were compared and standardized into one classification system (Bourgeron and Engelking 1994). In practice, the names of the plant associations given by the original author were adopted directly into the USNVC system unless there was a clear need to differentiate between different associations with the same original name (see Bourgeron 1988).

3. *Identifying plant associations successional to habitat types: western Montana*

In the habitat typing system, the use of the term plant association is restricted to the climax or potential natural vegetation (Daubenmire 1968, Pfister et al. 1977). In order to meet the Conservancy's objective of a classification of existing vegetation, it was necessary to identify communities that are compositionally and structurally maintained by recurring natural disturbances, such as fire, avalanches, and grazing by large ungulates. In western Montana, successional stages of coniferous *Pseudotsuga menziesii* forests are maintained in the vegetation mosaic by fires of different intensities and frequencies. Data and fire ecology studies from Pfister et al. (1977), Fisher and Clayton (1983), and Arno et al. (1985) were used to identify successional stages within the *Pseudotsuga menziesii / Vaccinium membranaceum* Forest habitat type. Following stand-replacing wildfire, stands of old-growth plant associations dominated by *P. menziesii* may be replaced by one of several successional shrubland types (not currently classified in the USNVC) dominated by a mix of shrubs such as *Xerophyllum tenax, Ceanothus velutinous,* or *Vaccinium membranaceum*. Succession may proceed through sapling, "pole," and later mature stages, with *Pinus contorta* often dominating in the sapling and pole stages, and *P. menziesii* gradually becoming co-dominant over time. The *Pseudotsuga menziesii / Vaccinium membranaceum* plant association is the theoretical end of the successional sequence. The USNVC system recognizes four types, including the climax association, which all can be found in a landscape that is still under natural fire regimes[5].

Using Local and Rangewide Quantitative Analyses

4. *Rocky summit communities of higher elevations: southern Blue Ridge*

Wiser (1993) and Wiser et al. (1996) conducted a detailed study of rocky summit communities and recognized nine community types based on numerical classification. Seven of these associations have been recognized in the USNVC. Two

[5] See TNC codes 0145, 0175, 0169 (pages 19-20), and 0466 (page 36) in Volume II of this document (Anderson et al. 1998) for the specific associations referred to in this example.

associations were considered too similar to distinguish them, and another was considered to be too finely embedded spatially with another association to warrant recognition in the USNVC. Most of the recognized associations have been placed in the *Saxifraga michauxii* Herbaceous Alliance. Closely related vegetation within this alliance occurs north of Wiser's study area and is also found at lower elevations than those she studied. The related vegetation north of the study area was studied by Rawinski and Wieboldt (1993) and Fleming (*personal communication*), and an additional two associations were defined based on this research. After discussion with experts, Conservancy ecologists from the Southeast Regional Office added an additional lower elevation association in the alliance[6].

5. *High elevation red oak* (Quercus rubra) *communities: southern Blue Ridge*

In an unpublished thesis, DeLapp (1978) studied higher elevation communities in the southern Blue Ridge dominated by northern red oak (*Quercus rubra*). These differ from *Quercus rubra* communities of lower elevations and of more northern areas, so the study amounts to a monograph on an alliance in a portion of its distribution. Using plot data and cluster analyses, DeLapp recognized seven "phases." Based on the classification criteria of the USNVC, Regional Office ecologists reinterpreted his results and recognized three associations[7]. The finer distinctions made by DeLapp likely warrant recogni-tion as phases or subassociations. Additional associations may prove to be warranted following expert review and analysis utilizing additional data.

6. *Classification of vegetation using on-site plot data with rangewide data: Assateague Island, Maryland*

Conservancy ecologists were contracted to map the vegetation of Assateague Island National Seashore using USNVC types. In order to derive vegetation types that were based on national data, site-based plots were combined with data from the same alliance from other sites. As an example, data collected from the seven plots located in *Hudsonia tomentosa* vegetation on Assateague Island were reduced to presence-absence data and analyzed, using TWINSPAN (Hill 1979), along with plots and species lists that had been assembled from other published sources describing *Hudsonia* vegetation. The published data used in the analysis were those believed to be from the same alliance (*Hudsonia tomentosa* Dwarf-Shrubland Alliance) or closely related vegetation based on descriptions of habitat and species composition. The data included were from maritime dunes in the northeast and mid-Atlantic, *Hudsonia*-dominated riverwash vegetation from a New England River, as well as *Hudsonia* vegetation described from sandy lake-shores in New Hampshire. The analysis resulted in the classification of four associations[8]. Although the classification was based on presence-absence data collected in variable ways, the level of classification confidence for these associations is relatively high because the data represented a number of sites across the range of this alliance and related alliances. Additional data from sites in Wisconsin, Saskatchewan, and Ontario were also included in the analysis, although the identification of USNVC associations in these areas is still incomplete (Sneddon, *unpublished data*).

7. *Rangewide classification of pondshore vegetation: northeastern Coastal Plain*

Pondshores—shallow basins supporting Coastal Plain flora—are wide-ranging in North America.

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[6] See TNC codes 3814 (page 171), 3951 (page 229), 4074 (page 257), 4277, 4278, 4279, 4280, 4281, 4283, and 4524 (pages 330-331) in Volume II of this document (Anderson et al. 1998).

[7] See TNC codes 7298, 7299, and 7300 on page 70 of Volume II of this document (Anderson et al. 1998).

[8] These correspond to TNC codes 6143, 6233, 3950 on page 229, and 6232 on page 232 of Volume II of this document (Anderson et al. 1998).

The dynamic hydrology of these sites results in floristically related but widely variable community structure and composition, presenting a challenging classification problem. In an attempt to develop a preliminary classification of Coastal Plain pondshore communities in the northeast, Sneddon and Anderson (1994) selected a subset of ponds: those basins in states north of Virginia, supporting Coastal Plain flora, and occurring on the Coastal Plain, Atlantic Plain, or sandy outwash deposits of New England. Relevé data within each physiognomically distinct zone were collected along a transect from upland forest to the water's edge. Field work was carried out by ecologists from each of the state Heritage Programs and the Conservancy's East Regional Office using standardized sample forms. Vegetation data were analyzed using TWINSPAN (Hill 1979), and environmental data using CANOCO (ter Braak 1990). The preliminary classification resulted in the identification of thirteen associations[9]. Further data analysis, incorporating more recently collected data, is planned.

V

Using Qualitative Analyses and Field Surveys

8. *Dune grasslands and shrubland communities: Florida coast*

Ecologists from the Florida Natural Areas Inventory gathered qualitative information on the composition of dune grasslands and shrubland communities as part of an inventory focused on the identification and conservation prioritization of remaining examples of coastal natural communities (Johnson et al. 1990, Johnson et al. 1992, Johnson and Muller 1992, Kruer 1992, Johnson and Muller 1993*a*, *b*). In their publications, they discussed regional variation in broad community types (such as "Dune Grass," "Coastal Berm," and "Coastal Strand") and presented tabular information on species composition and relative abundance. Although they did not recognize formal divisions in these broad types, tabular analysis and interpretation of their information allowed Conservancy ecologists to recognize associations with relatively high confidence levels[10]. These associations need additional review and testing, but provide a framework for future classification work in Florida and nearby states of the South Atlantic and East Gulf Coastal Plain shoreline.

9. *Tropical hardwood hammocks: southern Florida*

Numerous journal articles, National Park Service publications, and unpublished reports describe tropical hardwood hammocks in southern Florida. (The substantial floristic differences between tropical hardwood communities in Florida and those in the West Indies make it clear that the associations developed for Florida are endemic to that state.) No rigorous analysis of the available information is possible as these sources differ in types of information gathered, purposes of the studies, and classification philosophies. The abundance of descriptive information, and of very local classifications addressing parts of southern Florida only, enabled the Conservancy's Regional Office ecology staff to develop a tentative classification, recognizing seven associations[11]. The classification is based on the interpretation of floristic information, landscape position, and biogeographic location. Because of the variable

[9] See TNC codes 6221, 6242 (page 214), 6208 (page 233), 6243, 4120, 6332, 6035, 6300, 6264, 6210, 6261 (pages 282-292), 6016 (page 298), and 6086 (page 342) in Volume II of this document (Anderson et al. 1998). Some additional pondshore associations were identified subsequent to the submittal of Volume II for printing. Contact the Conservancy's East Regional Office for more information.

[10] See TNC codes 3781, 3782, 3785, 3793 (pages 167-169), 3811, 3812 (page 172), 3966 (page 243), 4000, 4001 (page 246), 4040, 4041 (page 251), 4051 (page 299), and 4093 (page 267) in Volume II of this document (Anderson et al. 1998).

[11] See TNC codes 7001, 7002, 7003, 7004, 7005, 7007, and 7008 on page 2 of Volume II of this document (Anderson et al. 1998).

data and the absence of studies that address the classification of these communities in a comprehensive manner, the classification has a lower confidence level; the recognized associations may overlap in concept, may differ in the degree of "lumping" or "splitting," may be less distinct than appeared in the original sources, or may be insufficientin number. Additional data and subsequent review by experts will be needed to validate, modify, or refine the classification of these types in the future.

Using Expert Review of Broadly Understood Groups

10. *Beech-magnolia* (Fagus grandifolia-Magnolia grandiflora) *forests: southeastern Coastal Plain*

Upland beech-magnolia forests of the deep southern United States have long been recognized as a community type. Even a superficial comparison of stands, though, reveals that composition (excluding the two characteristic tree species) varies considerably, most obviously in response to topographic position, soil fertility, and biogeographic location. This variation has not been studied in a comprehensive manner. The Conservancy sponsored a series of meetings to review and develop the USNVC types in the southeastern Coastal Plain involving Natural Heritage, federal agency, state agency, academic, and private ecologists knowledgeable about this vegetation. These meetings served to develop a preliminary classification of USNVC associations in the *Fagus grandifolia - Magnolia grandiflora* Forest Alliance, in which nine associations are currently recognized[12]. This is a functional classification that can be further evaluated and refined as additional information and data become available.

Combining Qualitative, Quantitative, and Expert Analyses

11. *Mesic tallgrass prairies: Midwest*

Mesic tallgrass prairies have been widely described across the Midwest. Big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and Indian grass (*Sorghastrum nutans*) are typical associates across much of the tallgrass prairie region (Weaver and Fitzpatrick 1934). The *Andropogon gerardii - (Sorghastrum nutans)* Herbaceous Alliance describes this broad-ranging type. A thorough review of books, journals, and Midwest state Natural Heritage Program classifications and surveys was conducted (e.g., Heidel 1984), followed by a series of meetings with Natural Heritage Program ecologists. A total of fourteen associations were recognized[13]. Other Great Plains ecologists reviewed these associations, clarifying rangewide distributions and leading to the recognition of an additional association[14]. One association, the *Andropogon gerardii - Stipa spartea - Sporobolus heterolepis* Herbaceous Vegetation[15] (Northern Mesic Tallgrass Prairie), illustrates the variety of sources used to define associations. This type had been defined by Diamond and Smeins (1988) through a quantitative analysis of western tallgrass prairie plot data from Manitoba to Texas. The authors included a map showing the distribution of the type to be

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[12] Four associations are listed in the *Fagus grandifolia - Magnolia grandiflora* Alliance in Volume II of this document (Anderson et al. 1998). These correspond to TNC codes 7459, 7458, 7460, and 7461, found on page 92. Additional review, resulting in the identification of nine associations, occurred after the submittal of Volume II for printing. Contact the Conservancy's Southeast Regional Office for the current types.

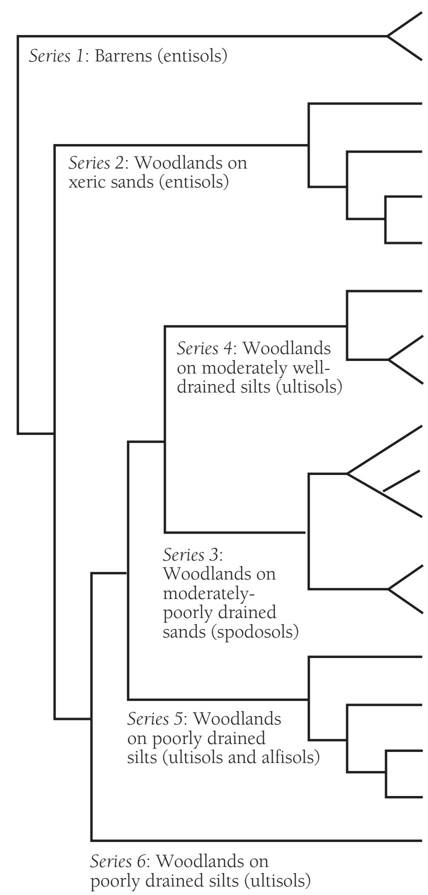
[13] Associations in this alliance can be found on pages 247-248 of Volume II of this document (Anderson et al. 1998).

[14] This is TNC code 1461, *Andropogon gerardii - Calamovilfa longifolia* Herbaceous Vegetation, identified after Volume II was submitted for printing. Contact the Conservancy's Midwest Regional Office for more information.

[15] This association is TNC code 2202, and is called the *Andropogon gerardii - (Sorghastrum nutans)* Northern Herbaceous Vegetation in Volume II (Anderson et al. 1998). Refinement of the association name occurred after the submission of Volume II for printing.

North Carolina Vegetation Survey

Square corners (⌈)=numerical classifications; forks (<)=decisions based on MDS ordination



North Carolina Vegetation Survey		North Carolina Natural Heritage	USNVC[16]	
Group Code	Sample Size (n)	Schafale Type (Variant)	Association	Alliance
A1	3	Xeric Sandhill Scrub (Coastal Plain)	*Pinus palustris / Quercus laevis / Aristida stricta / Cladonia* spp. Woodland	*Pinus palustris / Quercus* spp. Woodland Alliance
A2	2	Xeric Sandhill Scrub (Coastal Fringe)	*Pinus palustris / Quercus laevis - Quercus geminata / (Selaginella arenicola* ssp. *anthonota) - Stipulicida setacea - Rhynchospora megalocarpa* Woodland	
B	5	Pine / Scrub Oak Sandhill (Mixed Oak)	*Pinus palustris / Quercus laevis - Quercus margarettiae / Gaylussacia frondosa* var. *frondosa / Aristida stricta* Woodland	
C	4	Coastal Fringe Sandhill (Typic)	*Pinus palustris - Pinus taeda / Quercus geminata - Quercus hemisphaerica - Osmanthus americanus* var. *americanus / Aristida stricta* Woodland	
D	5	Coastal Fringe Sandhill (Typic)	*Pinus palustris / Quercus laevis - Quercus geminata / Vaccinium tenellum / Aristida stricta* Woodland	
E	18	Pine Scrub / Oak Sandhill (Mixed Oak)	*Pinus palustris / Quercus laevis - Quercus incana / Gaylussacia dumosa* var. *dumosa / Aristida stricta* Woodland	
I	16	Mesic Pine Flatwoods (Coastal Plane)	*Pinus palustris / Amorpha herbacea* var. *herbacea / Aristida stricta - Sorghastrum nutans* Woodland	*Pinus palustris* Woodland Alliance
J	8	Mesic Pine Flatwoods (Coastal Plane)	new	
K	9	Pine Savanna (Lumbee)	*Pinus palustris - Pinus taeda - Pinus serotina / Quercus marilandica / (Quercus pumila) / Aristida stricta* Woodland	*Pinus palustris - Pinus (elliottii, serotina)* Saturated Woodland Alliance
F	18	Wet Pine Flatwoods (Wet Spodosol)	new	
G1	12	Wet Pine Flatwoods (Leiophyllium)	*Pinus palustris / Leiophyllum buxifolium / Aristida stricta* Woodland	
G2	20	Wet Pine Flatwoods (Wet Spodosol)	*Pinus palustris / Ilex glabra / Aristida stricta* Woodland	
H1	17	Pine Savanna (Wet Spodosol)	*Pinus palustris - Pinus serotina / Pleea tenuifolia - Aristida stricta* Woodland	
H2	8	Pine Savanna (Wet Pleea Flat)	*Pinus palustris - Pinus serotina / Ctenium aromaticum - Muhlenbergia expansa - Carphephorus odoratissimus* Woodland	
L	2	Pine Savanna (Very Wet Clay)	*Pinus palustris - Pinus serotina / Magnolia virginiana / Sporobolus teretifolius - Carex striata* Woodland	
M	5	Pine Savanna (Wet Ultisol)	*Pinus palustris - Pinus serotina / Ctenium aromaticum - Muhlenbergia expansa - Rhynchospora latifolia* Woodland	
N	5	Pine Savanna (Wet Ultisol)	*Pinus palustris - Pinus serotina / Sporobolus* species I - *Aristida stricta - Eryngium integrifolium* Woodland	
O	5	Pine Savanna (Very Wet Clay)	*Pinus palustris - Pinus serotina / Sporobolus* species I - *Ctenium aromaticum - Eriocaulon decangulare* var. *decangulare* Woodland	
P	3	not recognized	*Pinus palustris / Arundinaria gigantea* ssp. *tecta - Liquidambar styraciflua / Andropogon glomeratus - Sarracenia minor* Woodland	

FIGURE 3. Longleaf Pine Communities of the Outer and Middle North Carolina Coastal Plain

[16] Associations in this figure can be found on pages 126-128 and 144-145 of Volume II of this document (Anderson et al. 1998). Alliances in this figure reflect a more current classification than that presented in Volume II. Contact the Conservancy's Southeast Regional Office for more information.

western Minnesota, southeastern Manitoba, the eastern Dakotas, and northwestern Iowa. A quantitative analysis of northern Iowa prairies showed that northwestern Iowa prairies were floristically distinct from northeastern Iowa prairies (White and Glenn-Lewin 1984). Based on their field expertise, Minnesota Natural Heritage Program ecologists also separated their state's western prairies from those in the southeast and described each of their types (Minnesota Natural Heritage Program 1993). All of this information contributed to the recognition of the association in the USNVC.

12. *Longleaf pine* (Pinus palustris) *communities: North Carolina and adjacent states*

In the North Carolina Natural Heritage Program classification of natural communities, Schafale and Weakley (1990) presented a classification of longleaf pine communities. Later, based on additional qualitative information and a decision that the great variation in these communities needed additional recognition, Schafale (1994) presented a refined and more detailed classification of longleaf pine dominated communities by adding a lower hierarchical level, the "variant." In the outer and middle North Carolina Coastal Plain, for example, Schafale recognized twenty variants based on criteria closely concordant with those developed for the USNVC. In the meantime, the North Carolina Vegetation Survey gathered extensive plot data in this area, and a preliminary analysis based on numerical classification and ordination (multidimensional scaling) resulted in nineteen groups. The longleaf pine types suggested by the analysis of plot data corresponded well with Schafale's more qualitatively defined types (and with the three longleaf pine alliances recognized in the USNVC). At finer classification levels, many identical types were identified by both approaches (see Figure 3). Most of these types are now included as associations in the USNVC, with some types awaiting additional discussion by regional experts.

V.C. Relationship of the USNVC to Other Major Classification Systems

Classification units in many other major vegetation classification systems are equivalent or comparable to USNVC types, and the relationships between associations in the USNVC system and communities in other major national and regional classification systems are recorded as a component of the USNVC vegetation descriptions (see Section VI.A.2.). Broad relationships between the USNVC and some major systems are briefly discussed here.

1. Federal Geographic Data Committee Vegetation Classification and Information Standards

The Federal Geographic Data Committee has recently endorsed a set of Vegetation Classification and Information Standards to support the production of uniform statistics on vegetation resources at the national level (FGDC 1997). This vegetation classification standard is a direct derivative of the USNVC (which, in turn, was developed from UNESCO [1973] and Driscoll et al. [1984]). Although the USNVC was originally developed to support the conservation objectives of the Conservancy and of state Heritage Programs, the FGDC conceived a few modifications to the USNVC, and these were adopted to allow the system to better support the needs of partners in federal agencies. The most fundamental of these was the addition of the subgroup level in the USNVC's hierarchy—a change made for agencies which needed a standard framework and classification approach for both natural and cultivated types. Thus, the USNVC system and the FGDC-endorsed standard are essentially identical in overall structure and in specific vegetation types. Future development of the

FGDC/USNVC classification is anticipated to be a collaborative effort involving the multiple agencies and organizations that use and contribute to it.

2. *Society of American Foresters (SAF) cover types*

SAF cover types are "a descriptive classification of forest land based on present occupancy of an area by tree species" (Eyre 1980). By contrast the USNVC uses all vascular plant species present in a community to help define vegetation units. Where dominant tree species are also diagnostic for a community type, similar, though not identical, units are identified by SAF cover type and USNVC alliance. Examples include the Jack Pine Forest Cover Type and the *Pinus banksiana* Forest Alliance, and the Post Oak-Blackjack Oak Forest Cover Type and the *Quercus stellata - Quercus marilandica* Forest Alliance. In other cases, the SAF cover types are more broad-ranging over both structural and environmental gradients than are the alliances recognized in the USNVC. For example, the Black Spruce Cover Type is separated by the USNVC into an upland *Picea mariana* Forest Alliance, a *Picea mariana* Saturated Forest Alliance, and a *Picea mariana* Saturated Woodland Alliance. The primary difference between these systems is that the SAF cover types are defined exclusively for forest vegetation, whereas the USNVC classifies all terrestrial vegetation.

3. *Habitat type association*

Habitat types identify ecologically equivalent landscape units that produce a climax vegetation type (Pfister and Arno 1980, Kotar et al. 1988) (see Section II.E.2.). The application of this approach is primarily restricted to types in the western United States. Because many forest stands are not in climax condition with respect to the tree layer, ground layer vegetation of any closed-canopy forest is used to infer potential natural vegetation. As such, vegetation units of very different successional status may be treated as part of the same habitat type (although the early- to mid-seral stage may be referred to as a "community type," as distinct from the late-seral "plant association"). By contrast, the USNVC identifies all existing vegetation types as plant associations, despite similarities in underlying ecological features. Thus, the early- to mid-seral stage may be treated as a separate USNVC association from the late-seral stage. The late-seral stage may be classified as the same association in both classifications (see examples 2 and 3 in Section V.B.2.).

4. *Multi-factor integrated approach*

Classification units developed with a multi-factor integrated approach represent a unique combination of potential natural vegetation, soils, landscape features, and climate (see Section II.A.). Like habitat types, these ecological land units are hypothesized to produce similar climax vegetation and to demonstrate similar responses to management (Cleland et al. 1994). Because all factors are used together to help define ecological land units, the approach is conceptually integrated and multi-factored. By contrast, USNVC vegetation types are classified by the shared composition of species groups, without relation to potential production or management response. An ecological land unit and an USNVC unit may be the same if an ecological land unit is dominated primarily by a relatively homogeneous stand of mature vegetation. Fine-scale ecological land units developed in Michigan rely in part on vegetation and are intended to fit into the national ECOMAP effort (Avers et al. 1994). These can be analogous to plant associations in the USNVC. For example, the Black Ash - Basswood / Viola, fine loamy substratum, poorly drained ecological land type phase 74 (Cleland et al. 1994) is similar to the *Fraxinus nigra* - Mixed Hardwood-Conifer / *Cornus sericea* / *Carex* spp. Forest association of the USNVC. Similarly, the Black Oak - White Oak / Vaccinium group ecological land type phase 10 is comparable to the *Quercus velutina - Quercus alba / Vaccinium (angustifolium, pallidum) / Carex pensyl-vanica* Forest association. In general, however, USNVC plant associations do not have a one-to-one correspondence with ecological land units, and a single USNVC association often occurs in a number of different but related fine-scale ecological land units.

5. Multi-factored component approach

Multi-factored classification units using the component approach are defined by developing separate vegetation and soil classifications within ecological regions. Patterns in these components are compared and used to define operational groups that have similar responses to management (Sims et al. 1989) (see Section II.A.). The vegetation classifications are defined primarily by existing overstory and understory floristic patterns in order to distinguish successional types. Vegetation units in these classifications are very comparable to USNVC units, and, where available, as in many provinces in Canada, they are regarded as more or less equivalent to types in the USNVC. The Black Spruce / Feathermoss type of Sims et al. (1989), for example, is directly comparable to the USNVC *Picea mariana / Pleurozium schreberi* Forest association, found in the northeastern United States.

6. Cowardin Wetland Classification

Cowardin et al. (1979) developed a wetland classification system in which wetlands are defined by plants, soils, and frequency of flooding. The hierarchical levels are defined by water body types (e.g., marine, riverine, palustrine), substrate material, flooding regime, and vegetation dominance type (see Section II.A.). The units developed by Cowardin are quite different from those of the USNVC. Many of the flooding regimes proved to be a useful descriptor of wetlands, so the USNVC includes Cowardin hydrologic modifiers wherever particular physiognomic and floristic types are found under that hydrology. For example, Cowardin's "temporarily flooded" hydrologic modifier is applied to the "Temporarily Flooded Tropical or Subtropical Rainforest" formation, the "*Populus deltoides* Temporarily Flooded Woodland Alliance" and the "*Pinus taeda - Liquidambar styraciflua - Nyssa biflora* Temporarily Flooded Forest" association.

7. Küchler's potential natural vegetation

Küchler's (1964, 1975) approach relied on the identification of potential natural vegetation types and recognized geographically extensive vegetation at a very coarse scale (see Section II.D.). The USNVC relies on existing vegetation and recognizes types at a much finer scale. Küchler's (1964) conifer bog (*Larix-Picea-Thuja*) type, for example, includes a large number of USNVC conifer and mixed conifer-hardwood alliances. Thus, the units are rarely directly comparable, except at the alliance level for very extensive late-successional types.

VI

The U.S. National Vegetation Classification

Status of Classification and Information

This section presents a summary of the overall status of the USNVC as of April 1997. This summary includes the number of types that have been developed at all levels of the classification hierarchy, the identified gaps in coverage of the current classification system, and a discussion of the level of completion for descriptions at the alliance and association levels. In addition, the geographic distribution of currently identified associations is described.

VI.A. Status of the Classification and Description of Types

More than 4100 vegetation association records currently exist in the Conservancy's data system. Each record contains a minimum set of information on the structure and physiognomy (class, subclass, group, subgroup, and formation), the vegetation alliance (name), the conservation rank, the distribution pattern by state and U.S. Forest Service ecoregion (Bailey 1995), and an indication of the level of description that has been completed for each type. These database records represent a considerable investment in data development. The data can be applied to the interpretation of vegetation types, the identification of richness and rarity patterns across the landscape, and the identification of priority areas for conservation. However, there remains a considerable amount of data that has yet to be developed.

VI.A.1 Number of Types

The number of natural and semi-natural vegetation types that has been identified for each level of the classification hierarchy is presented in Table 4. Even with additional inventory and classification work across the United States and beyond, the numbers of vegetation types listed at the levels of class, subclass, group, and subgroup are not projected to change significantly [17]. It is expected that some additional

TABLE 4.

Total Number of Vegetation Types at Each Level of the USNVC

Level	Number of Types
Class	7
Subclass	22
Group	63
Formation	218
Alliance	1571
Association	4149

Data from Natural Heritage Central Databases, April 1997.

[17] It is possible, at some future time, that an overall conceptual review of the links between floristic and physiognomic units could lead to changes in the physiognomic levels of the USNVC.

TABLE 5. Total Number of Associations by Class and Subclass in the USNVC

CLASS	SUBCLASS	NUMBER OF ASSOCIATIONS	% OF ALL ASSOCIATIONS
Forest		**1388**	**33.5**
	Evergreen Forest	716	
	Deciduous Forest	502	
	Mixed Evergreen-Deciduous Forest	170	
Woodland		**755**	**18.2**
	Evergreen Woodland	560	
	Deciduous Woodland	142	
	Mixed Evergreen-Deciduous Woodland	53	
Shrubland		**686**	**16.5**
	Evergreen Shrubland	351	
	Deciduous Shrubland	320	
	Mixed Evergreen-Deciduous	15	
Dwarf-shrubland		**129**	**3.1**
	Evergreen Dwarf-Shrubland	104	
	Deciduous Dwarf-Shrubland	24	
	Mixed Evergreen-Deciduous Dwarf-Shrubland	1	
Herbaceous		**1095**	**26.4**
	Perennial Graminoid Vegetation	882	
	Perennial Forb Vegetation	149	
	Hydromorphic Rooted Vegetation	53	
	Annual Graminoid or Forb Vegetation	11	
Nonvascular		**9**	**0.2**
	Bryophyte Vegetation	2	
	Lichen Vegetation	6	
	Alga Vegetation	1	
Sparse Vegetation		**87**	**2.1**
	Consolidated Rock Sparse Vegetation	37	
	Boulder, Gravel, Cobble, or Talus Sparse Vegetation	12	
	Unconsolidated Material Sparse Vegetation	38	
TOTAL		**4149**	**100**

Data from Natural Heritage Central Databases, April 1997.

types will be added at the formation level, particularly in the process of fully implementing the classification across different climatic and hydrologic regimes. Most of the changes to the classification system will occur in the floristic levels of the hierarchy. Many of the existing alliances and associations will be refined, and additional types will be identified in the United States as the classification develops through future inventory and analyses. For example, approximately 320 associations are presently classified as "provisional." These "provisional" types will eventually be classified into one, two, or more associations. A complete list of the current types in the U.S. National Vegetation Classification is presented in Volume II of this report (Anderson et al. 1998).

The hierarchical structure of the USNVC allows the taxonomic diversity of communities to be assessed at any level of the classification. Table 5 presents the number of associations that are presently recognized at the class and subclass levels.

The highest number of USNVC associations are found in the Forest Class (almost 1400 associations) and the Herbaceous Class (almost 1100 associations). At the subclass level, the highest number of associations are found in the Perennial Graminoid Vegetation Subclass (over 800) and the Evergreen Forest Subclass (716), which together account for nearly 40% of the currently defined associations.

VI.A.2 Description of Types

Type descriptions at all levels of the hierarchy are critical to the appropriate and consistent use of the USNVC. At the floristic (alliance and association) levels, detailed descriptions are essential for recognition of the type in the field. Conservancy ecologists have completed descriptions of 48% of the 1571 classified alliances. Ongoing Conservancy research will result in the completion of about 650 additional alliance descriptions in 1998 and 1999.

Due to the finer level of analyses and description required, only 28% of the 4149 associations have been described to date. Descriptions are intended to provide information on the geographical distribution, level of acceptable physiognomic and compositional variation, and the key ecological processes and environmental/abiotic factors that are associated with a type. For example, a summary description and occurrence map of the association *Quercus marilandica - Juniperus virginiana* var. *virginiana / Schizachyrium scoparium - Hypericum gentianoides* Wooded Herbaceous Vegetation is provided in Box 2.

VI

BOX 2

An Example of an Association Description

DESCRIPTION OF *Quercus marilandica - Juniperus virginiana var. virginiana / Schizachyrium scoparium - Hypericum gentianoides* Wooded Herbaceous Vegetation

This association occurs on the upper slopes and ridgetops of south-facing bluffs and escarpments in the Shawnee Hills of southern Illinois, western Kentucky, and southern Indiana. Bedrock is sandstone, which occurs on the surface as massive outcrops, level benches, and boulders. The substrate is a strongly acidic silt loam, which is thin, poorly developed, and very well drained (dry to xeric). *Quercus stellata*, *Q. stellata*, and *Juniperus virginiana* are the dominant trees, which can be found scattered or in patches throughout the occurrence. These trees are generally small, stunted, and limby. The overstory cover seldom exceeds 50%. The subcanopy is conspicuously thin or absent. Scattered individual and patches of shrubs occur in this community, with *Vaccinium arboreum* and *Ulmus alata* the most commonly encountered. *Schizachyrium scoparium*, *Danthonia spicata*, *Andropogon virginicus*, and *Dichanthelium* spp.

BOX 2 (continued)

dominate the herbaceous layer, along with a diverse mixture of forbs.

COMMON NAME: Blackjack oak - red cedar / little bluestem - side-oats grama Wooded Herbaceous Vegetation

SYNONYM: Shawnee Sandstone Glade

TNC SYSTEM: Terrestrial

CLASS: Herbaceous

SUBCLASS: Perennial Graminoid Vegetation

GROUP: Temperate or Subpolar Grassland with a Sparse Tree Layer

SUBGROUP: Natural/Semi-natural

FORMATION: Medium-tall Temperate or Subpolar Grassland with a Sparse Needle-leaved or Mixed Tree Layer.

ALLIANCE: *Schizachyrium scoparium - Danthonia* spp. Evergreen or Mixed Wooded Herbaceous Alliance

CLASSIFICATION CONFIDENCE LEVEL: 2 (Moderate).

RANGE: This community occurs in southern Illinois, southern Indiana, and Kentucky. It is associated with the Shawnee Hills and Highland Rim regions of the Interior Low Plateau (McNab and Avers 1994) where sandstone bedrock is at or near the surface. The present range of this community is probably very close to presettlement range.

ENVIRONMENTAL DESCRIPTION: This community occurs primarily on south- and southwest-facing slopes. This droughty environment has thin, acidic soils that can erode easily. The slope aspect results in frequent periods of freeze and thaw and consequent erosion and mass wasting. Aspect also contributes to summer temperatures well in excess of cooler and wetter north- and east-facing slopes.

USFWS WETLAND SYSTEM: Not applicable

MOST ABUNDANT SPECIES: *Quercus stellata, Quercus marilandica, Juniperus virginiana, Ulmus alata, Vaccinium arboreum, Smilax bona-nox, Danthonia spicata, Schizachyrium scoparium, Parmelia* spp., *Polytrichum* spp.

DIAGNOSTIC SPECIES: *Quercus marilandica, Vaccinium arboreum, Smilax bona-nox, Schizachyrium scoparium, Hypericum gentianoides*

VEGETATION DESCRIPTION: This community is dominated by graminoid species with scattered *Quercus marilandica* and *Juniperus virginiana*. The patchiness and uneven distribution of trees, shrubs, and herbaceous vegetation is a response to thin infertile soils and droughty conditions. *Quercus stellata*, *Quercus marilandica*, and *Juniperus virginiana* are the dominant trees, which can be found scattered or in patches throughout the occurrence. These trees are generally small, stunted, and limby.

(continued on page 50)

VI

BOX 2 (continued)

The overstory cover seldom exceeds 50%. The subcanopy is conspicuously thin or absent. Scattered individual and patches of shrubs occur here, with *Vaccinium arboreum* and *Ulmus alata* the most commonly encountered. *Schizachyrium scoparium*, *Danthonia spicata*, *Andropogon virginicus*, and *Dichanthelium* spp. dominate the herbaceous layer, along with a diverse mixture of forbs. *Toxicodendron radicans* is found here, but *Smilax bona-nox* is more indicative of conditions found in this sparse woodland community. Lichens and mosses are common on exposed bedrock surfaces and on soils not covered with organic debris (leaf litter, wood).

OTHER NOTEWORTHY SPECIES: Other species that occur selectively within this natural community include *Saxifraga forbesi* and *Collinsia violacea*.

RELATED VEGETATION TYPES (USNVC): A closely related association is *Quercus stellata - Quercus marilandica - Carya texana / Schizachyrium scoparium* Woodland, which has a more closed and mature canopy, and a less diverse herb layer.

RELATED VEGETATION TYPES (OTHER NATIONAL AND REGIONAL SYSTEMS): Intersects, but is not directly comparable to, SAF Cover Type 46-Eastern Red Cedar (Eyre 1980) and Küchler (1964, 1975) type 83-Cedar glades (*Juniperus-Quercus-Sporoblus*).

SUCCESSIONAL STATUS/HISTORY: Natural disturbance includes periodic fire, wind, storm, and drought. Environmental extremes, including rapidly drained, thin, stony soils, summer droughts lasting 3-5 weeks or more, and limited water availability for most of the growing season, favor the establishment of this glade association. Periodic fire may help to maintain this community, especially after disturbance from logging or grazing. Fire suppression encourages a transition from glade to woodland. Herds of elk, deer, and buffalo once roamed these hills, and their grazing and browsing may have provided a mechanism for maintaining the "barrens" or glade character.

CONSERVATION RANK: G3?

RANK JUSTIFICATION: This community has a restricted distribution.

MANAGEMENT COMMENTS: Prescribed fire is becoming a commonly used tool for barrens or glade restoration. Although little data are available concerning presettlement fire frequency, a reduction in this frequency has contributed to recent increases in woody species coverage (Robertson and Heikens 1994). Some researchers suggest that mechanical removal of larger trees and periodic burning (every 2-3 years) may be necessary to maintain sparse woodland physiognomy (Heikens et al. 1994).

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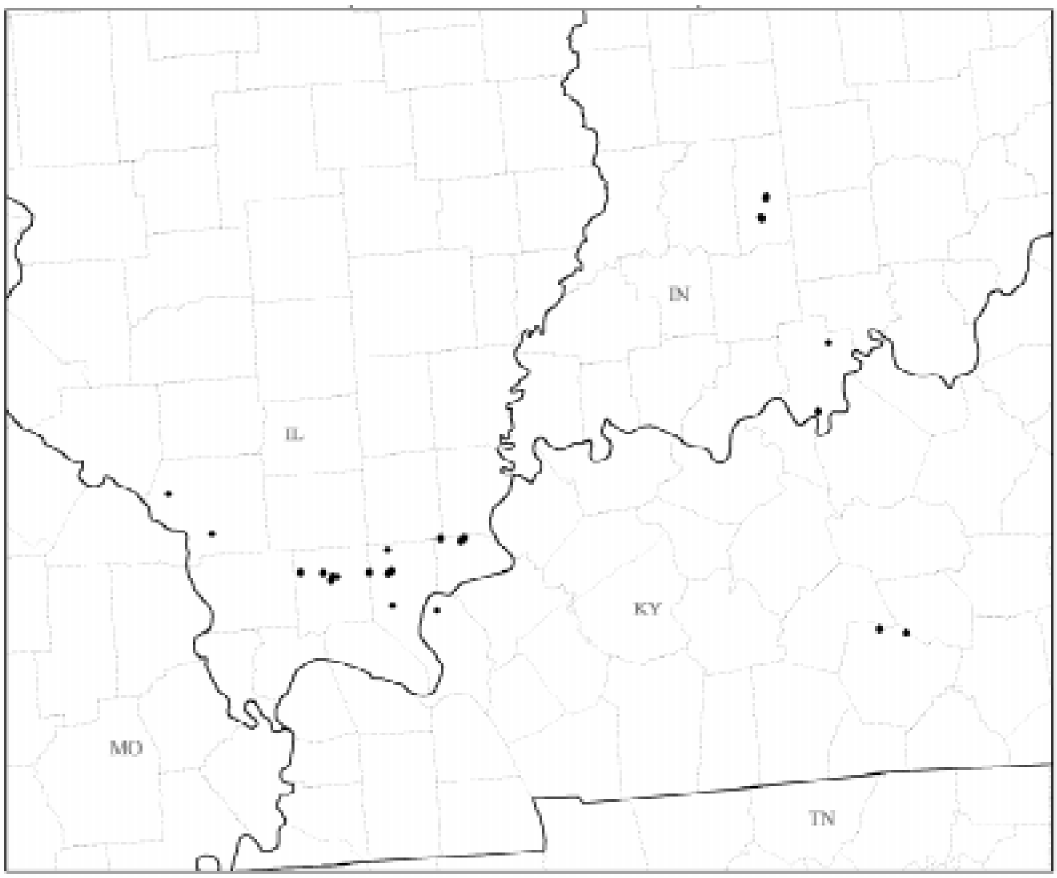
————. 1975. Potential natural vegetation of the conterminous United States (map). Second edition. American Geographical Society, New York, New York, USA. [Scale: 1: 3,168,000.]

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

BOX 2 (continued)

Robertson, P. A., and A. L. Heikens. 1994. Fire frequency in oak-hickory forests of southern Illinois. Castanea 59: 286-291.

MAP: *Quercus marilandica - Juniperus virginiana* var *virginiana / Schizachyrium scoparium - Hypericum gentianoides* Wooded Herbaceous Vegetation (Shawnee Sandstone Glade)



OCCURRENCE DATA ARE FROM THE FOLLOWING SOURCES: the Illinois Department of Natural Resources, Division of Natural Heritage; the Division of Nature Preserves, Indiana Department of Natural Resources; and the Kentucky State Nature Preserves Commission.

MAP CREATED BY: The Nature Conservancy, Midwest Conservation Science Department, Copyright April 1998, The Nature Conservancy.

The data depicted here are not based on an exhaustive inventory of each state. The lack of data for any geographic area cannot be construed to mean that no occurrences are present. Neither the state Natural Heritage Programs or TNC are responsible for any inaccuracies in the data and do not necessarily endorse any interpretations or products derived from the data. The data were compiled from a variety of sources including state surveys, universities, systematic collections, non-game programs, county inventories, government organizations, field searches, and individual biologists. Additions and changes to those data are constant. This map only depicts the state of knowledge on the date listed.

VI

VI.B. Level of Completeness of the Current USNVC

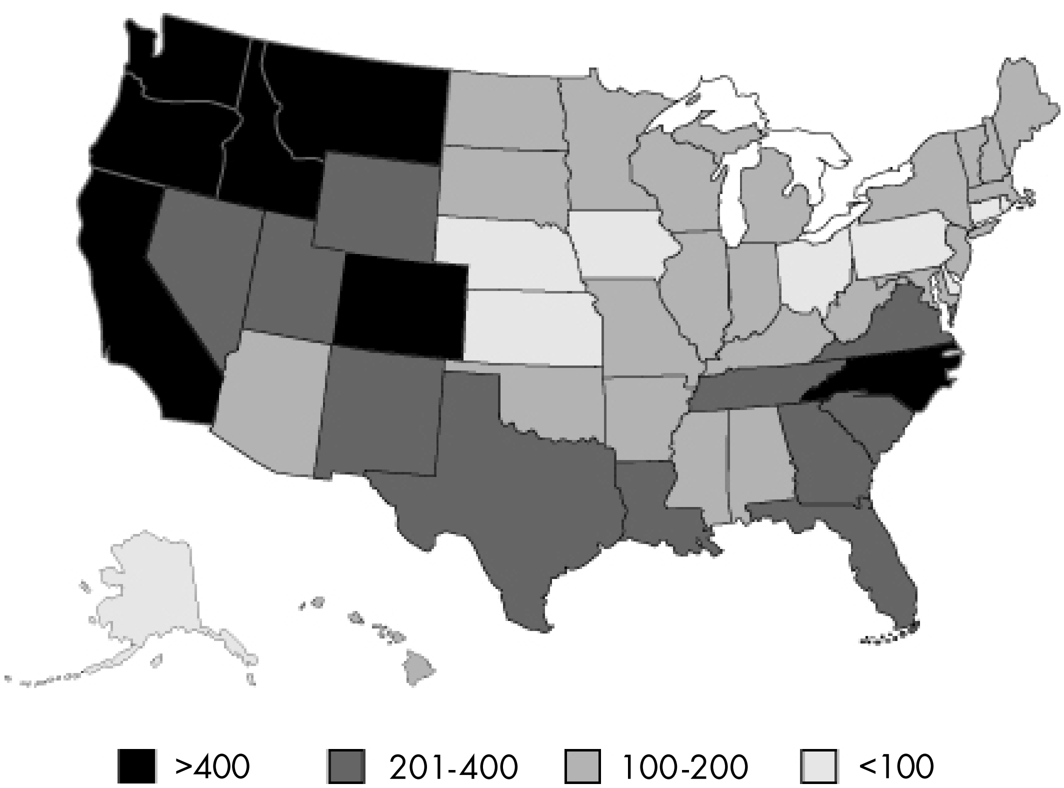
As previously discussed, the list of classification units at the physiognomic levels of the classification hierarchy is nearly complete for all of the natural/semi-natural vegetation in the United States. This does not hold true at the floristic levels of the classification hierarchy. Types and examples of classification gaps at the floristic levels include the following.

Taxonomic information gaps refer to groups of related vegetation that have not been adequately or consistently inventoried and classified. For example, in the western United States, herbaceous and shrubland communities have not been as well inventoried and classified as forests. In general, more information is available for Forest, Woodland, Shrubland, and Herbaceous Classes than for Dwarf-Shrubland, Nonvascular, and Sparse Vegetation Classes. Shortgrass prairie vegetation and many riparian types have not been consistently classified. In addition, the degree of classification confidence for upland types is generally higher than for wetland types. The classification of communities that occur as vegetation complexes will also require additional research and analysis.

Geographic information gaps refer to particular regions which are not adequately inventoried, classified, or otherwise represented in the USNVC. Some well documented geographic data gaps include the Great Basin, Alaska, California, and parts of the southeastern United States (Alabama, Georgia, Mississippi, and Tennessee).

Classification confidence gaps represent cases

FIGURE 4. Current Number of Associations by State

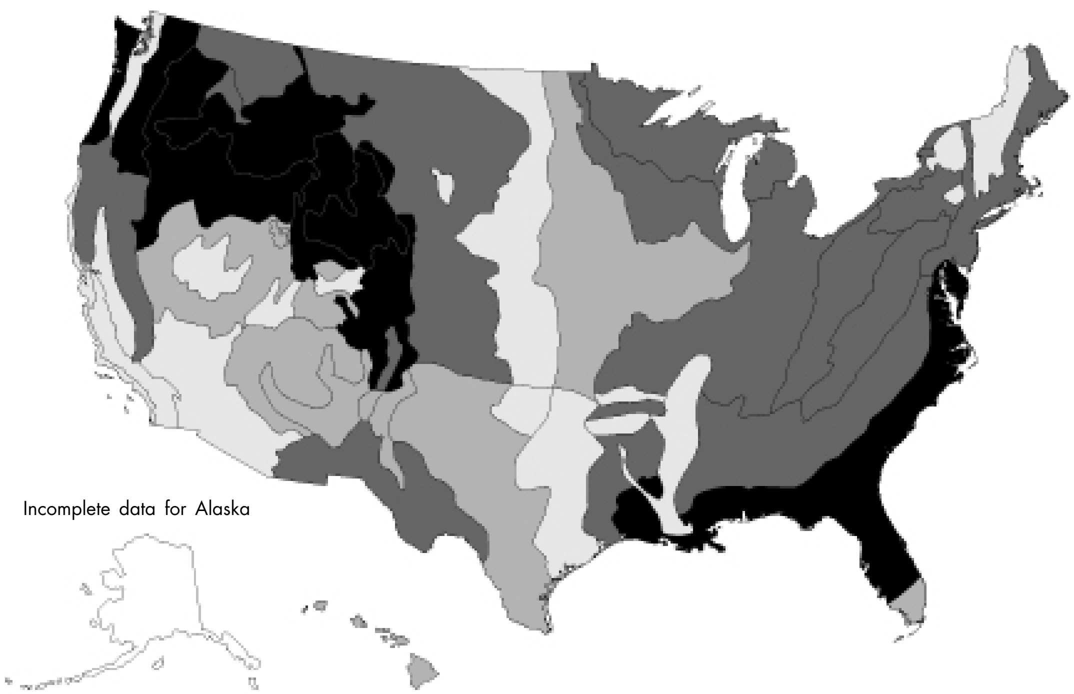


in which the components of the classification for a region or for a taxonomic group are based on an insufficient quantity of data, or on data of questionable quality or incomplete resolution. Many of these associations are poorly defined and are identified as "provisional" types. The acquisition and analysis of additional data may result in the splitting of some broadly defined types and in the combination of others that are classified too finely or represent the same conceptual entity. Some regions or taxonomic groups may appear to be thoroughly classified, but the classification is not based on good information. These will need to undergo major stages of refinement. This type of classification gap is the most difficult to assess, but it exists to some extent in many facets of the USNVC.

See Appendix B for a state-by-state compilation of information on taxonomic and geographic strengths and weaknesses in the current version of the USNVC.

Regardless of the level of classification confidence and completeness, many USNVC types have not been fully described. Completing the descriptions is necessary so that users can recognize the vegetation types in the field and understand the recognized degree of variation within each type, the distribution of the type, the relationships to key ecological processes, and the conservation and management status of each type. Many of the vegetation types do not have enough information available to enable a broad audience of users to make better informed conservation and management decisions. Seventy-two percent of the currently identified associations have not been described, and 22% have not been assessed for their current conservation status.

FIGURE 5. Current Number of Associations by Bailey's Ecoregion (Province Level)



>400 | 201-400 | 100-200 | <100

VI

VI.C. Geographic Distribution of Associations

The geographic distribution of associations in the United States is tracked at the association level by the state(s) and the U.S. Forest Service ecoregion(s) (Province level) (Bailey 1995) where the associations are known or strongly predicted to occur. Although geopolitical boundaries, such as states, are a commonly applied framework for examining the distribution of associations, ecoregional boundaries provide a more ecologically useful background on which to view these patterns of diversity. Figures 4 and 5 show the current number of associations that are listed for each state and ecoregional province. These data not only represent the level of biological diversity associated with each geographic unit, but also the level of classification maturity for these areas.

The distribution of associations indicates that the Pacific Northwest, northern Rocky Mountain region, and the southeastern coastal region are areas of high relative ecological diversity. It is possible that the patterns will shift significantly as additional classification refinement is completed (particularly in the Great Basin, Alaska, California, and parts of the southeastern United States).

VI

VII

The U.S. National Vegetation Classification

Data Management Systems Supporting the U.S. National Vegetation Classification

This section outlines the primary systems either in place or being developed to manage and analyze both "raw" data obtained from field sampling and detailed information related to all facets of the USNVC types.

VII.A. Plot Databases and Analytical Standards

The use of standardized inventory methods by the Conservancy and other groups to collect quantitative data for the purpose of vegetation classification and mapping is steadily increasing. The associated requirements for consistent standards in data management have led to the development of plot databases. Two databases are presently being developed and supported by the Conservancy to manage the vegetation data generated from field samples.

A plot and polygon database has been developed by the Conservancy to manage information on vegetation and the environment. Initially constructed to manage and report plot data for the National Park Service Vegetation Mapping Program, the database is basically an electronic version of the standard field forms (see Appendix A). It manages plot and polygon level data concerning locational information, environmental information, full species lists, and much more. The database is programmed with standard selections to populate each data field, and the PLANTS Database (as of December 1996) is included to ensure quality and consistency in standard plant taxonomy. The "Plots" database does not have internal analytical capabilities, but is programmed with export utilities that format output plot data for many standard analytical software packages.

The Conservancy has also cooperated with the U.S. Forest Service to implement an integrated set of relational databases and analytical software packages that are programmed for environmental assessment and ecosystem analysis as well as for standard vegetation descriptions and analysis. "ECADS" (Ecosystem Characterization And Description System) (Jensen et al. 1994) was developed to facilitate the efficient and consistent description of ecosystem components including vegetation, soil, stream, wildlife, and topography at multiple scales from the plots to sites. Data can be exported to a sophisticated set of statistical analysis packages which allow classification of vegetation and other ecosystem components. ECADS also supports the modeling of ecological processes such as fire behavior, and it helps predict resource values of particular plots or sites (e.g., forage values, habitat suitability, etc.). A polygon database provides descriptions of digitized map themes to support environmental assessment programs. The prototype of ECADS was provided to Heritage Programs in the western United States for testing. Following this test, the system will be evaluated for its broader utility at a national level.

VII.B. The Biological and Conservation Data System

The Nature Conservancy and the Natural Heritage Network manage relevant information for conservation planning in a relational database, the Biological and Conservation Data (BCD) System. A set of files has recently been developed within the BCD system to manage information related to the USNVC. These community files, which are presented in greater detail below, are presently being tested across the national, regional, and state nodes of the database network. They will eventually be integrated into the BCD system with complementary files on sites and managed areas, stewardship and management information, and monitoring training (TNC, Conservation Science Division, in association with the network of Natural Heritage Programs and Conservation Data Centers 1996). A database reporting tool has also been developed to help create reports out of the BCD system.

1. Community Classification Maintenance

The vegetation classification hierarchy is maintained in the Classification files. There is one file for each level of the hierarchy (from the class level through the alliance level) that manages the codes, names, and brief descriptions of every type defined within the classification hierarchy. These files are linked hierarchically and track the placement of every type in the overall hierarchy.

2. Community Element Tracking

The Nature Conservancy and the Natural Heritage Network track species and communities as the fundamental "elements" of conservation. The terrestrial community elements that are tracked are the lowest level of the vegetation classification system that has been defined. This level is usually the association, but may be an alliance or formation when more detailed information or classification is not forthcoming. The Element Tracking (ET) file serves as a condensed index to the codes, names, classification, and conservation rank and status of all community elements in the USNVC. It also lists the relationship between types in the USNVC and related types in other state or regional classification systems. The ET file is used to identify the individual or office that has responsibility for gathering and managing detailed data on each type (especially for assessing global conservation ranks and for writing descriptions). A global, national, and state (subnational) version of these files allows tracking of community elements at these different geographic scales.

3. Community Element Ranking

The Element Ranking file houses information on the global conservation status, the relative rarity, or degree of rangewide imperilment for each community element. The criteria used to determine that rank are documented in this file, along with information on research, inventory, protection and stewardship needs for that element. The file also contains fields for developing a definition of a "viable occurrence" of that community and specifications for ranking the quality of different occurrences. A global, national, and state (subnational) version of these files allows ranking of community elements at these different geographic scales.

4. Community Element Occurrence Documentation

The Element Occurrence Record (EOR) file carries information on the known high quality viable occurrences of each community element. In most cases, an occurrence is defined as a stand representing a specific association. (For more information on "occurrences" of elements see TNC, in cooperation with the network of Natural Heritage Programs and Conservation Data Centers 1997.) Each occurrence of an association is coded, ranked, and described in considerable detail. Association occurrence descriptions include fields for a basic description of the vegetation, its physiognomic structure, biotic composition, and heterogeneity. Fields housing information on key environmental factors, dynamic processes, landscape relations, and disturbance history are included in each record. This file also has fields for information on location, protection status, and ownership for each occurrence, as well as references to past research and the documentation of methods used for inventory and sampling.

5. Community Element Characterization

The Community Characterization Abstract file manages detailed descriptive information about each community element in the USNVC. Fields in this file house basic descriptions of the vegetation, its physiognomic structure, and biotic composition. Also housed here are data on the key environmental factors, dynamic processes, landscape relations, community variability, threats, and management and protection needs associated with each type. Fields housing information on the relationship of each type to types from other classification systems are also included in the data structure. A global, national, state (subnational), and local version of these files allows characterization of community elements at different geographic scales. The Conservancy has identified a minimum subset of the fields that provide a satisfactory description of a vegetation type. An example of a CCA is included as Box 2 in Section VI.A.2.

6. Community Ecoregion Distribution

The Ecoregion files manage information on the Conservation Ecoregions developed by the Conservancy as well as the ecoregions defined by the U.S. Forest Service (Avers et al. 1994). These files enable tracking of the distribution of alliances, community elements, and community element occurrences within both ecoregional approaches. In addition to global ecoregional distributions, national, state (subnational), and local ecoregional distributions can be tracked.

7. Community Information Sources

The Source Abstract files serve as an electronic catalogue of information sources related to the USNVC and individual community elements. This file includes references to articles, books, maps, photos, and any other source material. It may be used to generate bibliographies on any related subject, geographic area, or author. Each record contains a code, a formal citation, a brief abstract, a set of keywords to characterize the source, and a set of geographic locator fields. Each record also contains a “shelf-note,” which identifies where this information is filed, and a rating of the usefulness of the source.

VIII

Applications and Future Challenges

Applications of the U.S. National Vegetation Classification

Many conservation and resource management applications require classifications, and the existence of a national vegetation classification system is providing a higher level of efficiency and consistency for many of these. This section provides examples of selected applications of the USNVC.

VIII.A. Vegetation Inventory and Mapping

Both baseline and trend information about vegetation are critical for the valuation, conservation, and management of natural resources. The vegetation information to support these assessments is developed through inventory, monitoring, and mapping programs.

The USNVC system provides a uniform framework to support inventory and monitoring activities. The results of local inventories can be assessed in relation to other studies that have applied the same system. The use of common field methods, data management, and classification standards ensures that data from each study will be useful to all users. A common information structure enables the aggregation and assessment of local and regional inventories. Patterns of relationships between vegetation and species, and between vegetation and ecological processes, can then be developed across the landscape. Understanding these patterns is critical to the development and achievement of realistic conservation and management goals. The conservation goals for a vegetation type are developed and refined through the assessment of its current status and distribution rangewide. Repeated application of the same vegetation standards and procedures also supports the monitoring of vegetation change over time across a landscape. These data can be used to refine the USNVC and develop a better understanding of the vegetation types. Thus, conservation and management goals can be implemented and adapted with greater confidence to meet the desired future objectives for the resource.

One common approach to inventory is to analyze imagery, and a standard product of this analysis is a vegetation map. The USNVC provides an important, standardized system for the development of consistent vegetation maps. A vegetation classification can be used to develop pure vegetation maps (Küchler 1988*a*), or it can serve as an information component in the development of ecological maps (Küchler 1988*b*, Zonneveld 1988) or maps of land units (Zonneveld 1989).

Two large national mapping efforts, the Gap Analysis Program and the National Park Service Inventory and Monitoring Program, presently use the USNVC as the standard for vegetation mapping at the state and local levels.

The Gap Analysis Program develops land cover maps from Landsat satellite imagery for each state as a framework for assessing the conservation status of vegetation types and associated target species. This program specifies the standard use of the USNVC at the alliance level to develop these vegetation maps. This programmatic implementation of the USNVC system ensures that state maps can be integrated across regions for presentation, analysis, and reporting purposes.

As a foundation for its inventory and monitoring program, the National Park Service (NPS) has instituted a vegetation mapping program to produce vegetation maps for all national park lands. The program uses 1:24,000 scale color infrared photography as the basis for mapping the USNVC, at the association level wherever possible. The maps will be used at the parks for resource management and planning purposes. An example of the application of the USNVC for the NPS Vegetation Mapping program at Scotts Bluff National Monument is presented in Box 3.

BOX 3

Vegetation Mapping at Scotts Bluff National Monument

Scotts Bluff, a prominent natural landmark in western Nebraska used by emigrants on the Oregon Trail, was set aside with Mitchell Pass and the adjacent prairie lands in a 3,000 acre national monument within the National Park Service system. The Nature Conservancy, as part of the U.S. Geological Survey's BRD/NPS Vegetation Mapping Program, inventoried and classified the USNVC types across the Monument and worked with photo-interpretation specialists to create a vegetation map. The methods used for developing the vegetation classification for Scotts Bluff National Monument followed the standards described in "Field Methods for Vegetation Mapping" (TNC and ESRI 1994).

Eighteen vegetation associations were delineated for Scotts Bluff National Monument, including 3 woodland types, 3 shrubland types, 7 herbaceous types, and 5 sparsely vegetated types. In addition, 2 mosaic communities were designated. These combine a prairie type and sparsely vegetated types. The upland herbaceous communities (grasslands) and the sparsely vegetated communities occupy the vast majority of the Monument, with communities dominated by woody or wetland herbaceous vegetation forming minor components.

Staff at the Monument had previously delineated 24 disturbance polygons. These are sites that had been converted to human use (agriculture, golf, etc.) and are currently in various stages of recovery from that disturbance. These polygons have been designated for (or are in the process of) restoration by the Monument staff. At the request of the Monument staff, all of these polygons were sampled to characterize them. These sites were placed in one of two community categories: Mixedgrass Prairie (Restored/Reseeded), and *Kochia scoparia/Bromus* spp. Early Seral Community.

The vegetation map of Scotts Bluff National Monument completed for this project is shown on the back cover. For each of the vegetation types identified on the map, a description was provided, characterizing the type on a rangewide basis, as well as its local expression at the Monument. A vegetation key was also developed to facilitate identification of the types in the field and thus ensure maximal use of the classification for conservationists and resource managers. (Appendix C presents the vegetation key and an example of a type description.)

Staff at the Monument plan to use the map and associated descriptions to direct searches for state-listed rare plant species suspected to occur within the Monument, to locate long-term monitoring plots in major prairie types, to monitor the results of their restoration efforts, and to track long-term changes in vegetation at the Monument. The staff also intend to use the vegetation descriptions as a means of assessing potential fuel loads and fire behavior when they plan prescribed burns. Finally, the map and descriptions will form the basis of interpretive displays used to provide visitors with an understanding of the range of vegetation types found within the National Monument.

VIII.B. Conservation

Although many approaches to conservation focus on biological species, the concept of conservation at levels of biological organization above the species has become an important component of the conservationist approach (EDF 1995, Frankel et al. 1995, Noss and Peters 1995, Noss 1996). Basic knowledge concerning ecological community types and their distribution is critical to their identification, protection, and management. To prioritize effective and efficient conservation and management strategies, the classification of these types must be standardized so that a status assessment of the rangewide rarity and threats associated with each can be completed.

VIII.B.1. TNC Conservation Agenda

The mission of The Nature Conservancy is to preserve plants, animals, and natural communities that represent the diversity of life on Earth by protecting the land and waters they need to survive. The conservation of natural communities, typically characterized using vegetation, is included as part of the Conservancy's mission because (1) communities have inherent value that is worth conserving (e.g., they provide important ecosystem functions); (2) they can be used as coarse filters to protect most species; that is, by protecting communities, many species are protected as well; and (3) they can be used as surrogates in areas where little is known about species patterns or ecological processes. The conservation of exemplary occurrences of all community types (as well as those of rare species) has been fundamental to the conservation strategy of The Nature Conservancy and the Natural Heritage Programs for many years. The USNVC is critical to the consistent application of conservation status ranks, which are the basis for prioritizing conservation action within the Conservancy. The mission of protecting the best remaining occurrences of rare and threatened species and natural communities has been carried out on a site-by-site basis at the Conservancy's state field offices. A recent initiative (TNC 1996), calls for the identification of a portfolio of conservation sites that would adequately protect *all* representative biological diversity on an ecoregion-by-ecoregion basis. The USNVC is providing the framework for the overall identification of important conservation sites in most of these ecoregional efforts.

VIII.B.1.a. Conservation Ranking and Its Use in Planning

Natural vegetation types are assigned conservation ranks [18] to support the Conservancy's approach to the identification and prioritization of critical areas for the conservation of biological diversity. Conservation ranks are ideally assigned at the association level in the USNVC hierarchy, because it is at this level that conservation action is most effective. For types occurring in the United States, conservation ranks have been assigned at the association level. Conservation ranks could be completed at the alliance or formation level in areas of the world where vegetation is not well inventoried and classified.

The methodology of assigning conservation ranks was adapted from a process developed for species (Master 1991). The ranks listed in Table 6 are based on a number of relative endangerment factors. These factors include the estimated number of occurrences, rangewide acreage, condition of occurrences, threats, degree of decline from historic extent [19], degree of alteration of the supporting natural processes, and the environ-

[18] Ranks for modified, alien, and ruderal vegetation types have recently been developed so that information on all vegetation types can be managed (see Appendix E).

[19] The status of ecological systems is determined through the assessment of their present distribution in relation to their historic distribution (see Noss et al. 1995). The historical distribution in the United States in often measured from the time of European settlement, and is usually completed on an ad hoc basis for individual ecological systems.

VIII

mental specificity exhibited by the type. Conservation ranks are customarily assigned by the various members of the network of Natural Heritage Programs and by national, regional, and state offices of The Nature Conservancy. For each community type, a rank can be assigned at three geographic scales: global (the rangewide rank or GRANK), national (the national rank or NRANK), and subnational (the state, province, or other subnational unit rank or SRANK). This ranking system is described in greater detail in Appendix D.

The combination of ranking and classification standards enables the assignment of global conservation ranks to all vegetation types. Approximately 22% of the 4149 classified associations have not yet been ranked, and 3% cannot be ranked until additional data are collected and evaluated. The identification of high conservation priority types has been the primary focus of classification and ranking efforts to date, and a relatively small percentage of these unranked and unrankable types are expected to be critically imperiled or imperiled (G1 or G2).

Table 6 and Figure 6 present the distribution of global conservation ranks that are assigned to the 4149 currently listed USNVC associations in the United States.

Approximately 50% of the known associations are considered vulnerable (G3) or imperiled (G1,G2). All vulnerable and imperiled communities are actively assessed to determine the urgency of conservation action. Although the Conservancy is dedicated to conserving the best examples of all natural vegetation types, imperiled and vulnerable types (and species)—those ranked G1, G2, or G3—are often regarded as the principal targets for conservation action. All G1-G3 ranked communities are assessed for conservation status (through rangewide assessment; see Section VIII.B.1.d.), and active steps are taken to ensure adequate protection. Special attention is focused on types with a high level of imminent endangerment, because conservation opportunities for these are more limited in space and in time.

The taxonomic distribution (by class and subclass) of imperiled (G1, G2) associations is presented in Table 7.

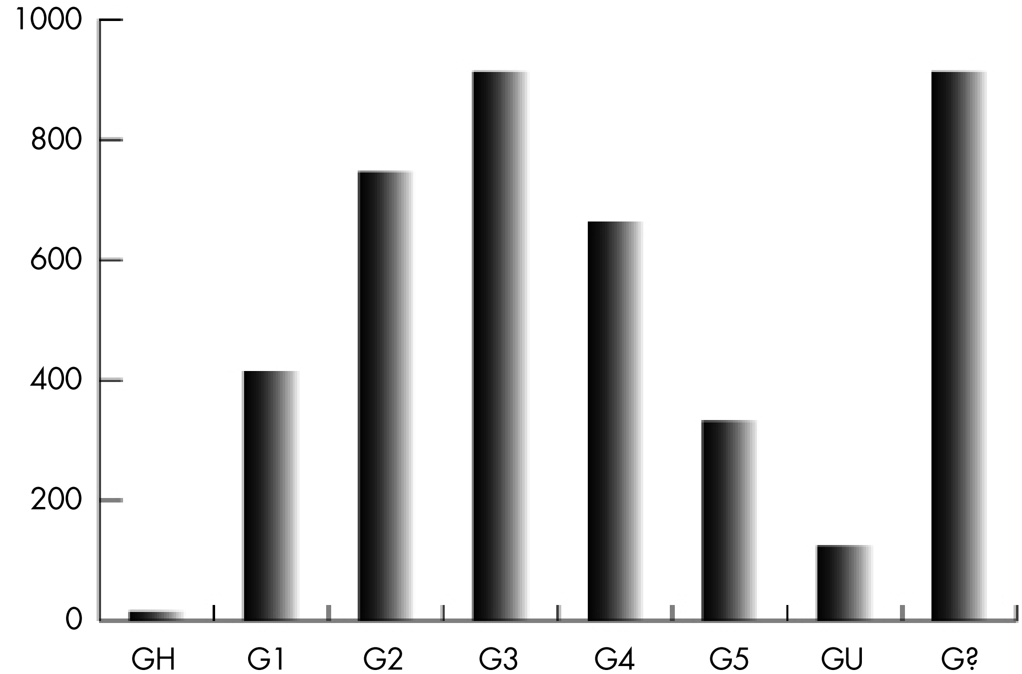
The highest numbers of imperiled associations are found in the Herbaceous, Forest, and Woodland Classes. This is primarily due to conversion of these lands to agriculture, resource extraction, and development. More detailed patterns of imperilment can be discerned; for example, the deciduous woodlands are markedly more imperiled than the evergreen or mixed woodlands.

All USNVC associations are tracked by the states and by the U.S. Forest Service ecoregional

TABLE 6. Conservation Ranks for Associations

Global Conservation Rank	% of Associations
GX – Eliminated	0
GH – Presumed eliminated (historic)	<1
G1 – Critically imperiled	10
G2 – Imperiled	18
G3 – Vulnerable	22
G4 – Apparently secure	16
G5 – Secure	8
GU – Unrankable	3
G? – Unranked	22

FIGURE 6. Total Number of Associations by Conservation Rank.



provinces (Bailey 1995) in which they are known or predicted to occur. Patterns of community richness (see Figures 4 and 5 in Section VI.C.) and the distribution of rare and imperiled associations can help to identify priorities for conservation action. Figures 7 and 8 demonstrate the number of known imperiled (G1, G2) associations for each state and ecoregional province.

States with the highest numbers of known imperiled associations include those in the Pacific Northwest, as well as California, Texas, Florida, North Carolina, and Virginia. When imperilment is evaluated on an ecoregional basis (Figure 8), areas in the Midwest and the Appalachian Mountains appear to have the highest number of imperiled associations. These patterns of imperilment are likely to change as additional classification and ranking of USNVC types is completed. A view of these data which is less biased by the level of classification and development is displayed by the *percentage* of all associations that are imperiled (G1, G2) in a state (Figure 9) or ecoregion (Figure 10). In these analyses, the Midwest, Appalachian Mountains, southeastern Coastal Plain and Florida, Hawaii, the Central Valley of California, and the Willamette Valley of Washington and Oregon are conspicuous for their high percentage of imperiled communities. It is possible that the patterns exhibited in these figures will also shift as additional inventory and classification of the Great Basin, Alaska, California, and parts of the southeastern United States is completed. Nonetheless, these data are extremely useful in identifying the potential large-scale geographic patterns of rarity and endangerment in vegetation types. This utility for conservation objectives will continue to increase as the USNVC becomes more fully developed.

VIII.B.1.b. Identification of Conservation Priorities within an Ecological Region

The USNVC is a valuable tool for prioritizing specific community conservation targets over large areas, such as ecological regions. Many coarse-scale conservation assessments have documented a catastrophic decline of the Prairie

(continued on page 66)

VIII

TABLE 7. Taxonomic Distribution of Imperiled Associations (G1, G2) at the Class and Subclass Levels of the USNVC.

CLASS Subclass	NUMBER OF ASSOCIATIONS	NUMBER OF IMPERILED (G1, G2) ASSOCIATIONS	PERCENT IMPERILED ASSOCIATIONS
Forest	**1388**	**325**	**23.4**
Evergreen Forest	716	173	24.1
Deciduous Forest	502	120	23.9
Mixed Evergreen-Deciduous Forest	170	32	18.8
Woodland	**755**	**259**	**34.3**
Evergreen Woodland	560	174	31.1
Deciduous Woodland	142	66	46.5
Mixed Evergreen-Deciduous Woodland	53	19	35.8
Shrubland	**686**	**159**	**23.2**
Evergreen Shrubland	351	77	21.9
Deciduous Shrubland	320	75	23.4
Mixed Evergreen-Deciduous	15	7	46.7
Dwarf-Shrubland	**129**	**37**	**28.7**
Evergreen Dwarf-Shrubland	104	28	26.9
Deciduous Dwarf-Shrubland	24	9	37.5
Mixed Evergreen-Deciduous Dwarf-Shrubland	1	0	0
Herbaceous	**1095**	**382**	**34.9**
Perennial Graminoid Vegetation	882	332	37.6
Perennial Forb Vegetation	149	36	24.2
Hydromorphic Rooted Vegetation	53	10	18.9
Annual Graminoid or Forb Vegetation	11	4	36.4
Nonvascular	**9**	**3**	**33.3**
Bryophyte Vegetation	2	1	50.0
Lichen Vegetation	6	2	33.3
Alga Vegetation	1	0	0
Sparse Vegetation	**87**	**16**	**18.4**
Vegetation	37	5	13.5
Boulder, Gravel, Cobble, or Talus Sparse Vegetation	12	0	0
Unconsolidated Material Sparse Vegetation	38	11	28.9
TOTAL	**4149**	**1181**	**28.5**

Data from Natural Heritage Central Databases, April 1997.

VIII

FIGURE 7. Total Number of Imperiled (G1, G2) Associations by State

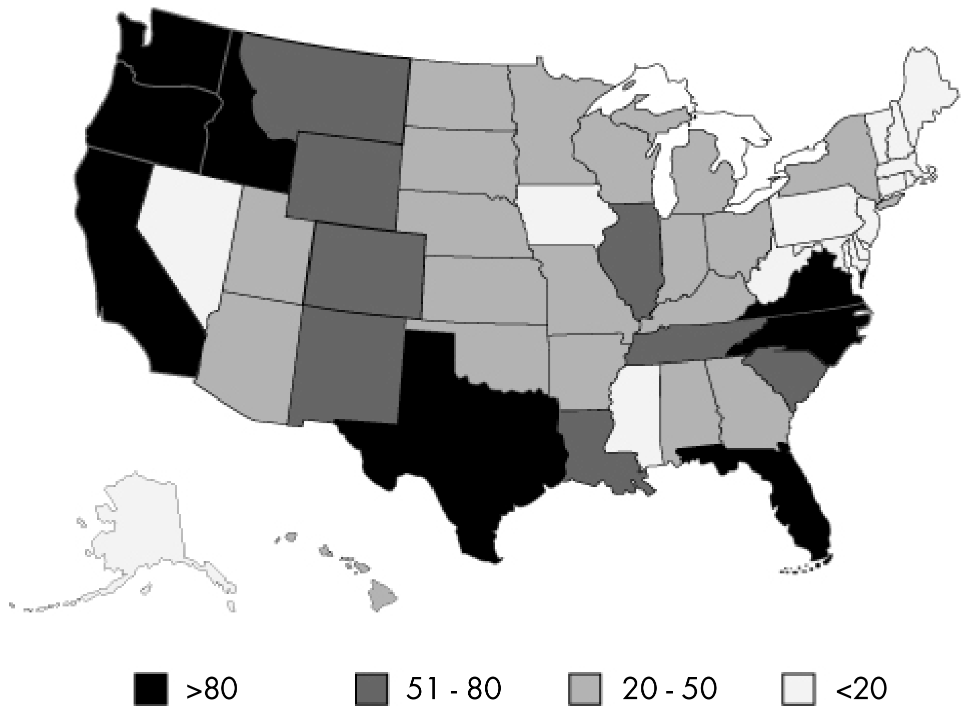


FIGURE 8. Total Number of Imperiled (G1, G2) Associations by Bailey's Ecoregion (Province Level)

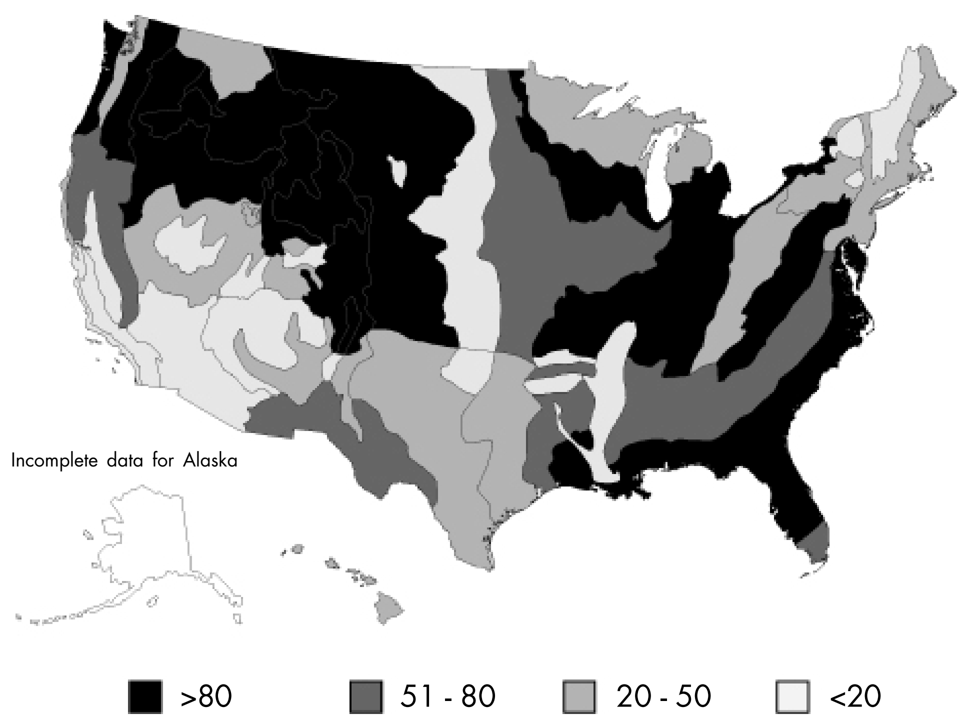
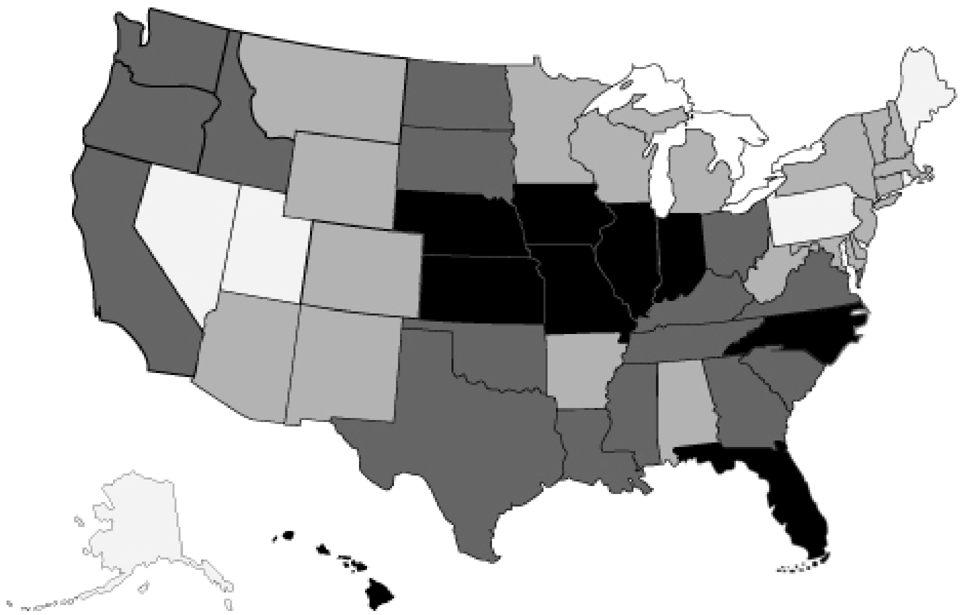
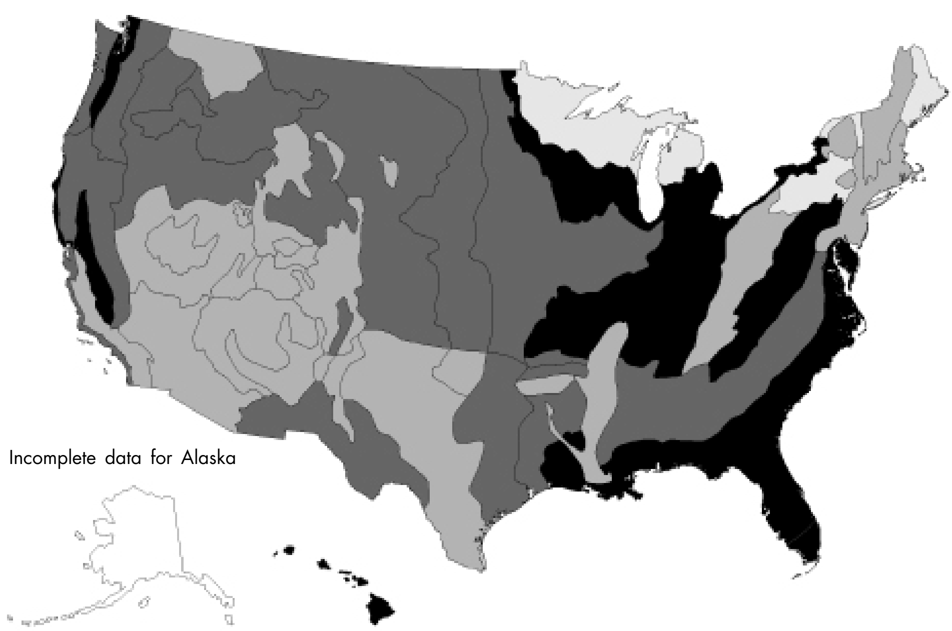


FIGURE 9. Percentage of Associations by State that are Imperiled (G1, G2)



■ >30 ■ 20 - 30 ■ 10 - 20 □ <10

FIGURE 10. Percentage of Associations by Bailey's Ecoregion (Province Level) that are Imperiled (G1, G2)



■ >30 ■ 20 - 30 ■ 10 - 20 □ <10

VIII

Parkland (Tallgrass Prairie) Ecoregion (Bailey 1995) over the last century. This region covers about 6% of the United States (see Klopatek et al. 1979, Hannah et al. 1995, O'Neill et al. 1997, WWF 1997). Most of the conservation efforts resulting from these assessments have focused primarily on the protection of the well known representative herbaceous prairie vegetation. The maturity of the USNVC now provides the information to identify more specific conservation priorities at a finer scale of ecological distinction across the ecological region.

Approximately 186 associations have now been identified in the Prairie Parkland Province. A representative set of these communities and their conservation ranks are displayed in Table 8.

The USNVC's systematic, detailed classification approach has made it clear that—in addition to the traditional prairie herbaceous associations associated with this ecoregion—

TABLE 8. Representative Natural Communities and Their Conservation Ranks Occurring in Bailey's Prairie Parkland (Temperate) Province Ecoregion (251)

ASSOCIATION	CONSERVATION RANK
Forests	
Populus deltoides - Platanus occidentalis Floodplain Forest	G1
Quercus alba - Carya ovata / Ostrya virginiana Forest	G2
Tilia americana - (Quercus macrocarpa) / Ostrya virginiana Forest	G2
Populus deltoides - Ulmus americana - Celtis spp. Forest	G3
Carya illinoinensis - Celtis laevigata Forest	G4
Quercus alba - Quercus rubra - Carya ovata Forest	G4
Woodlands	
Quercus macrocarpa - Quercus muehlenbergii / Andropogon spp. Woodland	G1
Quercus macrocarpa / Andropogon gerardii - Stipa spartea Woodland	G2
Quercus stellata - Quercus marilandica / Schizachyrium scoparium Cross Timbers Woodland	G4
Shrublands	
Malus ioensis - Crataegus spp. Prairie Shrubland	G1
Spiraea tomentosa / Andropogon gerardii Shrubland	G1
Betula pumila - Salix spp. Prairie Transition Fen Shrubland	G3
Herbaceous Vegetation	
Carex lanuginosa - Scirpus spp. Eastern Great Plains Seepage Herbaceous Vegetation	G1
Distichlis spicata - Scirpus maritimus - Salicornia rubra Herbaceous Vegetation	G1
Andropogon gerardii - Calamagrostis canadensis - Helianthus grosseserratus Herbaceous Vegetation	G2
Andropogon gerardii - Stipa spartea - Sporobolus heterolepis Herbaceous Vegetation	G2
Schizachyrium scoparium - Sorghastrum nutans - Bouteloua curtipendula Dry - Mesic Herbaceous Vegetation	G2
Carex oligosperma - Carex lasiocarpa / Sphagnum spp. - Polytrichum spp. Herbaceous Vegetation	G3
Typha spp. - *Equisetum hyemale - Carex* spp. Seep Herbaceous Vegetation	G3
Carex lacustris Herbaceous Vegetation	G4

Data from Natural Heritage Central Databases, April 1997.

there are many forest, woodland, and shrubland types which play an important biological and ecological role in the overall system and which are currently rare and imperiled. Examples are the *Populus deltoides - Platanus occidentalis* Floodplain Forest, the *Quercus macrocarpa - Quercus muehlenbergii / Andropogon* spp. Woodland, and the *Malus ioensis - Crataegus* spp. Prairie Shrubland. Additionally, while there *are* many rare and imperiled herba-ceous associations (e.g., *Carex lanuginosa - Scirpus* spp. Eastern Great Plains Seepage Herbaceous Vegetation, *Distichlis spicata - Scirpus maritimus - Salicornia rubra* Herbaceous Vegetation) in this ecoregion, there are other herbaceous associations that are apparently or demonstrably secure across their range (e.g., *Carex lacustris* Herbaceous Vegetation). Thus, the detailed level of classification and ranking available for this ecological region allows conservationists to focus limited resources on all vegetation types that are highly imperiled.

It is part of a growing trend across the international conservation community to address conservation at larger scales. The ecoregional approach has now been embraced as a new framework for conservation within the Conservancy (TNC 1996). The recently published *Designing a Geography of Hope* (TNC Ecoregional Working Group 1997) describes the necessity of planning at the ecoregional scale to successfully address the long-term mission of protecting biological diversity. The report sets forth a clear and compelling new goal for the Conservancy: to identify and protect portfolios of sites that contain all representative biological diversity within every ecoregion. To achieve this goal and ensure the long-term survival of all viable species and communities, the Conservancy faces the challenge of carrying out effective on-the-ground conservation action within broad-scale ecoregional assessments and plans.

Natural vegetation types have begun to play a pivotal role in the identification of all representative elements of biological diversity for an ecoregion. The Great Plains ecoregion plan provides an example of the role of vegetation types in this new ecoregional planning initiative. The Great Plains encompass nearly one million acres in interior North America—roughly 14% of the continent's land mass—stretching from the boreal forests of Canada to northern Mexico. The Conservancy recently completed a major review of the biological diversity of this ecoregion entitled *The Status of the Biodiversity of the Great Plains* (Ostlie et al. 1997). The report includes a complete synthesis of existing natural community information, the compilation of which simultaneously furthered the development of the USNVC for this region (Schneider et al. 1997).

Over 619 plant associations were identified throughout the Great Plains (including Canada). These are primarily grasslands, but also include forests, woodlands, and shrublands. Nearly half of these associations were considered to be endemic or near-endemic, with their distribution wholly or mostly within the Great Plains ecoregion. These associations, along with the ecological functions they support, greatly contribute to the unique character of the region; maintaining the best examples of each of them is an essential part of the conservation strategy for the region. Forty-two percent of these communities are ranked as imperiled or vulnerable (G1-G3). Nearly one-third of these endemic/near-endemic associations had no known protected occurrences. In fact, the G1-G3 types were found to be somewhat *less* protected than the more globally secure types (Ostlie et al. 1997).

The scale of the analysis of natural communities at the association level across a large region like the Great Plains was unprecedented in this country. It represents a substantial leap forward in targeting vegetation associations as important elements for overall conservation planning. The identification of associations that are most in need of protection is presently influencing the selection of specific sites for inclusion in the ecoregional conservation portfolio.

VIII.B.1.c. Communities as a "Coarse Filter"

More common and less imperiled community associations—those ranked G4 and G5—are also considered to be conservation priorities for the Conservancy and others. Many of the common, widespread community types have been subject to a high degree of alteration and degradation through human action, resulting in fragmentation and loss of functionality. In Eastern North America, for example, a large high quality tract of a common eastern deciduous forest type that occurs in an essentially intact landscape would be a very high priority for conservation. Though the vegetation type itself may be common, large high quality examples are extremely rare, and opportunities to conserve them are limited.

The conservation of more common community types is generally focused on occurrences in especially good condition, of large extent, with a high degree of landscape integrity/connectivity, and/or possessing ancillary conservation benefits. The conservation of many species, both rare and common, is dependent upon the protection of these intact community occurrences and their associated ecological processes. Thus, in addition to the importance of conserving communities and ecosystems in their own right (see Daily et al. 1997), their conservation is viewed as a "coarse filter" approach for the conservation of all species, particularly those taxa which are poorly known (e.g., invertebrates, nonvascular plants, fungi).

In other cases, rare associations have been a very important "filter" to identify those sites that may support a high concentration of rare species. For example, Lanier Quarry Savanna in North Carolina was acquired by the Conservancy because of a unique community association (*Pinus palustris - Pinus serotina / Sporobolus* species 1 - *Ctenium aromaticum - Eriocaulon decangulare* var. *decangulare* Woodland [Weakley et al. 1996]) that is characterized by the presence of numerous calciphilic plants. This site became a Conservancy project in the early 1980s based on the known presence of this G1 ranked vegetation type, two G2 ranked species, and two G3 ranked species. Additional studies on this site over the last fifteen years have revealed the presence of numerous additional imperiled (G1-G3 ranked) species, including many invertebrates and a new species of sedge, which are endemic to Lanier Quarry, and have led to the identification of four other important sites within a three kilometer radius. There are currently about fifteen G1 and G2 species known to occur in an area of less than 100 hectares. If this site had not been identified and prioritized on the basis of the rare association, it would have been destroyed before the additional inventory could be completed.

VIII.B.1.d. Rangewide Assessment

Rangewide assessment is a process developed by the network of Natural Heritage Programs that results in the identification of the subset of occurrences of species, vegetation types, and other "elements" of biodiversity that are the most important to protect in order to ensure their long-term survival. Rangewide assessment involves pooling all occurrence information over the entire distribution of the element, comparing these occurrences based on their "occurrence rank" (a reflection of the quality, condition, viability, and defensibility of the occurrence), and assessing the geographic range and rangewide variability to determine which occurrences are the most important to protect. For vegetation types, the basic concept of a rangewide assessment is invalid if a standard classification approach is not followed.

One of the most important benefits of a rangewide assessment is the standardized application of occurrence ranking across an element's range. Examining an element across its entire range encourages collaboration among conservation scientists and managers interested in the same species or vegetation type and identifies common threats, research needs, and management issues. This level of detail allows occurrences to be consistently compared to each other in order to determine which will have the highest importance and the greatest long term probability for conservation success. Rangewide assessments for vegetation types can also result in lists of all association occurrences that are considered viable conservation targets, along with maps that show the locations of high priority occurrences (often backed up by more detailed information on each occurrence). When rangewide assessment data from all associations are projected on a state or ecoregional map, they provide the basis for selection of high priority conservation sites across that region.

VIII.B.2.
Rarity, Diversity, and Representativeness Assessment

Evaluating areas for conservation selection requires information on the distribution of biotic as well as abiotic components and a rationale by which to prioritize these components. Rarity, diversity, and representativeness are commonly chosen as critical values for the selection of conservation areas. Rarity and diversity focus on the biotic elements of an area, including plant communities. Both rarity and diversity are relatively straightforward criteria to apply to the selection of conservation areas, and they have been routinely addressed in land management planning by federal agencies and non-governmental organizations (Scott et al. 1987, 1990, Bourgeron et al. 1995).

Representativeness is a criterion that has only recently become more widely applied for the selection of conservation areas (Austin and Margules 1986, Usher 1986, Margules and Nicholls 1987, Pressey and Nicholls 1989*a*, *b*, Pressey 1990, Rebelo and Siegfried 1990, Pressy and Nicholls 1991, Bedward et al. 1992, Rebelo and Siegfried 1992, Pressey et al. 1993, DeVelice et al. 1994, Pressy et al. 1994, Bourgeron et al. 1995). Representativeness explicitly attempts to include the range of natural variation of both biotic and abiotic features (e.g., landforms, soils, elevation zones) of a region within a system of preserves (Austin and Margules 1986). To assess the representativeness of particular conservation areas, coarser-scale descriptions of the regional patterns of environmental and biological variability are required, as well as the environmental relationships of the biota, and the actual biotic distribution patterns (Austin and Margules 1986, Margules et al. 1987, Mackey et al. 1988, 1989, Margules and Stein 1989).

Rarity, diversity, and representativeness were all used to assess the conservation value of the Gray Ranch in southwestern New Mexico in relation to the Mexican Highlands ecoregion (Bailey 1976) within which the Ranch is found (Engelking et al. 1994, Bourgeron et al. 1995). The goals of the study were to characterize the patterns of vegetation and floristic variability in relation to the range of environmental variability on the Ranch and within the Mexican Highlands ecoregion. The USNVC associations which had been developed across the western United States were used in this study (Bourgeron and Engelking 1994). Analysis and interpretation of the survey results found that much of the floristic and vegetative diversity of the Gray Ranch is related to broad-scale climate patterns, as well as precipitation patterns resulting from topographic relief. Additional results showed that the Ranch contains a significant proportion of the biotic and environmental variability found throughout the Mexican Highlands. Although the Ranch represents only 3% of the Mexican Highlands ecoregion's land area, 21% of the plant communities and 19% of the physical environments of the ecoregion were found to occur on this site (Engelking et al. 1994, Bourgeron et al. 1995). Using any of the three criteria, the Gray Ranch stood out as a site of significant conservation value.

A use of the USNVC for representativeness assessment and planning is also being carried out in the U.S. Forest Service Research Natural Area (RNA) program. A principal purpose of the RNA system on Forest Service lands is to maintain a representative array of natural ecosystems as baseline sites for research, monitoring, and biodiversity protection, and reference areas for management activities (U.S. Forest Service 1995, Chadde et al. 1996). To accomplish this objective, a large part of both the biotic and abiotic variability found on U.S. Forest Service lands must be represented within the RNA system. In the Rocky Mountain Region (U.S. Forest Service Region 2), biological elements targeted for inclusion in the RNA system are roughly equivalent to the alliance level of the USNVC (U.S. Forest Service 1995). The goal of this RNA program is to have one example of each alliance encompassed in an RNA in every Region 2 subdivision in which it occurs. This represents an attempt to capture the range of variability of each community in relation to the range of environmental variability. In the Eastern and Southeastern Forest Service Regions (Regions 8 and 9) the RNA program specifically adopted the USNVC for use in identifying target biological elements (Tyrrell 1996, Faber-Langendoen et al. 1998). Both alliances and plant associations are targets for inclusion in the RNA system, and the higher levels in the hierarchy (class, subclass, group, and formation) are also tracked for their presence in the system.

VIII.C. Resource Management and Planning

A national classification system is critical for many resource management and planning applications. One example is the recent effort to conduct a comparison of existing vegetation with pre-European settlement vegetation across Michigan, Minnesota, and Wisconsin (Shands 1988). Some of the data on existing vegetation were obtained from the Forest Inventory Assessment (FIA) program. These data were classified to varying levels of detail depending upon the physiognomic type and successional status of the vegetation. Additional cover data on existing vegetation were developed through photo-interpreted state-level maps. These primarily characterized the forests by broad cover type and other types of vegetation at even coarser physiognomic levels. In addition, the photo-interpretation efforts did not adhere to a consistent classification methodology and standard across the three states. The presettlement vegetation classifications were derived from historical records and did not conform to a consistent standard across physiognomic classes. The final comparison between current and presettlement vegetation patterns had to be completed at a common level of classification across all products. This common level was very coarse because of the lack of consistency in the classification systems used, and the resulting product could not provide the desired level of utility for ecological management objectives. This type of an analysis would have been more useful if a particular set of USNVC levels had been applied consistently by all parties for the development of the maps of existing vegetation and the interpretation of historical records.

Another example of the need for a national vegetation classification system emerged from the efforts to monitor the ecological effect of the 1996 flood throughout the Upper Mississippi Basin (SAST 1994). These monitoring efforts were less productive than anticipated due to incompatibilities in vegetation classifications and maps. The coarse land-use/land-cover categories developed from LANDSAT imagery taken after the flood were not compatible with the more detailed vegetation classifications that were in use by the state Natural Heritage Programs. The situation was further complicated by inconsistencies between the detailed classifications in use by the individual states. Because of these factors, it was not possible to identify the distribution of imperiled natural communities throughout the basin before the flood, or to evaluate the subsequent impact of the flood on these types.

The initiative by federal agencies to plan resource management and conservation action within the ecosystem context is both innovative and important. Although different federal agencies have adopted individual ecoregional approaches based on their history and their specific objectives, the application of the USNVC will provide a common terminology that will help describe the vegetation of these different ecoregions. For example, as the U.S. Forest Service was developing descriptions of ecoregional subsections within the ECOMAP hierarchy (Avers et al. 1994), it recognized a need for a consistent description of the vegetation component of these land units. Vegetation types from the USNVC are presently being added as a key descriptor to all of the ecoregional subsections to assist with their characterization and in the development of planning documents.

It is hoped that the increasingly wide use of the USNVC will promote a greater level of knowledge and understanding of the full range of vegetation in the United States among and within agencies and other organizations responsible for natural resource conservation and management.

IX

Applications and Future Challenges

Future Challenges

Over the past decade a national classification system for vegetation has been developed and many types within that system have been identified and characterized. The development of the classification framework, and the synthesis of existing classifications into it, was initiated by The Nature Conservancy in partnership with the network of state Natural Heritage Programs to carry out the mission of biodiversity conservation. The classification units within this framework have proven to be invaluable in supporting the conservation planning, site identification, and biodiversity monitoring objectives of this partnership. The development and implementation of the classification system has now expanded to a broader partnership that includes conservationists, vegetation scientists, and resource managers across academic institutions, federal and state agencies, private organizations, and other non-profit organizations. Major challenges remain for the Conservancy and these partners in their ongoing efforts to develop, maintain, document, and support the classification.

IX.A. Development and Refinement of the Vegetation Types and the USNVC System

Although the classification structure has stabilized, and more than 4100 associations are currently recognized by the Conservancy, the overall classification effort is still in an early stage of development. Now that the first iteration of the floristically-defined types for the United States is in place, a thorough review of the floristic types and the "fit" between the physiognomic and floristic portions of the hierarchy is needed. In particular, because many of the floristic types were defined from the "top down" (i.e., by adding floristic types to already-defined physiognomic categories), a review of the physiognomic criteria used is necessary to ensure that these are sufficiently compatible with the floristic criteria. In addition, in some cases where data collection or the selection of data sets for analysis was restricted to a particular physiognomic group, it will be important to evaluate the effect of that initial constraint. This can be done, for example, by comparing the results of an analysis of floristic composition conducted on all evergreen needle-leaf forest plots to those of the same analysis conducted on all forest plots.

At the same time, as the classification is refined through new inventories and further analyses, many new alliances and associations will be identified across the United States. This will help to fill the geographic and taxonomic data gaps currently in the USNVC. Additional types will be included in the classification system upon review by regional ecologists. New types must have a unique combination of structure, biotic assemblage, and specific environmental conditions, and they must recur across the landscape. They will need to be reviewed in relation to data on comparable types from a rangewide perspective to guard against propagation of local variants of existing nationally recognized types. In addition to identifying new types, the ever-increasing body of knowledge concerning the biology, ecology, and geography of vegetation will help to continuously refine the system through the validation and refinement of existing associations and alliances.

The Nature Conservancy and the network

of state Heritage Programs will continue to strengthen and expand their work with partners to refine the classification of identified vegetation types. There is an ongoing program to collect and analyze new data to strengthen the existing classification, with a particular focus on communities of conservation concern, those in which classifications are lacking, and those in which classification confidence is low. Groups of experts will continue to be brought together on a project-by-project and geographic basis to refine the classification system and the descriptions of these vegetation types.

The classification system was developed for international applications, using a physiognomic-floristic hierarchical approach that is compatible with existing international classification activities. There is much basic inventory and classification work to be completed before the floristic levels of this system can be consistently applied internationally. In the short term, formations or alliances are proving to be appropriate classification levels for national planning efforts in many countries. Application of this classification system outside of the United States is presently restricted to places where the Conservancy is working with international partners in conservation. To date, this has largely been limited to Conservation Data Centers across Canadian provinces and to individual projects in Latin America and the Caribbean (e.g., Jamaica, Belize, Panama, and Guantanamo Bay, Cuba).

IX.B. Documentation of the USNVC

An immense amount of work remains in providing the level of documentation needed to ensure appropriate use of all types within the classification system. The utility of the classification system is completely dependent upon the users' ability to access materials that allow them to comprehend the system, to recognize the types in the field, and to understand how the system and the types can and cannot be used. Thus, the utility and acceptability of this effort will be dependent upon the level of documentation that accompanies the classification system. Users of the system require clear sets of regional vegetation keys to recognize the differentiating characteristics between the different associations. In addition, they require information on nomenclature, relationships to local classification units, rangewide distribution, associated plant and animal species, environmental relationships, conservation status (ranks for communities and rank specifications for stand quality), and other associated factors. The completion of keys and type descriptions is an immense task, and can only be completed through the development of a clear set of minimum standards. This work has begun, but it will require the development of a strong network of partners to successfully carry out this objective over time.

IX.C. Data Architecture and Management

The basic information describing the classification system and the vegetation types at all hierarchical levels is presently managed in the conservation database (BCD) system supported by the Conservancy and the network of Natural Heritage Programs. Refinements and updates to the classification framework and the descriptions and status of all vegetation units are continuously documented. The number of users and contributors, as well as the number of vegetation units, is expected to increase dramatically. The architecture and model for managing this data must similarly evolve to meet this growth. Additional data management tools are being planned to meet a number of identified future data management needs. These include: (1) efficient user access to all aspects of the data; (2) interactive review and development of the classification units and their descriptions; (3) continuous revision of the vegetation units and their supporting information; (4) reconstruction of the classification at any prior date; (5) efficient revision of botanical nomenclature and resolution of ambiguities associated with plant names; (6) ability of users to maintain local working copies of the data structure and easily transport information between computer database software and operating systems; (7) management of plot data at a national scale; and (8) capability for spatial representation and analysis of vegetation types (Peet et al., *unpublished manuscript*).

To meet these needs and ensure efficient information flow, the classification and information standards will need to be provided "on-line" to enable broad interaction and peer review concerning all aspects of the USNVC. A continually updated and fully archived internet-based classification system easily accessed by many user groups is currently being evaluated. This system would be open to proposals by contributors and users concerning both the classification framework and the specific units. These efforts will require the development of creative relationships between academia, federal and state agencies, private industry, and non-governmental organizations to support and manage this process into the future.

IX.D. The Importance of Partnership

Up to this point, the primary group of ecologists who have developed and implemented the classification system have come from The Nature Conservancy in partnership with scientists across the network of state Heritage Programs. Support for this effort has been provided by the Conservancy and federal partners that have also needed a national vegetation classification system to meet their objectives (e.g., the Gap Analysis Program, the NPS Vegetation Mapping Program). The existing partnerships between the Conservancy, Heritage Programs, and federal and state agencies have been very successful, resulting in the development of the USNVC structure and the first approximation of vegetation types. Future development and implementation of the classification will become increasingly dependent upon the strong shared vision of a national classification system and a continued spirit of cooperation between these partners. Simultaneously, new partnerships must be developed to address the future needs of a broader set of contributors and users of this dynamic, expanding network of information.

The Vegetation Subcommittee of the Federal Geographic Data Committee (FGDC) proposed the USNVC framework as a standard for use across all federal agencies. The formal acceptance of these Vegetation Classification and Information Standards by the FGDC in October 1997 (FGDC 1997) creates the need for even broader development and implementation of this system across federal agencies. A higher level of documentation will be needed to support the extensive range of applications that will result from this new federal standard.

The establishment of a Panel for Vegetation Classification by the Ecological Society of America (ESA) provides a valuable professional review for the developing standard. ESA provides a critical link to the network of professional ecologists across academia, federal and state agencies, and private organizations. This initiative has already brought together many additional ecologists to work on the refinement of stadards, and provide peer review for the floristic levels of the USNVC and a broader vision for the future development and dissemination of the classification standard.

The development of the USNVC has been immensely satisfying. This undertaking has gained momentum as the importance of a national classification system to address conservation, stewardship, and research challenges has become increasingly obvious. A momentous challenge remains: meeting the burgeoning requirements and expectations for long-term development, maintenance, and provision of this system to a growing number of users. The responsibilities involved in meeting this challenge must be strategically placed across the multiple agencies, organizations, and institutions that will benefit from the system and that are capable of significant contribution to its development and maintenance. Strong institutional commitments to the development of this National Vegetation Classification System are critical to its continued use for the effective conservation and management of natural vegetation across the United States.

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Appendix A

Standard Field Form for Data Collection

IDENTIFIERS/LOCATORS

Plot Code____ Polygon Code________________________________

Provisional Community Name____

State _____ Site Name____

Quad Name____Quad Code_____________________________

GPS file name________________Field UTM X__ __ __ __ __ __ __ m E Field UTM Y__ __ __ __ __ __ __ __ m N

please do not complete the following information when in the field
Corrected UTM X__ __ __ __ __ __ __ m E Corrected UTM Y__ __ __ __ __ __ __ __ m N UTM Zone__________

Survey Date_____________ Surveyors____

Directions to Plot

Plot length______ Plot width______ Plot Photos (y/n) ___ Roll Number _____ Frame Number _____ Plot Permanent (y/n) ____

Plot representativeness

ENVIRONMENTAL DESCRIPTION

Elevation ______________________ Slope _____________________ Aspect_________________________

Topographic Position

Landform

Surficial Geology

Cowardian System
___Upland
___Estuarine
___Riverine
___Palustrine
___Lacustrine

Hydrologic Modifiers
___Semipermanetly Flooded
___Seasonally Flooded
___Saturated
___Temporarily Flooded
___Intermittently Flooded
___Permanently Flooded
___Permanently Flooded-tidal
___Tidally Flooded

Salinity/Halinity Modifiers
___Saltwater
___Brackish
___Freshwater

Environmental Comments:

Soil Taxon/Description

Unvegetated Surface: *(please use the cover scale on next page)*
___ Bedrock
___ Large rocks (> 10 cm)
___ Small rocks (0.2-10 cm)
___ Sand (0.1-2 mm)
___ Other:____
___ Wood (> 1 cm)
___ Litter, duff
___ Bare soil

Soil Texture
___ sand ___ loamy sand ___ sandy loam ___ loam
___ silt loam ___ silt ___ clay loam ___ silty clay
___ clay ___ peat ___ muck

Soil Drainage
___ Rapidly drained
___ Moderately well drained
___ Poorly drained
___ Well drained
___ Somewhat poorly drained
___ Very poorly drained

VEGETATION DESCRIPTION

Leaf phenology (of dominant stratum)	Leaf Type (of dominant stratum)	Physiognomic class	Cover Scale for Strata & Unvegetated Surface		Height Scale for Strata	
<u>Trees and Shrubs</u>	___Broad-leaved	___Forest	01	<5%	01	<0.5 m
___Evergreen	___Needle-leaved	___Woodland	02	5-15%	02	0.5-1m
___Cold-deciduous	___Microphyllous	___Shrubland	03	15-25%	03	1-2 m
___Drought-deciduous	___Graminoid	___Dwarf Shrubland	04	25-35%	04	2-5 m
___Mixed evergreen - cold-deciduous	___Forb	___Herbaceous	05	35-45%	05	5-10 m
___Mixed evergreen - drought-deciduous	___Pteridophyte	___Nonvascular	06	45-55%	06	10-15 m
<u>Herbs</u>		___Sparsely Vegetated	07	55-65%	07	15-20 m
___Annual			08	65-75%	08	20-35 m
___Perennial			09	75-85%	09	35 - 50 m
			10	85-95%	10	>50 m
			11	95-100%		

Strata	Height Class	Cover Class	Diagnostic species (if known)
T1 Emergent	______	______	______
T2 Canopy	______	______	______
T3 Sub-canopy	______	______	______
S1 Tall shrub	______	______	______
S2 Short Shrub	______	______	______
S3 Dwarf Shrub	______	______	______
H Herbaceous	______	______	______
Grass	______	______	______
Forb	______	______	______
Fern	______	______	______
N Non-vascular	______	______	______
V Vine/liana	______	______	______
E Epiphyte	______	______	______

Please see above table for height and cover scales

Animal Use Evidence

Natural and Anthropogenic Disturbance Comments

Other Comments

Plot Code____

Species/percent cover. Starting with the uppermost stratum, list all species with % cover for each species in the stratum. For forests and woodlands, on a separate line below each tree species, list the DBH of all trees above 10 cm diameter. Separate measurements with a comma. Put an asterisk next to any species that are known diagnostics for a particular community in the classification. <u>Also list species outside the plot at the end of the table or designate with a 0 in in Cover Class column.</u>

Stratum Species Names	Cover	Stratum Species Names	Cover	Stratum Species Names	Cover
				Cover Scale for Species	
				01	< 1%
				02	1-5%
				03	5-25%
				04	25-50%
				05	50-75%
				06	75-100%

Instructions for Field Form

ENVIRONMENTAL DESCRIPTION

Plot Code - Unique identifier indicating the specific plot where data were collected.

Polygon Code - Code indicating the vegetation polygon where the plot was taken. Fill this out only if working from previously delineated photos.

Provisional Community Name - Using the classification system, assign the name of the vegetation type which most closely resembles this type. Enter the finest level of the classification possible. This is meant to be a field call of the vegetation classification and may change when the data are analyzed.

State - State where the survey was conducted.

Site Name - Provisional name assigned by field worker that describes where the data were collected; should represent an identifiable feature on topographic map.

Quad name(s) - appropriate name/scale from survey map used; use 7.5 minute quadrangle if possible.

Quad code(s) - code of USGS 7.5 minute quadrangle map.

GPS Filename - Enter the filename assigned to the plot when collecting GPS information. It should be in the form XXMMDDHH (unique plot identifier, month, day, hour, i.e. 23071313 - plot 23 collected on July 13 at 1pm)

Field UTM X - X coordinate of Universal Transerverse Mercator projection read from the GPS at the time of sampling.

Field UTM Y - Y coordinate of Universal Transerverse Mercator projection read from the GPS at the time of sampling.

Corrected UTM X - X coordinate of Universal Transerverse Mercator projection after post-processing correction. To be filled in at the office, not in the field.

Corrected UTM Y - Y coordinate of Universal Transerverse Mercator projection after post-processing correction. To be filled in at the office, not in the field.

UTM Zone - Zone of the Universal Transverse Mercator projection. To be filled in at the office, not in the field.

Survey date - date the survey was taken; year, month, day.

Surveyors - Names (and addresses, if appropriate) of surveyors, principle surveyor listed first.

Directions to Plot - precise directions to the site using a readily locatable landmark (e.g., a city, a major highway, etc.) as the starting point on a state or local road map. Use clear sentences that will be understandable to someone who is unfamiliar with the area and has only your directions to follow. Give distances as closely as possible to the 0.1 mile and use compass directions. Give additional directions to the plot within the site.

Plot Length and Plot Width - enter width and length dimensions for rectangular (or square) plots, or radius length for circular plots. Choose the appropriate plot size based on the following table:

Forest:	200 - 500 m2
Shrubland:	50 - 200 m2
Grassland:	50 - 100 m2
Dwarf-shrub heath:	10 - 25 m2
Moss communities:	1 - 4 m2
Lichen communities:	0.1 - 1 m2

(Source: D. Mueller-Dombois and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons. NY.)

Plot Photos - Check-off indicating whether photos of the plot have been taken at the time of sampling.

Roll Number and Frame Number - If photos have been taken at the plot, enter the roll # and frame # to help identify the photos after film processing.

Plot representativeness - Does this plot well represent the average species composition and structure, and environmental setting of the polygon? If not, were additional plots taken to cover the range of variability within the polygon?

Plot Permanent - Check-off indicating whether the plot has been permanently marked.

ENVIRONMENTAL DESCRIPTION

Elevation - elevation of the plot, specify whether feet or meters (this will depend on the units used on the topographic map/DEM's being used).

Slope - measure slope degrees using a clinometer.

Aspect - enter slope aspect; use a compass (be sure to correct for the magnetic declination).

Topographic Position - topographic position of the plot. NOTE a comprehensive list of topographic positions is being developed. The list below provides an example of the topographic positions that might be included.

INTERFLUVE: (crest, summit, ridge): linear top of ridge, hill, or mountain; the elevated area between two fluves (drainageways) that sheds water to the drainageways.

HIGH SLOPE: (shoulder slope, upper slope, convex creep slope): geomorphic component that forms the uppermost inclined surface at the top of a slope. Comprises the transition zone from backslope to summit. Surface is dominantly convex in profile and erosional in origin.

HIGH LEVEL (mesa): level top of plateau

MIDSLOPE (transportational midslope, middle slope): intermediate slope position

BACKSLOPE (dipslope): subset of midslopes which are steep, linear, and may include cliff segments (fall faces).

STEP IN SLOPE (ledge, terracette): nearly level shelf interrupting a steep slope, rock wall, or cliff face.

LOWSLOPE (lower slope, foot slope, colluvial footslope): inner gently inclined surface at the base of a slope. Surface profile is generally concave and a transition between midslope or backslope, and toe slope.

TOESLOPE (alluvial toeslope): outermost gently inclined surface at base of a slope. In profile, commonly gentle and linear and characterized by alluvial deposition.

LOW LEVEL (terrace): valley floor or shoreline representing the former position of an alluvial plain, lake, or shore.

CHANNEL WALL (bank): sloping side of a channel.

CHANNEL BED (narrow valley bottom, gully arroyo): bed of single or braided watercourse commonly barren of vegetation and formed of modern alluvium.

BASIN FLOOR (depression): nearly level to gently sloping, bottom surface of a basin.

Landform - (from Driscoll, R.S. et al. 1984. An Ecological Land Classification Framework for the United States. USDA Forest ServiceMiscellaneous Publication # 1439. U.S.Government Printing Office, Washington D.C. 32-48.)

VALUES:

ACTIVE SLOPE - (metastable slope) A mountain or hill slope that is responding to valley incision, and has detritus accumulated behind obstructions, indicating contemporary transport of slope alluvium. Slope gradients commonly exceed 45 percent.

ALLUVIAL CONE - The material washed down mountain and hill slopes by ephemeral streams and deposited at the mouth of gorges in the form of a moderately steep, conical mass descending equally in all directions from the point of issue.

ALLUVIAL FAN - A body of alluvium, with or without debris flow deposits, whose surface forms a segment of a cone that radiates downslope from the point where the stream emerges from a narrow valley onto a less sloping surface. Common longitudinal profiles are gently sloping and nearly linear. Source uplands range in relief and aerial extent from mountains and plateaus to gullied terrains on hill and piedmont slopes.

ALLUVIAL FLAT - A nearly level, graded, alluvial surface.

ALLUVIAL PLAIN - A flood plain or a low-gradient delta. It may be modern or relict.

ARROYO - (wash) The flat-floored channel or an ephemeral stream, commonly with very steep to vertical banks cut in alluvium.

BACKSWAMP - (valley flat) Extensive marshy, depressed areas of flood plains between the natural levee borders of channel belts and valley sides or terraces.

BAR - An elongated landform generated by waves and currents and usually running parallel to the shore, composed predominantly of unconsolidated sand, gravel, cobbles, or stones with water on two sides.

BASIN - A depressed area with no or limited surface outlet. Examples are closed depressions in a glacial till plain, lake basin, river basin, or fault-bordered intermontane structure such as the Bighorn Basin of Wyoming.

BEACH - The unconsolidated material that covers a gently sloping zone, typically with a concave profile, extending landward from the low-water line to the place where there is a definite change in material or physiographic form (such as a cliff) or to the line of permanent vegetation; the relatively thick and temporary accumulation of loose water-borne material (usually well-sorted sand and pebbles, accompanied by mud, cobbles, boulders, and smoothed rock and shell fragment) that is in active transit along, or deposited on the shore zone between the limits of low water and high water.

BLUFF - (a) A high bank or bold headland, with a broad, precipitous, sometimes rounded cliff face overlooking a plain or body of water, especially on the outside of a stream meander; (b) any cliff with a steep, broad face.

BRAIDED CHANNEL OR STREAM - (flood-plain landforms) A channel or stream with multiple channels that interweave as a result of repeated bifurcation and convergence of flow around interchannel bars, resembling in plan the strands of a complex braid. Braiding is generally confined to broad, shallow streams of low sinuosity, high bedload, non-cohesive bank material, and step gradient. At a given bank-full discharge, braided streams have steeper slopes and shallower, broader, and less stable channel cross sections than meandering streams.

CANYON - A long, deep, narrow, very steep-sided valley with high and precipitous walls in an area of high local relief.

CIRQUE - Semicircular, concave, bowl-like area with steep face primarily resulting from erosive activity of a mountain glacier.

CLIFF - Any high, very steep to perpendicular or overhanging face of rock or earth; a precipice.

CREST - (summit) The commonly linear top of a ridge, hill or mountain.

DELTA - A body of alluvium, nearly flat and fan-shaped, deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, usually a sea or lake.

DOME - A roughly symmetrical upfold, with bed dipping in all directions, more or less equally, from a point. A smoothly rounded landform or rock mass such as a rock-capped mountain summit, roughly resembling the dome of a building.

DRUMLIN - A low, smooth, elongated oval hill, mound, or ridge of compact glacial till that may or may not have a core of bedrock or stratified glacial drift. The longer axis is parallel to the general direction of glacier flow. Drumlins are products of streamline (laminar) flow of glaciers, which molded the subglacial floor through a combination of erosion and deposition.

DUNE - A mound, ridge, or hill of loose, windblown granular material (generally sand), either bare or covered with vegetation.

ESCARPMENT - (scarp) A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and produced by erosion or faulting. The term is more often applied to cliffs produced by differential erosion.

ESKER - A long, narrow sinuous, steep-sided ridge composed of irregularly stratified sand and gravel that was deposited by a subsurface stream flowing between ice walls, or in an ice tunnel of a retreating glacier, and was left behind when the ice melted.

FLAT - A general term for a level or nearly level surface or small area of land marked by little or no relief, eg. mud flat or valley flat.

FLOOD-PLAIN - (bottomland) The nearly level alluvial plain that borders a stream and is subject to inundation under flood-stage conditions unless protected artificially. It is usually a constructional landform built of sediment deposited during overflow and lateral migration of the stream.

GORGE - (a) A narrow, deep valley with nearly vertical rocky walls, enclosed by mountains, smaller than a canyon, and more steep-sided than a ravine; especially a restricted, steep-walled part of a canyon. (b) A narrow defile or passage between hills or mountains.

HILL - (foothills) A natural elevation of the land surface, rising as much as 300 m above the surrounding lowlands, usually of restricted summit area (relative to a tableland) and having a well-defined outline; hill slopes generally exceed 15%. The distinction between a hill and a mountain is often dependent on local usage.

HUMMOCK - A rounded or conical mound of knoll, hillock, or other small elevation. Also, a slight rise of ground above a level surface.

KAME - A moundlike hill of ice-contact glacial drift, composed chiefly of stratified sand and gravel.

KETTLE - A steep-sided bowl-shaped depression without surface drainage. It is in glacial drift deposits and believed to have formed by the melting of a large, detached block of stagnant ice buried in the glacial drift.

KNOB - (a) A rounded eminence, as a knoll, hillock, or small hill or mountain; especially a prominent or isolated hill with steep sides, commonly found in the southern United States. (b) A peak or other projection from the top of a hill or mountain. Also a boulder or group of boulders or an area of resistant rocks protruding from the side of a hill or mountain.

LEVEE - (floodwall, earth dike) An artificial or natural embankment built along the margin of a watercourse or an arm of the sea, to protect land from inundation or to confine streamflow to its channel.

MORAINE - A drift topography characterized by chaotic mounds and pits, generally randomly oriented, developed in superglacial drift by collapse and flow as the underlying stagnant ice melted. Slopes may be steep and unstable and there will be used and unused stream coursed and lake depressions interspersed with the morainic ridges. Consequently, there will be rapid or abrupt changes between materials of differing lithology.

MOUNTAIN - (hill) A natural elevation of the land surface, rising more than 300 m above surrounding lowlands, usually of restricted summit area (relative to a plateau), and generally having steep sides (greater than 25 percent slope) with or without considerable bare-rock surface. A mountain can occur as a single, isolated mass or in a group forming a chain or range. Mountains are primarily formed by deep-seated earth movements and/or volcanic action and secondarily by differential erosion.

OUTWASH PLAIN - (glacial outwash, kettles) An extensive lowland area of coarse textured, glaciofluvial material. An outwash plain is commonly smooth; where pitted, due to melt-out of incorporated ice masses, it is generally low in relief.

OXBOW - (meander belt, oxbow lake) A closely looping stream meander having an extreme curvature such that only a neck of land is left between the two parts of the stream. A term used in New England for the land enclosed, or partly enclosed, within an oxbow.

PINGO - A large frost mound; especially a relatively large conical mound of soil-covered ice (commonly 30 to 50 m high and up to 400 m in diameter) raised in part by hydrostatic pressure within and below the permafrost of Arctic regions, and of more than 1 year's duration.

PLAIN - (lowland, plateau) An extensive lowland area that ranges from level to gently sloping or undulating. A plain has few or no prominent hills or valleys, and usually occurs at low elevation with reference to surrounding areas (local relief generally less than 100m, although some, such as the Great Plains of the United States, are as much as 1000 to 1800 m above sea level.) Where dissected, remnants of a plain can form the local uplands.

PLATEAU - (mesa, plain) An extensive upland mass with a relatively flat summit area that is considerably elevated (more than 100m) above adjacent lowlands, and is separated from them on one or more sides by escarpments. A comparatively large part of a plateau surface is near summit level.

RAVINE - (gulch, draw) A small stream channel; narrow, steep-sided, and commonly V-shaped in cross section; and larger than a gully.

RIDGE - A long, narrow elevation of the land surface, usually sharp rested with steep sides and forming an extended upland between valleys. The term is used in areas of both hill and mountain relief.

SADDLE - A low point on a ridge or crestline, generally a divide (pass, col) between the heads of streams flowing in opposite directions.

SHOULDER - (hill slope) The geomorphic component that form the uppermost inclined surface at the top of a hillslope. It comprises the transition zone from backslope to summit of an upland. The surface is dominantly convex in profile and erosional in origin.

SINKHOLE - (doline) A closed depression formed either by solution of the surficial bedrock (e.g. limestone, gypsum, salt) or by collapse of underlying caves. Complexes of sinkholes in carbonate-rock terraces are the main components of karst topography.

SPIT - (a) A small point or low tongue or narrow embankment of land, commonly consisting of sand or gravel deposited by longshore drifting and having one end attached to the mainland and the other terminating in open water, usually the sea; a fingerlike extension of the beach. (b) A relatively long, narrow shoal or reef extending from the shore into a body of water.

SPLAY - A small alluvial fan or other outspread deposit formed where an overloaded stream breaks through a levee and deposits its material (often coarse-grained) on the flood plain.

SWALE - (a) A slight depression, sometimes swampy, in the midst of generally level land. (b) A shallow depression in an undulating ground moraine due to uneven glacial deposition. (c) A long, narrow, generally shallow, trough-like depression between two beach ridges, and aligned roughly parallel to the coastline.

TERRACE - A step-like surface, bordering a valley floor or shoreline, that represent the former position of an alluvial plain, or lake or sea shore. The term is usually applied to both the relatively flat summit surface (platform, tread), cut or built by stream or wave action, and the steeper descending slope (scarp, riser), graded to a lower base level of erosion.

VALLEY - (basin) An elongate, relatively large, externally drained depression of the earth's surface that is primarily developed by stream erosion.

OTHER - Additional landforms may be added. Please specify and define.

Surficial Geology - note the geologic substrate influencing the plant community (bedrock or surficial materials). NOTE a comprehensive list surficial geologic factors is being developed. The list below provides an example of the values that might be included.

IGNEOUS ROCKS
- Granitic (Granite, Schyolite, Syenite, Trachyte)
- Dioritic (Diorite, Dacite, Andesite)
- Gabbroic (Gabbro, Basalt, Pyroxenite, Peridotite)

SEDIMENTARY ROCKS
- Conglomerates and Breccias
- Sandstone
- Siltstone
- Shale
- Limestone and Dolomite
- Marl
- Gypsum

METAMORPHIC ROCKS
- Gneiss
- Schist
- Slate and Phyllite
- Marble
- Serpentine

GLACIAL DEPOSITS
- Undifferentiated glacial deposit
- Till
- Moraine
- Bedrock and till
- Glacio-fluvial deposits (outwash plains, ice-contacted GF deposits, eskers, kames, pro-glacial deltas, crevasse filling, etc.)
- Deltaic deposits (alluvial cones, deltaic complexes)
- Lacustrine and fluvial deposits (glacio-fluvial, fluvio-lacustrine, fresh-water sandy beaches, stony/gravelly shoreline)
- Marine deposits (bars, spits, sandy beaches, old shorelines, old beach ridges, old marine clays, etc.)

ORGANIC DEPOSITS
- Peat (with clear fibric structure)
- Muck
- Marsh, regularly flooded by lake or river (high mineral content)

SLOPE AND MODIFIED DEPOSITS
- Talus and scree slopes
- Colluvial
- Solifluction, landslide

AEOLIAN DEPOSITS
- Dunes
- Aeolian sand flats
- Loess deposits
- Cover sands

Cowardin System - If the system is a wetland, enter the name of the USFWS system which best describes it's hydrology and landform. Indicate "upland" if the system is not a wetland.

Hydrologic Regime - Assess the hydrologic regime of the plot using the descriptions below. Hydrological modifiers used to identify wetland units at the formation level (adapted from Cowardin et al. 1979).

SEMIPERMANENTLY FLOODED - Surface water persists throughout the growing season in most years. Land surface is normally saturated when water level drops below soil surface. Includes Cowardin's Intermittently Exposed and Semipermanently Flooded modifiers.

SEASONALLY FLOODED - Surface water is present for extended periods during the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is very variable, extending from saturated to a water table well below the ground surface. Includes Cowardin's Seasonal, Seasonal-Saturated, and Seasonal-Well Drained modifiers.

SATURATED - Surface water is seldom present, but substrate is saturated to surface for extended periods during the growing season. Equivalent to Cowardin's Saturated modifier.

TEMPORARILY FLOODED - Surface water present for brief periods during growing season, but water table usually lies well below soil surface. Often characterizes flood-plain wetlands. Equivalent to Cowardin's Temporary modifier.

INTERMITTENTLY FLOODED - Substrate is usually exposed, but surface watercan be present for variable periods without detectable seasonal periodicity. Inundation is not predictable to a given season and is dependent upon highly localized rain storms. This modifier was developed for use in the arid West for water regimes of Playa lakes, intermittent streams, and dry washes but can be used in other parts of the U.S. where appropriate. This modifier can be applied to both wetland and non-wetland situations. Equivalent to Cowardin's Intermittently Flooded modifier.

PERMANENTLY FLOODED - Water covers the land surface at all times of the year in all years. Equivalent to Cowardin's "permanently flooded".

PERMANENTLY FLOODED-TIDAL - Salt water covers the land surface at all times of the year in all years. This modifier applies only to permanently flooded area irregularly flooded by fresh tidal water. Equivalent to Cowardin's "permanently flooded/tidal".

TIDALLY FLOODED - Flooded by the alternate rise and fall of the surface of oceans, seas, and the bays, rivers, etc. connected to them, caused by the attraction of the moon and sun or by the back-up of water caused by unfavorable winds.

UNKNOWN — The water regime of the area is not known. The unit is simply described as "non-tidal wetland".

SALINITY/HALINITY MODIFIERS - enter the salinity/halinity modifiers of the hydrologic regime using the scale below.

INLAND		COASTAL TIDAL
Saltwater	>30 ppt	Saltwater-tidal
Brackish	0.5-30 ppt	Brackish
No Equivalent	< 0.5 ppt	Freshwater

Environmental Comments - Enter any additional noteworthy comments on the environmental setting.

Soil Taxon/Description - Provide the soil name and the name of the soil report/ map from which the information was obtained. Also provide a basic description of the soils noting the most significant features with respect to classifying the vegetation. A soil core should be taken. Describe the soil horizons and note the depth, texture, and color of each. Note significant changes such as depth to mottling, depth to water table, root penetration depth, depth of the organic layer. Also include general description soil depth class (shallow, deep, very deep, etc.) pH, stoniness, erosion potential and type, etc. If it is not possible to take a soil core, as much information as possible should be recorded from the soil report and it should be noted that no core was taken.

Unvegetated Surface - percentage of surface covered by each category, only including items covering over 5 percent.

VALUES:

BEDROCK: sheets of bedrock exposed at the surface

LARGE ROCKS: includes boulders and cobbles greater than 10 cm diameter

SMALL ROCKS: includes gravel, 0.2-10 cm diameter

SAND: small particles 0.1 - 2 mm diameter

BARE SOIL (mineral / organic): includes small particles less than 0.1 mm diameter

LITTER AND DUFF: litter includes freshly-fallen leaves, needles, twigs, bark, fruits, and wood fragments less than 1 cm. Duff is fermentation layer and humus layer (organic horizon).

WOOD: downed fragments greater than 1 cm.

WATER

Soil Texture - Using the key below, assess average soil texture.

SIMPLIFIED KEY TO SOIL TEXTURE *(Brewer and McCann, 1982)*

A1	Soil does not remain in a ball when squeezed	sand
A2	Soil remains in a ball when squeezed	B
B1	Squeeze the ball between your thumb and forefinger, attempting to make a ribbon that you push up over your finger. Soil makes no ribbon	loamy sand
B2	Soil makes a ribbon; may be very short	C
C1	Ribbon extends less than 1 inch before breaking	D
C2	Ribbon extends 1 inch or more before breaking	E
D1	Add excess water to small amount of soil; soil feels at least slightly gritty	loam or sandy loam
D2	Soil feels smooth	silt loam
E1	Soil makes a ribbon that breaks when 1-2 inches long; cracks if bent into a ring	F
E2	Soil makes a ribbon 2+ inches long; doesn't crack when bent into a ring	G
F1	Add excess water to small amount of soil; soil feels at least slightly gritty	sandy clay loam or clay loam
F2	Soil feels smooth	silty clay loam or silt
G1	Add excess water to a small amount of soil; soil feels at least slightly gritty	sandy clay or clay
G2	Soil feels smooth	silty clay

Soil Drainage - The soil drainage classes are defined in terms of (1) actual moisture content (in excess of field moisture capacity), and (2) the extent of the period during which excess water is present in the plant-root zone.

It is recognized that permeability, level of groundwater, and seepage are factors affecting moisture status. However, because these are not easily observed or measured in the field, they cannot be used generally as criteria of moisture status. It is further recognized that soil profile morphology, for example mottling, normally, but not always, reflects soil moisture status. Although soil morphology may be a valuable field indication of moisture status, it should not be the overriding criterion. Soil drainage classes cannot be based solely on the presence or absence of mottling. Topographic position and vegetation as well as soil morphology are useful field criteria for assessing soil moisture status.

RAPIDLY DRAINED - The soil moisture content seldom exceeds field capacity in any horizon except immediately after water addition. Soils are free from any evidence of gleying throughout the profile. Rapidly drained soils are commonly coarse textured or soils on steep slopes.

WELL DRAINED - The soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year. Soils are usually free from mottling in the upper 3 feet, but may be mottled below this depth. B horizons, if present, are reddish, brownish, or yellowish.

MODERATELY WELL DRAINED - The soil moisture in excess of field capacity remains for a small but significant period of the year. Soils are commonly mottled (chroma < 2) in the lower B and C horizons or below a depth of 2 feet. The Ae horizon, if present, may be faintly mottled in fine-textured soils and in medium-textured soils that have a slowly permeable layer below the solum. In grassland soils the B and C horizons may be only faintly mottled and the A horizon may be relatively thick and dark.

SOMEWHAT POORLY DRAINED - The soil moisture in excess of field capacity remains in subsurface horizons for moderately long periods during the year. Soils are commonly mottled in the B and C horizons; the Ae horizon, if present, may be mottled. The matrix generally has a lower chroma than in the well-drained soil on similar parent material.

POORLY DRAINED - The soil moisture in excess of field capacity remains in all horizons for a large part of the year. The soils are usually very strongly gleyed. Except in high-chroma parent materials the B, if present, and upper C horizons usually have matrix colors of low chroma. Faint mottling may occur throughout.

VERY POORLY DRAINED - Free water remains at or within 12 inches of the surface most of the year. The soils are usually very strongly gleyed. Subsurface horizons usually are of low chroma and yellowish to bluish hues. Mottling may be present but at depth in the profile. Very poorly drained soils usually have a mucky or peaty surface horizon.Simplified Key to Soil Texture (Brewer and McCann, 1982)

VEGETATION DESCRIPTION

Leaf phenology - Select the value which best describes the leaf phenology of the dominant stratum.

EVERGREEN - Greater than 75% of the total woody cover is never without green foliage.

DECIDUOUS - Greater than 75% of the total woody cover sheds its foliage simultaneously in connection with the unfavorable season.

COLD DECIDUOUS - Unfavorable season mainly characterized by winter frost.

DROUGHT DECIDUOUS - Unfavorable season mainly characterized by drought, in most cases winter-drought. Foliage is shed regularly every year. Most trees with relatively thick, fissured bark.

MIXED EVERGREEN - DECIDUOUS - Evergreen and deciduous species generally contribute 25-75% of the total woody cover.

MIXED EVERGREEN - COLD DECIDUOUS - Evergreen and cold-deciduous species admixed.

MIXED EVERGREEN - DROUGHT DECIDUOUS - Evergreen and drought-deciduous species admixed

PERENNIAL - Herbaceous vegetation composed of more than 50% perennial species.

ANNUAL - Herbaceous vegetation composed of more than 50% annual species.

Leaf type - Select one value which best describes the leaf form of the dominant stratum.

BROAD-LEAF - Woody vegetation primarily broad-leaved (generally contribute to greater than 50% of the total woody cover).

NEEDLE-LEAF - Woody vegetation primarily needle-leaved (generally contribute to greater than 50% cover).

MICROPHYLLOUS - Woody cover primarily microphyllous.

GRAMINOID - Herbaceous vegetation composed of more than 50% graminoid/ stipe leaf species

BROAD-LEAF-HERBACEOUS (FORB) - Herbaceous vegetation composed of more than 50% broad-leaf forb species.

PTERIDOPHTYE - Herbaceous vegetation composed of more than 50% species with frond or frond-like leaves.

Physiognomic class - Select the value which best describes the physiognomy. Definitions are modified from the 1973 UNESCO and 1984 Driscoll et al. Formation Classes and are defined by the relative percent cover of the tree, shrub, dwarf-shrub, herbaceous, and nonvascular strata.

FOREST - Trees with their crowns overlapping (generally forming 60-100% cover).

WOODLAND - Open stands of trees with crowns not usually touching (generally forming 25-60% cover). Canopy tree cover may be less than 25% in cases where it exceeds shrub, dwarf-shrub, herb, and nonvascular cover, respectively.

SHRUBLAND - Shrubs generally greater than 0.5 m tall with individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees generally less than 25% cover). Shrub cover may be less than 25% where it exceeds tree, dwarf-shrub, herb, and nonvascular cover, respectively. Vegetation dominated by woody vines is generally treated in this class.

DWARF- SHRUBLAND - Low-growing shrubs usually under 0.5 m tall. Individuals or clumps overlapping to not touching (generally forming more than 25% cover, trees and tall shrubs generally less than 25% cover). Dwarf-shrub cover may be less than 25% where it exceeds tree, shrub, herb, and nonvascular cover, respectively

HERBACEOUS - Herbs (graminoids, forbs, and ferns) dominant (generally forming at least 25% cover, trees, shrubs, and dwarf-shrubs generally with less than 25% cover). Herb cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and nonvascular cover, respectively.

NONVASCULAR - Nonvascular cover (bryophytes, non-crustose lichens, and algae) dominant (generally forming at least 25% cover). Nonvascular cover may be less than 25% where it exceeds tree, shrub, dwarf-shrub, and herb cover, respectively.

SPARSE VEGETATION - Abiotic substrate features dominant. Vegetation is scattered to nearly absent and generally restricted to areas of concentrated resources (total vegetation cover is typically less than 25% and greater than 0%).

Strata/lifeform, height, cover, diagnostic species - Visually divide the community into vegetation layers (strata). Indicate the average height of the stratum in the first column, and average percent cover (using the cover scale below) of the whole stratum in the second column. Trees are defined as single-stemmed woody plants, generally greater than 5m in height or greater at maturity and under optimal growing conditions. Shrubs are defined as multiple-stemmed woody plants generally less than 5m in height at maturity and under optimal growing conditions. If species known to be diagnostic of a particular vegetation type are present, list them. Leave blank if the diagnostics are not known.

Cover Scale for Strata

01	<5%
02	5 - 15%
03	15 - 25%
04	25 - 35%
05	35-45%
06	45-55%
07	55-65%
08	65-75%
09	75-85%
10	85-95%
11	95-100%

Height Scale for Strata

01	<0.5 m
02	0.5-1m
03	1-2 m
04	2-5 m
05	5-10 m
06	10-15 m
07	15-20 m
08	20-35 m
09	35 - 50 m
10	>50 m

Strata/Lifeforms -

EMERGENT TREE
TREE CANOPY
TREE SUB-CANOPY
TALL SHRUB (2-5m)
SHORT SHRUB (0.5-2m)
DWARF SHRUB (<0.5m)
HERBACEOUS
   GRAMINOID

FORB
FERN
NON-VASCULAR
EPIPHYTE
VINE/LIANA

Animal Use Evidence - Comment on any evidence of use of the plot/polygon by non-domestic animals (i.e, tracks, scat, gopher or prairie dog mounds, etc.). Notes on domestic animals should be made below.

Natural and Anthropogenic Disturbance - Comment on any evidence of natural or anthropogenic disturbance and specify the source.

Species / percent cover - Starting with the uppermost stratum, list all the species present and the percent cover (using the scale provided below) of each species in the stratum. For forests and woodlands, list on a separate line below each tree species the DBH of all trees above 10 cm diameter. Separate the measurements with a comma and note whether in cm or inches. The first line of each stratum should be used to identify which stratum is being described. The codes listed below can be used as an abbreviation. The codes provided by the NRCS PLANTS database can be used for species. See the example below. Also list any species that were observed to occur outside of the plot.

Strata

T1 Emergent
T2 Canopy
T3 Sub-canopy
S1 Tall shrub
S2 Short Shrub
H Herbaceous
N Non-vascular
V Vine/liana
E Epiphyte

Cover Scale for Species Percent Cover

01	< 1%
02	1-5%
03	5-25%
04	25-50%
05	50-75%
06	75-100%

EXAMPLE OF A COMPLETED SPECIES LIST

T1	
Quercus rubra (or QURU2)	04
52, 37, 15, 27, 18, 48, 40 cm	
Acer saccharum (ACSA)	03
16, 14, 16,	
T2	
Cornus florida (COFL)	03
13, 16	
S1	
Hamamelis virginiana (HAVI)	02
H	
Polystichum acrostichoides (POAC)	02
Medeola virginiana (MEVI)	01
Outside Plot	
Vaccinium angustifolium (VAAN)	
Quercus alba (QUAL)	
Corylus cornuta (COCO6)	

Appendix B

Geographic and Taxonomic Data Gaps for Each State

State	Taxonomic comments	Geographic comments
AK	A partial crosswalk has been completed between the Alaska classification and the national classification. Forest plant associations of the temperate rainforests have been added to the USNVC records.	Most of the state needs additional inventory and classification work, except the Arctic coastal plain and forest types of the temperate rainforest zone of the SE portion of the state.
AL	Non-vascular and sparse vegetation types are poorly developed.	
AR	Non-vascular and sparse vegetation types are poorly developed.	
AZ	Riparian types and desert grasslands need further survey and classification work.	The Colorado Plateau and Mojave Desert portions of the state need inventory.
CA	Approximately 700 associations are known for the state, with 2000 predicted. Forest types are probably the best surveyed. Further work needs to be done to incorporate the state classification into the national.	The Mojave and Colorado deserts need inventory.
CO	Great Plains and montane grassland types need further survey and classification work. Riparian types have received inventory and classification attention, but need to be reviewed in relation to the entire western region.	The Great Plains (eastern 1/2 of state) and the lower elevations of the western portion of the state need inventory. The entire state has good coverage for riparian
CT	Calcareous uplands need work, but otherwise good coverage and high agreement between state and national types.	
DE	Good data on forested swamps and reasonable estimates of many other types.	
FL	Non-vascular and sparse vegetation types are poorly developed.	
GA	Non-vascular and sparse vegetation types are poorly developed.	The Blue Ridge portion of the state is best covered.
HI	Vegetation of the state is well known, with the exception of types induced by human activities.	
IA	State uses national classification. Sedge meadows and northeastern forests require further review.	Coverage across the state is fairly even for prairie and fen types only, and the southeastern part is perhaps the least surveyed.
ID	A thorough crosswalk between the state and national classifications has been completed, but 28% of the state types require further crosswalking and review. The classification of pinyon-juniper woodlands is currently being revised.	Southwestern Idaho, the central Idaho batholith, and riparian areas of the Snake River Plain require survey work. Inter- and intra-state crosswalks of riparian/wetland types are needed.
IL	A detailed crosswalk now exists between state natural community classification and national classification. Sedge meadows, marshes, and floodplain forests require further review.	Coverage across the state is fairly even due to extensive county surveys from the late 1970s.
IN	A detailed crosswalk exists between state natural community (and vegetation) classification and national classification. Upland forests, floodplain forests, sedge meadows and marshes require further review.	Coverage across the state is fairly even, due to extensive natural area surveys. Surveys are under way in the Lake Erie basin.
KS	State uses national classification. Herbaceous wetland types, including in the playa lake region require further review.	Upland prairies have been well surveyed in the eastern third of the state, but other types and regions are not well surveyed.
KY	Non-vascular and sparse vegetation types are poorly developed.	
LA	Non-vascular and sparse vegetation types are poorly developed.	
MA	Classification under intensive development. Current state draft is a modification of the regional alliance classification.	
MD	Current classification is a modification of regional alliance classification combined with intensive survey/sampling work in shale barrens, floodplain forests, coastal systems, and limestone uplands	
ME	Useful state classification in place. Extensive sampling of calcareous wetlands, floodplains, peatlands and forest types on public lands has recently taken place. A thorough synthesis of state and national associations is currently underway.	Enormous amount of data collected in last few years. Northern part of state is not well known.
MI	State is in the process of resolving state classification with national classification. State will utilize several community complex types (e.g., wooded dune-and-swale) as well as vegetation types to assist with protection analysis.	Coverage across the state is somewhat even, with less information in the Upper Peninsula. More emphasis has been placed on wetlands and Great Lakes coastal systems, particularly rarer ones.
MN	State vegetation classification and national classification utilize similar units. State wetland types are rather coarse. State is currently conducting an extensive releve analysis of all forested and other northern types, to be completed in 1998.	Coverage in the northern third of the state is weak, though the classification is quite comprehensive. Elsewhere, selected county biological surveys have produced detailed information on community patterns.
MO	A detailed crosswalk now exists between state natural community classification and national classification. Herbaceous wetland types need further review.	Coverage across the state is somewhat even due to extensive county surveys, but less emphasis has been placed on wetlands. Common forest types are also less well surveyed.
MS	Non-vascular and sparse vegetation types are poorly developed.	

State	Taxonomic comments	Geographic comments
MT	Grassland associations of the eastern third of the state are not adequately inventoried or classified. Rare or uncommon wetland types need review. Seral types require extensive review and classification work.	The eastern prairie (eastern 2/3 of the state) requires survey work; also alpine and non-forested subalpine regions of the northwest and west-central portions of the state.
NC	Non-vascular and sparse vegetation types are poorly developed.	
ND	State uses national classification. Mixedgrass prairie, sedge meadows and marsh types, especially in the prairie pothole region, need further review.	Coverage across the state is uneven; the western half of the state is less well surveyed.
NE	State uses national classification. Mixedgrass prairie, sedge meadow and marsh types need further review.	Coverage across the state is somewhat even, but the western half of the state is less well surveyed.
NH	Field studies of pondshores, calcareous wetlands, peatlands, basin wetlands, high elevation and coastal systems have been recently completed. Classification is under extensive revision including a synthesis with national associations.	
NJ	The existing state classification is currently being revised to match the national types, as well as incorporate new data from pine barrens, trap rock glades, and limestone areas. Many new types are proposed.	
NM	Riparian types, the desert grasslands, and pinyon-juniper woodlands need further inventory and classification review.	The Great Plains (eastern 1/2 of state) and high elevation alpine regions are poorly surveyed.
NV	Pinyon-juniper woodlands and forests, riparian and wetland types, dry subalpine shrublands, and low elevation shrublands all need further review and inventory work.	Much of the state has not been surveyed for vegetation classification work; large portions of the state are poorly known.
NY	A stable and well utilized state classification exists. Extensive data has been collected on most communities. Revisions to match national types are currently focused on the mountainous and coastal regions of the state.	
OH	A close correspondence exists between state vegetation classification and national classification. Upland and wetland forests, sedge meadows, and marshes need further review.	Forest types in the southeastern part of the state are less well surveyed. Detailed surveys of the Lake Erie basin of northern Ohio have been completed.
OK	Non-vascular and sparse vegetation types are poorly developed.	
OR	Saltmarsh and marine communities require inventory and classification review, especially in conjunction with a marine and estuarine classification from Washington. Salt desert scrub, chapparal, and montane shrublands all need work.	Shrubland types in much of the state (except northwest) are poorly known or described. The western Oregon forests need to be reviewed with adjacent states for level of classification consistency.
PA	The existing state classification is currently being revised to better meet the needs of several state agencies. Where possible, types are being matched or thoroughly crosswalked to the national types.	East and west parts of state need to be unified.
RI	Existing classification is useful but rather rudimentary, extensive community survey work is currently underway.	
SC	Non-vascular and sparse vegetation types are poorly developed.	
SD	State uses national classification. Mixedgrass prairie, sedge meadows, and marsh types, especially in the prairie pothole region, need further review.	Few places in the state have been well-surveyed, but the central part of the state is the least surveyed. A Black Hills and an eastern Prairie Coteau survey are under way.
TN	Non-vascular and sparse vegetation types are poorly developed.	The Blue Ridge portion of the state is best covered.
TX	Non-vascular and sparse vegetation types are poorly developed.	West TX and east TX are covered best.
UT	Pinyon-juniper woodlands and forests, riparian and wetland types, dry subalpine shrublands, and low elevation shrublands all need further review and inventory work.	The Colorado Plateau region needs inventory.
VA	Existing state classification is very broad. The state, however, has accumulated large amounts of community data over the last 5 years. Plans to incorporate the information into a nationally compatible fine-scale classification are underway.	Most work in the state has been done in the mountains.
VT	Existing state classification has recently been revised to incorporate copious new data and provide a synonymy to the national types. Current state-wide survey work is focused on cedar swamps and floodplain systems.	The northern part of the state is best represented.
WA	A detailed crosswalk exists between state natural community classification and national classification, and the state is in the process of updating their classification.	The wetlands of the western portion of the state, along both sides of the Cascades, need to be reviewed in conjunction with adjacent portions of British Columbia. The southwest of the state is poorly classified.
WI		Coverage across the state is fairly even. Surveys are currently being conducted in the Lake Superior basin.
WV	A first draft of a state classification now exists, based primarily on literature, recent surveys, and the regional/national alliance classification. Extensive sampling and development underway in eastern half of state.	Western 1/2 of state has had very little attention.

Appendix C

Vegetation Key and a Sample Type Description from Scotts Bluff National Monument

Vegetation Key

1. Site more than 25% vegetated.

    2. More than 25% of site covered by woody plants **more than** 2 m tall.

        3. Broadleaf (dicot) trees predominate; site riverine
        ***Populus deltoides-(Salix amygdaloides)/Salix exigua* Floodplain Woodland**

        3. Needleleaf (conifer) trees predominate; upland sites and draws.

            4. *Pinus ponderosa* and *Juniperus scopulorum* predominate; canopies usually intermingled
            ***Pinus ponderosa/Juniperus scopulorum* Woodland**

            4. *Juniperus scopulorum* predominates (*Pinus ponderosa* cover less than 10%); canopies usually intermingled
            ***Juniperus scopulorum/Oryzopsis micrantha* Woodland**

    2. Less than 25% of site covered by woody plants **more than** 2 m tall.

        5. More than 25% of site covered by woody plants **less than** 2 m tall.

            6. Site riverine or palustrine. Herbaceous stratum poorly represented or absent; *Salix exigua* dominant; stream margins
            ***Salix exigua* Shrubland**

            6. Site upland (including intermittently flooded draws).

                7. Site on middle slopes of bluffs; *Cercocarpus montanus* dominant
                ***Cercocarpus montanus/Bouteloua curtipendula* Shrubland**

                7. Site on low slopes or in draws; *Rhus aromatica*, *Symphoricarpos occidentalis* dominant
                ***Symphoricarpos occidentalis* Shrubland ***

        5. Less than 25% of site covered by woody plants **less than** 2 m tall (except for small inclusions).

*** A description of this type is provided following the key on page 116. Its distribution at the monument is shown on page 119.**

8. Site riverine or palustrine wetland.

    9. Soil saturated most of season; *Typha latifolia*, *Eleocharis erythropoda*, *Scirpus pungens* among dominants; annual and biennial plants uncom-mon or absent
    ***Typha* spp. Inland Great Plains Herbaceous Vegetation**

    9. Soil rarely saturated; *Typha*, *Eleocharis*, and *Scirpus* uncommon; annual and biennial plants conspicuous
    ***Andropogon gerardii-Calamagrostis canadensis-Helianthus grosseserratus* Herbaceous Vegetation**

8. Site upland, never flooded.

    10. Community dominated by exotic grasses and forbs and/or native weedy forbs (the exception is *Pascopyrum smithii,* a native grass which is sometimes co-dominant in this community).
    ***Kochia scoparia/Bromus* spp. Early Seral Community**

    10. Community dominated by native grasses and sedges. Exotic grasses and forbs and native weedy forbs may be present but are not dominant except in small localized areas.

        11. Dominant species include one or more of the following: *Carex filifolia*, *Bouteloua gracilis*, or *Stipa comata*.

            12. *Carex filifolia* cover more than 25% or *Stipa comata* dominant (areas where *Carex filifolia* cover has been reduced by deposition of erosional material or past overgrazing)
            ***Stipa comata-Bouteloua gracilis-Carex filifolia* Herbaceous Vegetation**

            12. *Carex filifoila* cover less than 25%, *Bouteloua gracilis* co-dominant, areas interspersed with rock outcrops, on or near top of bluffs
            Siltstone-Clay Butte Sparse Vegetation <u>and</u> *Stipa comata-Bouteloua gracilis-Carex filifolia* Herbaceous Vegetation <u>and</u> Inland Siltstone Bluff-Cliff Sparse Vegetation Complex

        11. Dominant species include one or more of the following: *Pascopyrum smithii*, *Bouteloua curtipendula*, *Schizachyrium scoparium*, *Calamovilfa longifolia*, or *Andropogon hallii*

            13. Dominant species including *Calamovilfa longifolia* and/or *Andro-pogon hallii*; soil sandy; *Yucca glauca* cover usually over 5% (except in draws); *Artemisia filifolia* often present (shrubs <25%)
            ***Andropogon hallii-Calamovilfa longifolia* Herbaceous Vegetation**

            13. Dominant species not including *Calamovilfa longifolia* and/or *Andropogon hallii*; *Yucca glauca* cover less than 5%. *Artemesia filifolia* usually absent.

14. Community an unnatural looking, reseeded grassland on a formerly disturbed site; overall plant diversity extremely low; *Stipa comata* and *Nassella viridula* not abundant.
    Mixedgrass Prairie (Reseeded/Restored)

14. Community a natural looking grassland not on a formerly disturbed site; overall plant diversity not extremely low. *Stipa comata* and *Nasella viridula* abundant.
    ***Pascopyrum smithii* Herbaceous Vegetation**

1. Site less than 25% vegetated.

15. Site riverine, mostly bare sand
    Riverine Sand Flats-Bars Sparse Vegetation

15. Site upland, mostly bare rock.

16. Site consisting of slopes of 60-90% grade; *Mentzelia decapetala* dominant
    Inland Siltstone Bluff-Cliff Sparse Vegetation

16. Site consisting of irregularly-eroded slopes of less than 60% grade; *Mentzelia decapetala* rarely (if ever) dominant.

17. Site less than 10% vegetated (except for small inclusions; % shrub cover (*Atriplex canescens*, *Chrysothamnus nauseosus*) often nearly equal to or exceeding % herbaceous cover; elevation less than 4000 ft
    Eroding Great Plains Badlands Sparse Vegetation

17. Site usually more than 10% vegetated; % shrub cover (*Rhus aromatica*, *Chrysomthamnus parryi*, *Kraschenninikovia lanata*, *Artemisia filifolia*) usually much less than % herbaceous cover.

18. Site situated on sandy or silty soil; elevation often less than 4000 ft
    Eroding Great Plains Bank Sparse Vegetation

18. Site situated on sandstone or siltstone outcrops.

19. Site situated on sandstone outcrops atop bluffs; elevation more than 4300 ft.
    Siltstone-Clay Butte Sparse Vegetation <u>and</u> *Stipa comata-Bouteloua gracilis-Carex filifolia* Herbaceous Vegetation Complex

19. Site situated on siltstone outcrops on sides of bluffs; elevation less than 4300 ft
    Siltstone-Clay Butte Sparse Vegetation

Description of a Vegetation Type

Symphoricarpos occidentalis **Shrubland**

COMMON NAME	Wolfberry Shrubland
SYNONYM	Shrub ravine
TNC SYSTEM	Terrestrial
CLASS	Shrubland
SUBCLASS	Deciduous shrubland
GROUP	Cold-deciduous shrubland
FORMATION	Temporarily flooded cold-deciduous shrubland
ALLIANCE	*Symphoricarpos occidentalis* Temporarily Flooded Shrubland Alliance
CLASSIFICATION CONFIDENCE LEVEL	2

RANGE This community is widespread in western Montana and North Dakota. It is also present in Nebraska, South Dakota, Manitoba, and Saskatchewan.

In Scotts Bluff NM, this community occurs throughout plains and lower- to mid-slopes of escarpments.

ENVIRONMENTAL DESCRIPTION Globally, this community is found in mesic swales, depressions, ravines and floodplains. Some examples of this community experience intermittent and brief flooding. The soils are fertile and well drained to imperfectly drained silts and loams.

In Scotts Bluff, NM, *Symphoricarpos occidentalis* Shrubland occupies lower-slopes of escarpments and walls, and beds of draws and channels on the plains. Soils are colluvial silt and sandy loam and not rapidly drained.

USFWS WETLAND SYSTEM Not applicable

MOST ABUNDANT SPECIES

Globally

Strata	**Species**
Short shrub	*Rhus aromatica*, *Rosa woodsii*, *Symphoricarpos occidentalis*
Woody vine	*Parthenocissus vitacea*
Herbaceous	*Artemisia ludoviciana*, *Pascopyrum smithii*

Scotts Bluff NM

Strata	Species
Short shrub	*Rhus aromatica*, *Ribes aureum* var. *villosum*, *Symphoricarpos occidentalis*, *Toxicodendron rydbergii*
Woody vine	*Parthenocissus vitacea*
Herbaceous	*Bromus* spp., *Clematis ligusticifolia*, *Poa pratensis*, *Parietaria pensylvanica*, *Nepeta cataria*

DIAGNOSTIC SPECIES

Globally	*Rhus aromatica*, *Symphoricarpos occidentalis*
Scotts Bluff NM	*Rhus aromatica*, *Symphoricarpos occidentalis*

VEGETATION DESCRIPTION Throughout its range this community is dominated by shrubs approximately 1 m tall. Shrub cover is typically greater than 50%. In places it can approach 100%. These shrubs form dense clumps that exclude most other species. *Symphoricarpos occidentalis* is the most common shrub, but *Rhus aromatica* and *Prunus virginiana* can be locally abundant. *R. aromatica* and *P. virginiana* can grow to 2-3 meters in places. Herbaceous species and smaller shrubs are most abundant at the edge of this community and in gaps between the clumps of taller shrubs where the shading is less complete. *Rosa woodsii* is a typical smaller shrub. *Achillea millefolium*, *Artemisia ludoviciana*, *Galium boreale*, and *Pascopyrum smithii* are common herbaceous species of this community. Woody vines sometimes occur. *Parthenocissus vitacea* is the most common vine.

At Scotts Bluff, NM, this community is densely vegetated, especially in deep narrow draws. It is dominated by *Rhus aromatica* and/or *Symphoricarpos occidentalis*, often with *Ribes aureum* var. *villosum* and *Prunus virginiana*. *Juniperus scopulorum* can be found in this community also, especially west of Scotts Bluff. *Toxicodendron rydbergii* is often abundant in the understory. The herbaceous stratum is poorly developed at most sites and consists of exotics such as *Bromus japonicus*, *Poa pratensis*, and *Nepeta cataria*. Where shrub cover is less dense prairie grasses such as *Bouteloua curtipendula*, *Calamovilfa longifolia*, and *Schizachyrium scoparium* are found. Woody and herbaceous vines (*Parthenocissus vitacea* and *Clematis ligusticifolia*, respectively) are frequently mixed in with the shrubs.

OTHER NOTEWORTHY SPECIES Information not available.

CONSERVATION RANK G4

RANK JUSTIFICATION Information not available.

COMMENTS Globally, this community often has a significant component of exotic species, especially where grazing has been intense. *Bromus inermis*, *Cirsium arvense*, and *Poa pratensis* are the most abundant of these exotics. Overgrazing of prairies can lead to the expansion of degraded forms of this community.

In Scotts Bluff NM, *Juniperus virginiana* occurs (and may have been planted) in some of the draws in which this community occurs. One large draw just north of Hwy 92 and west of Mitchell Pass contains significant *Juniperus* spp. but is placed in this community.

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Scotts Bluff

VEGETATION KEY

- Juniperus scopulorum/Oryzopsis micrantha Woodland
- Pinus ponderosa/Juniperus scopulorum Woodland
- Populus deltoides - (Salix amygdaloides)/Salix exigua Floodplain Woodland
- Cercocarpus montanus/Bouteloua curtipendula Shrubland
- Salix exigua Shrubland
- **Symphoricarpos occidentalis Shrubland**
- Andropogon gerardii - Calamagrostis canadensis - Helianthus grosseserratus Herbaceous Vegetation
- Andropogon hallii - Calamovilfa longifolia Herbaceous Vegetation
- Kochia scoparia/Bromus spp. Early Seral Community
- Mixedgrass Prairie (Reseeded/Restored)
- Pascopyrum smithii Herbaceous Vegetation
- Stipa comata - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation
- Typha ssp. Inland Great Plains Herbaceous Vegetation
- Inland Siltstone Bluff-Cliff Sparse Vegetation
- Siltstone - Clay Butte Sparse Vegetation
- Riverine Sand Flats-Bars Sparse Vegetation
- Eroding Great Plains Badlands Sparse Vegetation
- Eroding Great Plains Bank Sparse Vegetation
- Siltstone - Clay Butte Sparse Vegetation and Stipa comata - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation Complex
- Siltstone - Clay Butte Sparse Vegetation and Stipa comata - Bouteloua gracilis - Carex filifolia Herbaceous Vegetation and Inland Siltstone Bluff-Cliff Sparse Vegetation Complex
- Bare Ground
- Open Water
- Improvements

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Appendix D
Conservation Status Ranking

The USNVC was originally developed to provide a complete, standardized listing of all natural vegetation types that represent the variation in biological diversity at the community level *and to identify those communities that require protection* (Goodin and Grossman 1994; emphasis added). Determining which community types are most in need of protection is the critical question for targeting conservation resources appropriately. The Conservancy uses a two-pronged approach. First, all community types that occur in an ecoregion[1] are assessed for their current representation in protected areas. Gaps in protection of these types are one conservation priority (see TNC 1996). Another priority is to ensure the conservation of those types that are relatively rare and imperiled. To address the latter issue, the Natural Heritage Network and the Conservancy developed a method for evaluating community types and assigning appropriate conservation status ranks. These ranks are applied to the finest possible level of the hierarchy. Ranks indicating the rangewide (global) conservation status have been developed at the association level for types occurring in the United States.

Community types are ranked on a global (G), national (N), and subnational (S) scale of 1 to 5, with 1 indicating critical imperilment due to rarity, endemism, and/or threats[2], and 5 indicating little or no risk of extirpation or elimination. For example, a rank of G1 indicates critical imperilment on a rangewide basis, i.e., a great risk of "extinction" of the type worldwide; S1 indicates critical imperilment within a specific state, province, or other subnational jurisdiction, i.e., a great risk of extirpation of the type from the subnation.

Two primary ranking factors are used in assessing the appropriate conservation status rank for a community element: (1) the total number of occurrences and (2) the total area (acreage) of the element. Secondary ranking factors such as the geographic range over which the element occurs, the threats to the occurrences, and the viability[3] of the occurrences also affect the rank.

Although community ranking is best done when information on all the factors listed above is available, it is often necessary establish preliminary ranks when this information is lacking or incomplete. This is particularly true for communities that have not been well described. In practice, four main factors have been useful in arriving at a preliminary assessment of a community's rangewide (global) rank:

1. The geographic range over which the type occurs.

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[1] An ecoregion is a relatively large unit of land and water delineated by the biotic and abiotic factors that regulate the structure and function of the communities within it. It provids a unit of geography that is more relevant than political units for organizing and prioritizing conservation planning efforts (TNC 1996).

[2] Associations may be ranked G1-G3 due exclusively to rarity, i.e., in the absence of imminent threats. Examples are rare types occuring in areas remote from human alteration or unsuitable to human use, those that are endemic to a well-protected national park, or those that exhibit an inherent resistance to alteration or degradation. Although the relationship between rarity and vulnerability is not well defined, the two concepts have often been confounded. This may be, in part, because rarity per se confers some degree of inherent threat in that very rare species and communities can be threatened rapidly (Master 1991).

[3] Viability is assessed through element *occurrence* ranking on an excellent to poor scale based on degree of altered species composition and structure, condition, and inferred ecosystem processes. The Conservancy also uses these occcurrence ranks to ensure the protection of the best examples of *all* associations, as well as occurrences of rare and imperiled ones.

Global Rank Definitions

GX **ELIMINATED** throughout its range, with no restoration potential due to extinction of dominant or characteristic species.

GH **PRESUMED ELIMINATED (HISTORIC)** throughout its range, with no or virtually no likelihood that it will be rediscovered, but with the potential for restoration (e.g., *Castanea dentata* Forest).

G1 **CRITICALLY IMPERILED**. Generally 5 or fewer occurrences and/or very few remaining acres or very vulnerable to elimination throughout its range due to other factor(s).

G2 **IMPERILED**. Generally 6-20 occurrences and/or few remaining acres or very vulnerable to elimination throughout its range due to other factor(s).

G3 **VULNERABLE**. Generally 21-100 occurrences. Either very rare and local throughout its range or found locally, even abundantly, within a restricted range or vulnerable to elimination throughout its range due to specific factors.

G4 **APPARENTLY SECURE**. Uncommon, but not rare (although it may be quite rare in parts of its range, especially at the periphery). Apparently not vulnerable in most of its range.

G5 **SECURE**. Common, widespread, and abundant (though it may be quite rare in parts of its range, especially at the periphery). Not vulnerable in most of its range.

GU **UNRANKABLE**. Status cannot be determined at this time.

G? **UNRANKED**. Status has not yet been assessed.

Modifiers and Rank Ranges

? A question mark added to a rank expresses an uncertainty about the rank in the range of 1 either way on the 1-5 scale. For example a G2? rank indicates that the rank is thought to be a G2, but could be a G1 or a G3.

G#G# Greater uncertainty about a rank is expressed by indicating the full range of ranks which may be appropriate. For example, a G1G3 rank indicates the rank could be a G1, G2, or a G3.

Q A "Q" added to a rank denotes questionable taxonomy. It modifies the degree of imperilment and is *only* used in cases where the type would have a *less imperiled* rank if it were not recognized as a valid type (i.e., if it were combined with a more common type). A GUQ rank often indicates that the type is unrankable *because of* daunting taxonomic/definitional questions.

Note: "G" refers to global (rangewide) status. National (N) and subnational (S) ranks can also be assessed.

2. The long term decline of the type across this range.

3. The degree of site specificity exhibited by the type.

4. The rarity across the range based on state ranks assigned by state Natural Heritage Programs.

Most of the ranks currently applied to USNVC types are based on such preliminary assessments of rarity.

The table below presents definitions for all global ranks for community types. For further information on ranking see Master (1991). For information on specifications for "occurrences" of elements see TNC (1997).

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Appendix E

A Conceptual Framework for Categorizing and Ranking the Degree of "Naturalness" in Existing Vegetation

The U.S. National Vegetation Classification is a classification of existing vegetation. Many community classifications have focused strictly on "presettlement vegetation," "potential natural vegetation," or postulated "climax" or "late-seral" vegetation. Classification of existing vegetation has the advantage that it can be based on direct measurement, analysis, and interpretation.

The classification is, however, intended to have practical conservation applications. For this reason a broad distinction is made between natural/semi-natural vegetation and planted/cultivated vegetation. Furthermore, in order to help set conservation priorities, it is also helpful to distinguish those communities that have little or no modification by human activity (i.e. natural/near natural communities) from those with some or extensive modification by humans (i.e. semi-natural/altered communities). Such a distinction is based on the correlation that conservationists and others make between naturalness and conservation priority. This is not to say that semi-natural communities have no conservation value; e.g., they may serve as important habitat for a particular rare species.

The dynamic nature of vegetation presents some complications in the evaluation of the naturalness and conservation priority of community units. Early- and mid-seral vegetation may be readily classifiable (as distinct in composition and physiognomy from later seral vegetation), but may be transient on the landscape. Transience makes these early stages difficult to "track" and to evaluate for conservation action (in standard Heritage Program approaches), yet these types manifestly exist, often as a result of natural disturbance processes. The conservation of seral stages will generally require conservation of communities at landscape scales, and the maintenance in those landscapes of the ecological processes responsible for the periodic creation of successional natural communities.

In addition, disturbances cannot be clearly and cleanly classified as "natural" or "anthropogenic." Some anthropogenic disturbances are similar enough to natural disturbances that the resulting successional communities cannot be clearly distinguished, while others may create novel communities, unprecedented in the natural landscape.

Element ranking (the "element" being a species or community taxon) is one of the standard methodologies for the setting of conservation priorities developed and applied by The Nature Conservancy and the Heritage Network. Global, national, and subnational (state or province) element conservation ranks provide basic information on the relative imperilment or risk of extinction of an element within the specified geographic ranges. Element ranks for both species and communities are based on a five-point hierarchical scale, ranging from critically imperiled (G1,N1, or S1) to secure (G5, N5, or S5). However, for communities, the additional issue of the naturalness and successional status of the taxon suggest that it may be helpful to separate the natural/near-natural types from the semi-natural/altered types for the purposes of ranking. The following categorization of vegetation types and associated element ranks is still in the process of development, and is presented here for review and use.

I. NATURAL/SEMI-NATURAL VEGETATION
   ranks G1 through G5, GH, GX, GD, GW, GM

   A. Natural/Near-natural Vegetation
      ranks G1 through G5, GH, GX

B. Semi-natural/Altered Vegetation
   i. Ruderal Vegetation - rank GD
   ii. Invasive Vegetation - rank GW
   iii. Modified/Managed Vegetation - rank GM

II. PLANTED/CULTIVATED VEGETATION
   rank GC

PLANTED/CULTIVATED VEGETATION (GC rank)

Planted/cultivated areas are defined as being dominated by vegetation which has been planted in its current location by humans and/or is treated with annual tillage, a modified conservation tillage, or other intensive management or manipulation. The majority of these areas are planted and/or maintained for the production of food, feed, fiber, or seed (FGDC 1997).

The Nature Conservancy and the Natural Heritage Network generally have little interest in classifying, mapping, or conserving planted or cultivated vegetation, but other agencies and organizations do. It is important to conceptually separate planted/cultivated vegetation (such as short rotation pine plantations) from natural/semi-natural vegetation (such as sucessional and natural pine communities), and this is best done by explicitly accounting for these fundamentally different communities in the classification. Examples of planted/cultivated vegetation include apple orchards, lawns around National Park Service facilities, loblolly pine plantations, wheat fields, and cotton fields.

NATURAL/SEMI-NATURAL VEGETATION (G1-G5 [N1-N5, S1-S5], GH [NH, SH], GX [NX,SX], GD, GW, GM ranks)

Natural/semi-natural vegetation is defined broadly to include types which occur spontaneously without regular human management, maintenance, or planting, and which generally have a strong component of native species.

NATURAL / NEAR-NATURAL VEGETATION (G1-G5 [N1-N5, S1-S5], GH [NH, SH], GX [NX,SX] ranks)

Natural/near-natural vegetation refers to plant communities that appear not to have been modified by human activities, or to have only been marginally impacted by such activities. Where impacts are apparent, there exists a clear, naturally maintained analogue for the existing physiognomic *and* floristic patterns. Of thse natural/near-natural types, communities that are mid- and late-seral are nearly always the highest priority for development and refinement of the classification. These are the communities which The Nature Conservancy and Natural Heritage Network consistently classify and track in detail. Examples include oak forests of eastern North America, ponderosa pine forests of western North America, pinyon-juniper woodlands, calcareous glades, spruce forests, coastal marshes, and historic chestnut forests of the Appalachians.

Though early seral communities are "natural" communities they are currently rarely tracked by Heritage Programs as conservation targets. While the recognition of these communities as "natural" and "real" is conceptually important, they may be difficult or impossible to conserve by site conservation action. Examples include fireweed (*Epilobium angustifolium*) communities of boreal and montane areas resulting from fire, willow sandbars of the eastern United States, aspen thickets, and vine thickets resulting from hurricane blowdowns. Some successional communities result from anthropogenic disturbances but are close cognates of "natural" secondary successional communities; these should also be considered in this category.

SEMI-NATURAL / ALTERED VEGETATION (GD, GW, GM ranks)

Semi-natural/altered vegetation may be defined as plant communities where the species composition and/or the structure of the vegetation has been altered through anthropogenic disturbance such that no clear natural analogue is known.

RUDERAL COMMUNITIES (GD rank)

Ruderal communities are vegetation resulting from succession following anthropogenic disturbance of an area. They are generally characterized by unnatural combinations of species (primarily native species, though they often contain slight to substantial numbers and amounts of species alien to the region as well).

These communities are generally not priorities for conservation for their own sake, though they may support rare species or function as important landscape connectors or matrices in reserves. In many landscapes, ruderal communities occupy large areas—sometimes more than any other category of communities. They can provide important biodiversity functions. In landcover or GAP mapping, these ruderal types are important to map, because of their large extent. Examples include tulip tree successional stands following cropping, red-cedar pastures, and "secondary savannas" of the West Indies and other tropical areas with the woody layer often dominated by acacias, mesquite, or palms.

INVASIVE COMMUNITIES (GW rank)

Invasive communities are dominated by invasive alien species. Though these communities are often casually considered as "planted/cultivated," they are spontaneous, self-perpetuating, and not the (immediate) result of planting, cultivation, or human maintenance. Land occupied by invasive communities is generally permanently altered (converted) unless restoration efforts are undertaken. It is also important to recognize that these communities are novel; they are not merely a community "transplanted" from the native range of the dominant species. *Melaleuca* in south Florida, kudzu in the southeastern United States, tamarisk in the western United States, and red mangrove in Hawaii all form communities which have no equivalent in the home range of the dominant species (associated species, processes, landscape context, fauna, etc. are all significantly different).

These communities are important to recognize and classify since their invasive qualities mean that active suppression or control efforts may be needed in order to avoid the spread of these communities at the expense of natural communities. Examples include tallow-tree forests, tamarisk galleries along western streams, *Phragmites* marshes in non-native range, shrub steppes with alien grasses dominating beneath the shrubs, and mangrove (*Rhizophora mangle*) swamps in Hawaii.

MODIFIED/MANAGED COMMUNITIES (GM rank).

Modified/managed communities are vegetation resulting from the management or modification of natural/near natural vegetation, but producing a structural and floristic combination not clearly known to have a natural analogue. Modified vegetation may be easily restorable by either management, time, or restoration of ecological processes. It is not yet clear how to deal with these communities in the USNVC. Examples include jack pine barren stands that are managed for sharp-tailed grouse by annual burning (producing a bur oak-northern pin oak scrub grassland), longleaf pine woodlands with canopies converted to slash pine but retaining ground flora characteristic of the longleaf pine woodland, pine forests silviculturally thinned to woodland structures, "unimproved pastures" resulting from removal of trees, and strips of forest between lanes of divided highway (identifiable but "all edge").

A Conceptual Key to Global Rank Categories for Existing Vegetation

1 Vegetation planted or regularly maintained; [crops, lawns, orchards, plantations] .... GC
1 Vegetation not planted or regularly maintained.
  2 Dominant stratum of vegetation dominated by species alien to the ecoregion (dominance unlikely to change to more natural composition without active restoration effort); ["weed communities," generally structurally and compositionally simple, which in some cases should be actively suppressed] .... Weedy (GW)
  2 Dominant stratum of vegetation dominated by native species, though alien species may be present in small to moderate quantities in dominant stratum or in large quantities in a non-dominant stratum.
    3 Vegetation appears not to have been modified by human activities or to have only been marginally impacted by such activities. Where impacts are apparent, there exists a clear, naturally maintained analogue for the existing physiognomic *and* floristic patterns .... G1-G5, GH, GX
    3 Vegetation altered in composition, structure, condition, or (inferred) ecosystem processes such that no clear natural analogue exists.
      4 Vegetation highly altered (by human disturbance), not identifiable to a natural type based on existing composition and structure (and inference about the nature of the alteration) .... Ruderal (GD)
      4 Vegetation less altered, identifiable to a corresponding natural type based on existing composition (and inference about the nature of the alteration). Alteration may be either physiognomic or compositional, but is beyond the range of variation (range of "average expression") allowable for the corresponding natural type .... Modified (GM)

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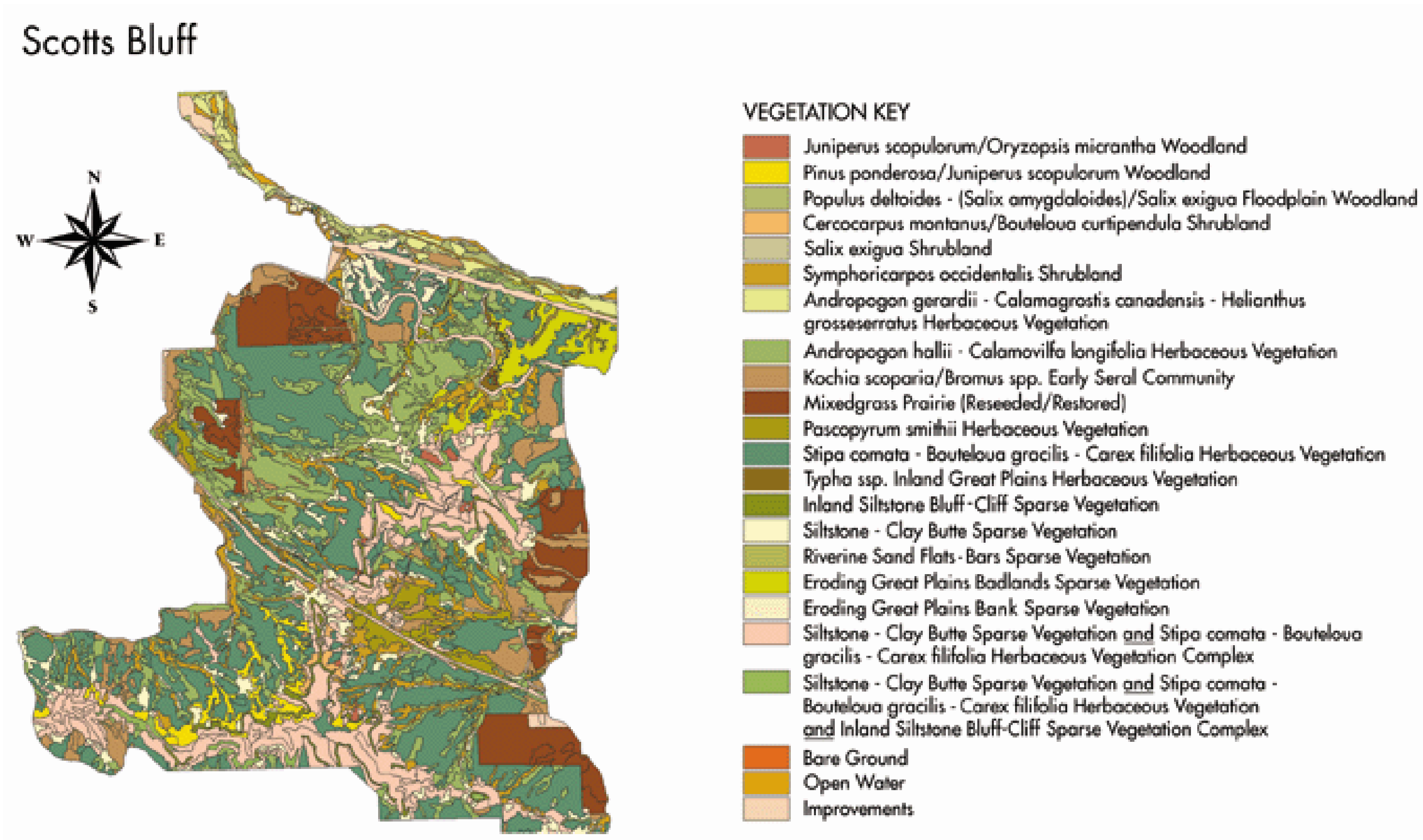

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