# APPENDIX I: Standards for Ecological Classification

A given terrestrial ecological system is defined as a group of plant community types that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients. A given terrestrial ecological system will typically manifest itself in a landscape at intermediate geographic scales of 10s to 1,000s of hectares and persist for 50 or more years. Ecological processes include natural disturbances such as fire and flooding. Substrates may include a variety of soil surface and bedrock features, such as shallow soils, alkaline parent materials, sandy/gravelling soils, or peatlands. Finally, environmental gradients include hydrologically defined patterns in coastal zones, arid grassland or desert areas, or montane, alpine or subalpine zones defined by climate.

By plant community type, we mean a vegetation classification unit at the association or alliance level of the US National Vegetation Classification (US-NVC) (Grossman et al. 1998, Jennings et al. 2003, NatureServe 2004), or, if these are not available, other comparable vegetation units. US-NVC associations are used wherever possible to describe the component biotic communities of each terrestrial system.

Ecological systems are defined using both spatial and temporal criteria that influence the grouping of associations. Associations that consistently co-occur on the landscape therefore define biotic components of each ecological system type. Our approach to ecological systems definition using US-NVC associations is similar to the biotope or habitat approach used, for example, by the EUNIS habitat classification, which explicitly links meso-scale habitat units to European Vegetation Survey alliance units (Rodwell et al. 2002).

Our concept of terrestrial ecological systems includes temporal and geographic scales intermediate between those commonly considered for local stand and landscape-scale analyses, which can range from 50 to 1,000s of years and 10s to 1,000s of hectares (Delcourt and Delcourt 1988). These “meso-scales” are intended to constrain the definition of system types to scales that are of prime interest for conservation and resource managers who are managing landscapes in the context of a region or state. More precise bounds on both temporal and geographic scales take into account specific attributes of the ecological patterns that characterize a given region.

*Temporal Scale:* Within the concept of each classification unit, we clearly acknowledge the dynamic nature of ecosystems over short and long time frames. If we assumed that characteristic environmental settings (e.g., landform, soil type) remain constant over the time period that applies to ecological systems (fifty to several hundred years), we would still encounter considerable variation in vegetation throughout any portion of the system occurrence due to disturbance and successional processes. The temporal scale we have chosen determines the means by which we account for both successional changes and disturbance regimes in each classification unit. Relatively rapid successional changes resulting from disturbances are encompassed within the concept of a given system unit. Therefore, daily tidal fluctuations will be encompassed within a system type. Some of the associations describing one system may represent multiple successional stages. For example, a given floodplain system may include both early successional associations and later mature woodland stages that form dynamic mosaics along a stretch of river. Many vegetation mosaics resulting from annual to decadal changes in coastal shorelines will be encompassed within a system type. Selecting this temporal scale shares some aspects with the “habitat type” approach to

Describe potential vegetation (Daubenmire 1952, Pfister and Arno 1980), but differs in that no "climax" vegetation is implied, and all "seral" components are explicitly included in the system concept.

*Pattern and Geographic Scale:* Spatial patterns that we observe at "intermediate" scales can often be explained by landscape attributes that control the location and dynamics of moisture, nutrients, and disturbance events. An example can be taken from floodplains. Rivers provide moisture, nutrients, and scouring soil disturbance that regulate the regeneration of some plant species. In these settings we find a number of associations co-occurring due to controlling factors in the environment. We see mosaics of associations from different alliances and formations, such as woodlands, shrublands, and herbaceous meadows, occurring in a complex mosaic along a riparian corridor. Some individual associations may be found in wetland environments apart from riparian areas. But we can often predict that along riparian corridors within a given elevation zone, and along a given river size and gradient, we should encounter a limited suite of associations. It is these "meso" spatial scales that we address using ecological systems.

## Diagnostic Classifiers

As the definition for ecological systems indicates, this is a multi-factor approach to ecological classification. Multiple environmental factors—or *diagnostic classifiers*—are evaluated and combined in different ways to explain the spatial co-occurrence of NVC associations (Box 1). Diagnostic classifiers include several factors representing bioclimate, biogeographic history, physiography, landform, physical and chemical substrates, dynamic processes, landscape juxtaposition, and vegetation structure and composition. Diagnostic classifiers are used here in the sense of Di Gregorio and Jansen (2000); that is, the structure of the ecological systems classification is more "modular" in that it aggregates diagnostic classifiers in multiple, varying combinations, without a specific hierarchy. The focus is on a single set of ecological system types. This is in contrast to, for example, the framework and approach of the US-NVC. The nested US-NVC hierarchy groups associations into alliances based on common dominant or diagnostic species in the upper most canopy. This provides more of a taxonomic aggregation with no presumption that associations co-occur in a given landscape. The ecological system unit links US-NVC associations using multiple factors that explain why they tend to be found together in a given landscape. Therefore, ecological systems tend to be better "grounded" as ecological units than most US-NVC alliances and are more readily identified, mapped, and understood as practical ecological classification units.

**Box 1**
**Diagnostic Classifiers**
*(Categories and Examples)*

**Ecological Divisions**
- Continental Bioclimate and Phytogeography

**Bioclimatic Variables**
- Regional Bioclimate

**Environment**
- Landscape Position, Hydrogeomorphology
- Soil Characteristics, Specialized Substrate

**Ecological Dynamics**
- Hydrologic Regime
- Fire Regime

**Landscape Juxtaposition**
- Upland-Wetland Mosaics

**Vegetation**
- Vertical Structure and Patch Type
- Composition of component associations
- Abundance of component association patches

*Biogeographic and Bioclimatic Classifiers:* Ecological Divisions are sub-continental landscapes reflecting both climate and biogeographic history, modified from Bailey (1995 and 1998) at the Division scale (Figure A1-1). Continent-scaled climatic variation, reflecting variable humidity and seasonality (e.g., Mediterranean vs. dry continental vs. humid oceanic) are reflected in these units, as are broad patterns in phytogeography (e.g., Takhtajan 1986). The Division lines were modified by using ecoregions established by The Nature Conservancy (Groves et al. 2002) and World Wildlife Fund (Olson et al. 2001) throughout the Western Hemisphere. These modified divisional units share much with hydrologic landscape units that have been drafted by USGS for the coterminous United States. They aid the development of system units because regional patterns of climate, physiography, disturbance regimes, and biogeographic history are well described by each

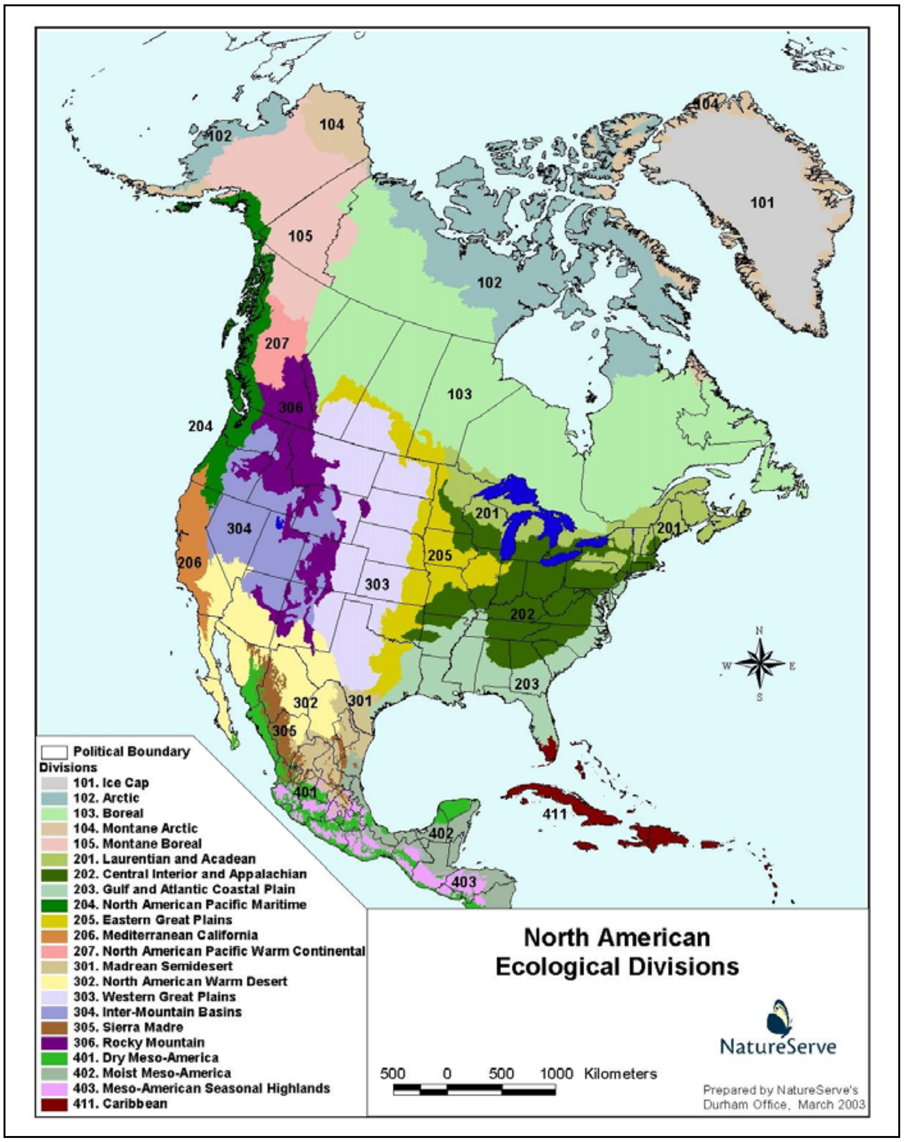


**Figure A1-1. Ecological Divisions of North America used in organization and nomenclature of NatureServe Ecological Systems.**

division.  These divisions then, provide a starting point for thinking about the scale and ecological characteristics of each ecological system.  Examples of these Divisions include the Inter- Mountain Basins, the North American Warm Desert, the Western Great Plains, the Eastern Great Plains, the Laurentian and Acadian region, the Rocky Mountains, and the Atlantic and Gulf Coastal Plain.  Subregional bioclimatic factors are also useful for classification purposes, especially where relatively abrupt elevation-based gradients exist, or where maritime climate has a strong influence on vegetation.  We integrated global bioclimatic categories of Rivas-Martinez (1997) to characterize subregional climatic classifiers.  These include relative temperature, moisture, and seasonality.  They may be applied globally, so they aid in describing life zone concepts (e.g., 'maritime,' 'lowland,' 'montane,' 'subalpine,' 'alpine') in appropriate context from arctic through tropical latitudes.

Biogeography and bioclimate are also utilized in our standard nomenclature for terrestrial ecological system units.  Along with reference to vegetation structure, composition, and local environment, a "Gulf and Atlantic Coastal Plain" ecological system type is entirely or predominantly found (>80% of its total range) within the Gulf and Atlantic Coastal Plain Division.  A "West Gulf Coastal Plain" ecological system type is limited in distribution to southern portions of the broader Gulf and Atlantic Coastal Plain Division.  In a few instances, ecological systems remain very similar across two or more Ecological Divisions.  In these instances, the Domain scale of Bailey (1998) was used to name and characterize the distribution of types; e.g. the "North American Arid West Emergent Marsh" spans the North American Dry Domain.

*Environment*: Within the context of biogeographic and bioclimatic factors, ecological composition, structure and function in upland and wetland systems is strongly influenced by factors determined by local physiography, landform, and surface substrate.  Some environmental variables are described through existing, standard classifications and serve as excellent diagnostic classifiers for ecological systems.  For example, soil moisture characteristics have been well described by the Natural Resource Conservation Service.  Practical hydrogeomorphic classes are established for describing all wetland circumstances (Brinson 1993).  Other factors such as landforms, specialized soil chemistry may be defined in standard ways to allow for their consistent application as diagnostic classifiers.

*Ecological Dynamics:*  Many dynamic processes are sufficiently understood to serve as diagnostic classifiers in ecosystem classification.  In many instances, a characteristic disturbance regime may provide the single driving factor that distinguishes system types.  For example, composition and structure of many similar woodland and forest systems are distinguishable based on the frequency, intensity, periodicity, and patch characteristics of wildfire (Barnes et al. 1998).  Many wetland systems are distinguishable based on the hydroperiod, as well as water flow rate, and direction (Brinson 1993; Cowardin 1979).  When characterized in standard form (e.g. Frost 1998), these and other dynamic processes can be used in a multi-factor classification.

*Landscape Juxtaposition:*  Local-scale climatic regime, physiography, substrate, and dynamic processes can often result in recurring mosaics.  For example, large rivers often support recurring patterns of levee, floodplain, and back swamps, all resulting from seasonal hydrodynamics that continually scour and deposit sediment. Many depressional wetlands or lakeshore have predictable vegetation zonation driven by water level fluctuation.  The recurrent juxtaposition of recognizable vegetation communities provides a useful and important criterion for multi-factor classification.

*Vegetation Structure, Composition, and Abundance*:  As is well recognized in vegetation classification, both the physiognomy and composition of vegetation suggests much about ecosystem composition, structure, and function.  However, the relative significance of vegetation physiognomy may vary among different ecosystems, especially at local scales.  For example, many upland systems support vegetation of distinct physiognomy in response to fire frequency and soil moisture regimes.  In general, physiognomic distinctions such as "forest and woodland," "shrubland" "savanna," "shrub steppe," "grassland, "and "sparsely vegetated" are useful distinctions in upland environments.  On the other hand, needleleaf or broadleaf tree species that are either evergreen or deciduous may co-occur in various combinations due more to variable responses to natural disturbance regimes or human activities than to current environmental conditions. Many wetland systems could support herbaceous vegetation, shrubland, and forest structures in the same location, again, based on the particular strategies of the species involved and local site history.

Therefore, while recognizable differences in vegetation physiognomy may initially suggest distinctions among ecosystem types, knowledge of vegetation composition should be relied upon more heavily to indicate significant distinctions. As in vegetation classification, we recognize beta diversity, or the turnover of species composition and abundance through space, as a primary means of differentiating ecosystem types. The task of classification is to recognize where that turnover is relatively abrupt, and to explain why that abrupt change occurs on the ground.

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