USDA
United States Department of Agriculture

Classification and Description of World Formation Types

Don Faber-Langendoen, Todd Keeler-Wolf, Del Meidinger, Carmen Josse, Alan Weakley, David Tart, Gonzalo Navarro, Bruce Hoagland, Serguei Ponomarenko, Gene Fults, Eileen Helmer





Forest Service

Rocky Mountain Research Station

General Technical Report RMRS-GTR-346

August 2016

Faber-Langendoen, D.; Keeler, T.; Meidinger, D.; Josse, C.; Weakley, A.; Tart, D.; Navarro, G.; Hoagland, B.; Ponomarenko, S.; Fults, G.; Helmer, E. 2016. **Classification and description of world formation types**. Gen. Tech. Rep. RMRS-GTR-346. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 222 p.

Abstract

An ecological vegetation classification approach has been developed in which a combination of vegetation attributes (physiognomy, structure, and floristics) and their response to ecological and biogeographic factors are used as the basis for classifying vegetation types. This approach can help support international, national, and subnational classification efforts. The classification structure was largely developed by the Hierarchy Revisions Working Group (HRWG), which contained members from across the Americas. The HRWG was authorized by the U.S. Federal Geographic Data Committee (FGDC) to develop a revised global vegetation classification to replace the earlier versions of the structure that guided the U.S. National Vegetation Classification and International Vegetation Classification, which formerly relied on the UNESCO (1973) global classification (see FGDC 1997; Grossman and others 1998). This document summarizes the development of the upper formation levels. We first describe the history of the Hierarchy Revisions Working Group and discuss the three main parameters that guide the classification—it focuses on vegetated parts of the globe, on existing vegetation, and includes (but distinguishes) both cultural and natural vegetation for which parallel hierarchies are provided. Part I of the report provides an introduction to the overall classification, focusing on the upper formation levels. Part II provides a description for each type, following a standardized template format. These descriptions are a first preliminary effort at global descriptions for formation types, and are provided to give some guidance to our concepts.

Cover photos of Cool Temperate Forests from around the world. Clockwise from top left:

1. Western Eurasian Forest & Woodland division: European beech (*Fagus sylvatica*) forest in Czech Republic (by Scott Franklin)

2. Eastern North American Forest & Woodland division: Eastern Hemlock-Sugar Maple (*Tsuga canadensis-Acer saccharum*) forest in central Wisconsin, United States (by Don Faber-Langendoen).

3. Eastern Asian Forest & Woodland division: Oak-pine / bamboo forest in Foping National Nature Reserve, Shaanxi Province, China (by Scott Franklin)

4. Valdivian Forest division: Southern beech (*Nothofagus* spp.) forest in Altos de Lircay National Reserve, Chile (by Bruce Young)

5. Southeast Australian Cool Temperate Forest & Woodland division: Australian Alps - mainly Mountain Ash (*Eucalyptus regnans*) (by Andy Gillison)

United States Department of Agriculture

Classification and Description of World Formation Types

Don Faber-Langendoen, Todd Keeler-Wolf, Del Meidinger, Carmen Josse, Alan Weakley, David Tart, Gonzalo Navarro, Bruce Hoagland, Serguei Ponomarenko, Gene Fults, Eileen Helmer

Hierarchy Revisions Working Group

FGDC Vegetation Subcommittee

Forest Service | Rocky Mountain Research Station | General Technical Report RMRS-GTR-346 | August 2016

Authors

(in order of authorship)

Don Faber-Langendoen: NatureServe, Conservation Science Division, Arlington, VA

Todd Keeler-Wolf: Biogeographic Data Branch, California Department of Fish and Game, Sacramento, CA

Del Meidinger: Meidinger Ecological Consultants Ltd., Victoria BC

Carmen Josse: NatureServe, Conservation Science Division, Arlington, VA

Alan Weakley: North Carolina Botanic Garden, University of North Carolina at Chapel Hill, Chapel Hill, NC

David Tart: USDA Forest Service - Intermountain Region, Natural Resources, Ogden, UT

Gonzalo Navarro: Universidad Católica Boliviana “San Pablo, Cochabamba, Bolivia

Bruce Hoagland: Oklahoma Biological Survey and Department of Geography, The University of Oklahoma, Norman, OK

Serguei Ponomarenko: Ecological Integrity Branch, Parks Canada, Gatineau, Québec

Gene Fults: Natural Resources Conservation Service - West National Technology Support Center, Portland, OR

Eileen Helmer: USDA Forest Service - International Institute of Tropical Forestry, Fort Collins, CO

Acknowledgments

The work produced here was supported by the U.S. National Vegetation Classification partnership between U.S. Federal agencies, the Ecological Society of America, and NatureServe staff, working through the Federal Geographic Data Committee (FGDC) Vegetation Subcommittee. FGDC sponsored the mandate of the Hierarchy Revisions Working Group, which included international expertise into the process. For that reason, this product represents a collaboration of national and international vegetation ecologists.

We thank Ralph Crawford, chair of the FGDC vegetation subcommittee. We gratefully acknowledge the support of the U.S. Federal agencies that helped fund the work of the Hierarchy Revisions Working Group from 2003 to 2012. We appreciate their patience with our slow progress on this effort. Most recently, the U.S. Geological Survey, and in particular Alexa McKerrow, has supported the development of the formation descriptions that are provided in this document.

We appreciate the support of the Ecological Society of America Vegetation Classification Panel for their peer review of this document. In particular, we thank the Panel's chair, Scott Franklin, for facilitating review among the panel and internationally. Through his efforts, we benefited from international reviewers, including Ken Baldwin, John Benson, Sara del Río González, Jesus Izco, David Keith, Ángel Penas Merino, Salvador Rivas-Martínez, Michael Rutherford, and Daniel Sánchez-Mata, and we thank them for their input. A special thanks to Ángel Penas Merino for creating the North American and European macrobioclimate maps for this report.

Over the years, various members of the HRWG have participated for a period of time. We thank Sherm Karl, Otto Huber, Jean-Pierre Saucier, and Andy Gray for their input at critical stages early on in the development of the formations.

We thank Mary Russo and Kristin Snow, of NatureServe, for maintaining and editing the classification database and producing the Level 1–Level 3 description documents for Part II.

Executive Summary

An ecological vegetation (EcoVeg) classification approach has been developed in which a combination of vegetation attributes (physiognomy, structure, and floristics) and their response to ecological and biogeographic factors are used as the basis for classifying vegetation types (Faber-Langendoen and others 2014). This approach can help support international, national, and subnational classification efforts. Support for many aspects of the development of classification was provided by the U.S. National Vegetation Classification (USNVC) partnership, in conjunction with development of the International Vegetation Classification (IVC) (FGDC 2008; Faber-Langendoen and others 2009; Jennings and others 2009). The classification structure was largely developed by the Hierarchy Revisions Working Group (HRWG), which contained members from across the Americas. The group was authorized by the U.S. Federal Geographic Data Committee (FGDC) Vegetation Subcommittee (chaired by the U.S. Forest Service), to develop a revised global vegetation classification to replace the earlier versions of the structure that guided the USNVC and IVC, which relied on the UNESCO (1973) global classification (see FGDC 1997; Grossman and others 1998). This document summarizes the development of the upper formation levels.

We first describe the history of the Hierarchy Revisions Working Group and discuss the three main parameters that guide the classification—it focuses on vegetated parts of the globe, on existing vegetation, and includes (but distinguishes) both cultural and natural vegetation for which parallel hierarchies are provided.

For natural vegetation, we define three main physiognomic levels: Formation Class, Formation Subclass, and Formation; each of the types for all three levels is also described. For cultural vegetation, we define and describe four main physiognomic levels: Cultural Class, Cultural Subclass, Cultural Formation, and Cultural Subformation. We use a fourth physiognomic level for cultural vegetation because the floristic/biogeographic patterns used for natural vegetation at the fourth level are not nearly as relevant for cultural vegetation. We provide guidance for developing formation type description and nomenclature.

The upper levels were not developed in a strictly top down manner. Rather, members of the HRWG had access to draft mid and lower level units (from Division to Association) for the United States and parts of Canada and Latin America. A comprehensive master spreadsheet of these draft units was organized under the upper levels and was used to critique the overall "naturalness" of the formation units. The HRWG reevaluated formation concepts where formations introduced undesirable splits in lower units that were otherwise ecologically and floristically similar. Our goal was to make splits between upper level types that had good ecological and vegetation support for them. Still, inevitably, given the multi-dimensional and continuous gradients affecting vegetation, some criteria for upper levels require splitting otherwise closely related floristic and physiognomic types (e.g., open woodland from grassland, floodplain forest from upland forest).

Part I of the report provides an introduction to the overall classification, focusing on the upper formation levels. Appendices provide important information on members of the working group, a draft set of formation types at all three levels, growth forms used to describe the types, and comparisons with other formation level classifications. Appendix I provides a key to Level 1. Appendix J introduces examples of the Division level, the level immediately below formation. A comprehensive set of Divisions for all formations is a key next step in the process of establishing an ecological vegetation classification framework.

Part II provides a description for each type, following a standardized template format. The HRWG had limited time to develop descriptions, and we focused more on developing consistent, meaningful concepts than extensive descriptive text. Thus, these descriptions are a first preliminary effort at global descriptions for formation types, and are provided to give some guidance to our concepts. Undoubtedly, even these preliminary descriptions are biased by our western hemisphere perspective. We look forward to engaging with a broader set of ecologists around the globe to continue improving both the concepts and the descriptions. We hope such collaboration can develop, in part, by identifying vegetation types at the Division level around the globe.

Contents

Part I: Development of the U.S. National Vegetation Classification Hierarchy

Introduction

There is currently no fully suitable classification framework by which vegetation ecologists can organize, define, and describe global vegetation patterns at multiple scales, from broad physiognomic types to narrowly defined floristic types. Some classification publications provide little more than a name. Others provide very expansive descriptions but with only some or little consistency to the classification, and others focus solely on either structural or floristic patterns. What is needed is a comprehensive, global vegetation classification approach that is multi-scalar, from broad global types to local fine scale types. It should be committed to a rigorous plot-based approach while building on the accumulated work of vegetation ecologists over the past century, open to ongoing peer review, and able to maintain an authoritative list of types at all times that can be used for description, inventory, monitoring, and mapping.

Here, we briefly introduce an ecological vegetation (EcoVeg) classification approach that addresses these needs and then focus on the development and rationale for the upper formation levels. These formations, both natural and cultural, provide a basic synopsis of the world's vegetation that is structured by specific criteria with sufficient detail to encourage consistent application anywhere in the world and within a multi-scale hierarchical structure. Details of the scientific basis for the classification approach are provided in Jennings and others (2009) and Faber-Langendoen and others (2014) who build on the integrated "physiognomic-floristic-ecologic," or EcoVeg, approach to vegetation classification (Bohn and others 2000-2003; Brown and others 1998; Davies and others 2004; Devilliers and others 1991, 1996; Rodwell and others 2002; Rübel 1930–1931, in Shimwell 1971; Whittaker 1962). Appendices to this report contain specific descriptions to each formation and a key to the uppermost formation class level, along with comparisons to other global formation level classifications. The classification has been developed to support the U.S. National Vegetation Classification (FGDC 2008), other partner classifications, such as the Canadian and Bolivian NVC, and constitutes a revision of the International Vegetation Classification (Grossman and others 1998) that was based on UNESCO (1973).

Background

Hierarchy Revisions Working Group

The U.S. National Vegetation Classification (USNVC) emerged through a partnership between Federal agencies and nongovernmental organizations—NatureServe and the Ecological Society of America's Vegetation Classification Panel (hereafter Panel)—through the auspices of the Federal Geographic Data Committee Vegetation Subcommittee (FGDC 1997), chaired by the U.S. Forest Service. The USNVC originally adopted the international structure of UNESCO (1973 see also Appendix B in Mueller-Dombois and Ellenberg 1974) for its classification. At the same time NatureServe supported applications of the UNESCO-based structure in other countries through the International Vegetation Classification (IVC) (Grossman and others 1998). Thus, when the USNVC partners agreed in 2003 to undertake a revision to the USNVC, an international approach was adopted, reflecting the goals to incorporate global classification concepts and to avoid an artificial national perspective on units. Our goal was to concentrate on the natural structuring of vegetation world-wide and to emphasize the physiognomic-structural, floristic and ecological components of vegetation, without relying on a particular emphasis on any single predominant criterion such as height, woodiness, cover, environmental schema, or other human uses. To this end, the partners agreed to form a Hierarchy Revisions Working Group (HRWG) sponsored by FGDC. The work of the HRWG progressed in two phases, the first phase from 2003–2008, and the second phase from 2010–2013.

Phase I:

The Hierarchy Revisions Working Group (HRWG) was formed in November of 2003, co-chaired by representatives of the U.S. Forest Service (USFS) and NatureServe. Members were drawn from State and Federal agencies and organizations in the United States, Canada, and Latin America. All were chosen based on either their familiarity with the USNVC, IVC and related classifications or for their expertise in vegetation classification. Members were also encouraged to have their own "teams" with which to consult, including the U.S. Forest Service Vegetation Technical Guide team that developed an existing vegetation classification and mapping manual (Brewer and others 2005; Tart and others 2005a,b), NatureServe staff who developed meso-scale classification units called ''terrestrial ecological systems'' (Comer and others 2003; Comer and Schulz 2007; Josse and others 2003), and California vegetation ecologists who tested the hierarchy above the alliance level on California's vegetation (see Sawyer and others 2009, Appendix 3). The HRWG interacted regularly with the ESA Panel, Federal agencies, and NatureServe staff.

The HRWG process was somewhat formal, consisting of more or less bimonthly phone calls between November 2003 and November 2007, and three face-to-face meetings (May 3–6, 2004 in Denver, Colorado; May 22–25, 2005 in Washington, DC; March 8–10, 2007 in Mojave, California). The result was a suggested eight-level hierarchy to replace the seven-level hierarchy then in use (FGDC 1997). The lower two floristic levels, alliance and association, were retained as is, and the top five formation levels were compressed into three to make way for three new physiognomic-floristic mid-levels. In 2006, FGDC began the formal process for the USNVC revision, incorporating both the HRWG suggestions on the full hierarchy and the ESA Panel's work on standards for the lower floristic levels. The HRWG continued to advise the USNVC partners through 2007 and 2008, leading to a formal revised FGDC Standard (2008). This Standard established the hierarchical framework of the USNVC and the processes for establishing and revising USNVC types. At that time, a formal report describing the EcoVeg approach that the USNVC is based on was drafted by the HRWG (Faber-Langendoen and others 2007), and later published (Faber-Langendoen and others 2012). Lower floristic level guidelines were published by Jennings and others (2009).

The revised standard was a substantial overhaul of the 1997 standard and the classification, as summarized by FGDC (2008):

a. *uses vegetation criteria to define all types (de-emphasizing abiotic criteria, such as hydrologic regimes in wetland types),*

b. *provides a clear distinction between natural (including semi-natural) vegetation and cultural vegetation wherever these can be observed from broad growth form patterns (rather than combining natural and cultural vegetation initially and separating them at lower levels),*
c. *defines, for natural vegetation, the upper levels of the hierarchy based on broad growth form patterns that reflect ecological relationships (rather than detailed structural criteria, which are more effectively used in combination with floristic criteria in lower levels of the hierarchy),*
d. *provides a new set of mid levels for natural vegetation units that bridge the large conceptual gap between alliance and formation,*
e. *integrates the physiognomic and floristic hierarchy levels based on ecologic vegetation patterns, rather than developing the physiognomic and floristic levels independently and then forcing them into a hierarchy,*
f. *provides detailed standards for plot data collection, type description and classification, data management and peer review of natural vegetation,*
g. *provides a dynamic content standard for the USNVC that allows the FGDC partner agencies and organizations to revise the classification and its component vegetation types through a peer review process, and*
h. *provides, for cultural vegetation, an independent set of levels that addresses the particular needs of cultural vegetation*.

The structure of the revised hierarchy is a substantial revision of the 1997 hierarchy, which relied heavily on the UNESCO (1973) physiognomic hierarchy for all levels above the alliance. The newly adopted national vegetation hierarchy consists of eight levels, organized into three upper levels, three middle levels, and two lower levels (Table 1). See also Table 3, which provides the details on both the natural and cultural 2008 hierarchies.

Table 1—Comparison of original 1997 USNVC Vegetation Hierarchy (adapted from UNESCO 1973) and the 2008 revision.

1997 FGDC Hierarchy	2008 Revised Hierarchy for Natural Vegetation	
Division — Vegetation vs. Non- vegetation	**Upper Levels**	
Order — Tree, Shrub, Herb, Nonvascular		
Level 1 — Formation Class		Level 1 — Formation Class
Level 2 — Formation Subclass		
Level 3 — Formation Group		Level 2 — Formation Subclass
Level 4 — Formation Subgroup — Natural/Cultural		
Level 5 — Formation		Level 3 — Formation
	Middle Levels	Level 4 — Division
		Level 5 — Macrogroup
		Level 6 — Group
Level 6 — Alliance	**Lower Levels**	Level 7 — Alliance
Level 7 — Association		Level 8 — Association

Phase II:

With the completion of the FGDC standard, USNVC partners began implementing revisions to the classification system, but two important issues remained to be resolved. First, the 2008 FGDC standard called for a screening/peer review process to induct proposed types into the revised USNVC. Thus, in June of 2010, FGDC requested the HRWG to take on the task of reviewing, revising, and describing the pilot upper level units (L1 – L3) provided in the FGDC 2008 standard (see Appendix G in FGDC 2008). Fortunately, most of the members of the original HRWG stayed with the project and new members were added (Appendix A).

During this phase of development, the HRWG was able to draw on extensive testing of the upper level units, which were being used as mid and lower level units in the USNVC (usnvc.org) and in Canada (cnvc-cnvc.ca). NatureServe and partners also began applying the same approach to revisions to the International Vegetation Classification (IVC) through projects in South America (Josse 2011; Navarro 2011) and Africa. Testing of the hierarchy in Africa led to one major proposed change: move all wetland formations under an expanded Class V – Hydromorphic and Hydrophytic Vegetation. This decision was only partly implemented (see below). A draft of world grassland types from Formation Class to Division was also published (Dixon and others 2014; Faber-Langendoen and Josse 2010).

The HRWG completed the initial review of the units in October of 2010, having found that information from proposed new mid-levels provided good support to the upper levels (see Division examples in Appendix J). The suggested revisions to move all wetlands under a single large class in Class V was not adopted. Instead, the decision was to move all shrub and herb wetlands under a single subclass, while keeping forested wetlands and aquatic vegetation wetlands in other classes (see "Wetlands" section below). The HRWG made other modest changes to the 2008 version (e.g., adding a Tropical Thorn Woodland formation, removing cryomorphic and xeromorphic rock vegetation formations from the "lithomorphic" or open cryptogam class and placing the vegetation within those formations within existing divisions of hydryomorphic and xeromorphic vegetation, modifying various formation names). After further consultation with the Ecological Society of America Vegetation Classification Panel (hereafter "ESA Panel"), the HRWG submitted a request to FGDC that the USNVC partners adopt the 2008 pilot units. FGDC approved the request, based on the process used to reach those decisions. The set of units is provided in Appendix B.

The HRWG then began writing detailed descriptions of each of the L1 – L3 units, following the standard description template. In addition, a key to Level 1 was produced (Appendix I).

Context for the Hierarchy

Several primary categories are helpful in describing the scope of the classification and placing it within a broader land cover context: vegetated – non-vegetated, existing vegetation, and natural – cultural vegetation.

Vegetated – Non-Vegetated:

The classification includes all vegetated areas with 1 percent or more of their surface area covered by live vegetation. This includes vegetation found on both upland environments and in wetlands (rooted emergent and floating vegetation). The classification excludes non-vegetated (i.e. less than 1 percent vegetation cover) natural lands (e.g., rock, glaciers, some deserts) and waters (e.g., lakes and rivers) and non-vegetated cultural lands (e.g., roads, buildings, mines) and waters (e.g., reservoirs, canals), though it can easily be linked to land cover classifications that do include these lands to provide a full terrestrial coverage (see "Natural and Cultural Vegetation" section below).

Existing Vegetation:

This classification includes only existing vegetation types, as described by FGDC (2008): "Existing vegetation is the plant cover, or floristic composition and vegetation structure, documented to occur at a specific location and time, preferably at the optimal time during the growing season." (see also Jennings and others 2009; Tart and others 2005a). Abiotic factors, geographic and successional relationships are used to help interpret the types. Existing vegetation can provide the basis for describing potential vegetation types.

Natural and Cultural Vegetation:

This classification provides separate categories for natural and cultural vegetation, a distinction that is consistent with other vegetation and land cover classifications (e.g., Anderson and others 1976; Di Gregorio2005; Küchler 1969). Although cultural and natural vegetation are distinguished in the classification, both are subsequently classified in a hierarchical framework that emphasizes primarily floristics at the lower levels, both physiognomic and floristics at mid levels, and primarily physiognomy at upper levels.

Natural (including semi-natural) vegetation is defined as vegetation where ecological processes primarily determine species composition and stand structure; that is, the vegetation is comprised of a set of plant species growing spontaneously (i.e., with little human influence) and is shaped by both abiotic and biotic processes (Küchler 1969; Westhoff and van der Maarel 1973). **Cultural vegetation** is defined as vegetation with a distinctive structure, composition, and development determined by regular human activity (cultural vegetation *sensu stricto* of Küchler 1969). The distinctive physiognomy, floristics, and dependence on human activity for its persistence set cultural vegetation apart from natural and semi-natural vegetation. These distinctive attributes typically include one or more of the following:

- Dominant herbaceous vegetation is regularly spaced and/or growing in rows, often in areas with substantial cover of bare soil for significant periods of the year, usually determined by tillage or chemical treatment.
- Dominant vegetation has highly manipulated growth forms. Structure is rarely the result of natural plant development, but is usually determined by mechanical pruning, mowing, clipping, etc.

- Dominant vegetation is comprised of species not native to the site or area that have been intentionally introduced by humans and that would not persist without active management by humans.

Recognition of cultural or “anthromorphic” vegetation classes parallels recent calls for recognition of an “Anthrosol” order for soils because of intrinsic properties of the soil caused by farming, fertilizing, irrigation, and tillage (Bryant and Galbraith 2003; Gong and others 2003).

Summary

We identify these fundamental aspects of vegetation using two categorical levels (Table 2a). These categories provide the organizing framework for the classification, beginning with Level 1. The framework allows the vegetation-ecologic approach to be easily extended to a full terrestrial approach by linking these categories to existing land cover classification systems, such as FAO Land Cover Classification System (Di Gregorio 2005) (Table 2b). Further examples of this approach are provided for the USNVC by FGDC (2008, Appendix B - Relationships to the U.S. National Land Cover Database (NLCD) (USGS 2001). See also Appendix B.

Table 2a—Conceptual categories and level one of the hierarchy (from FGDC 2008, Table 2.1).

Category 1	Category 2	Level 1
Vegetated	Semi-natural vegetation	Forest & Woodland (Mesomorphic Tree Vegetation)
		Shrub & Herb Vegetation (Mesomorphic Shrub & Herb Vegetation)
		Desert & Semi-Desert (Xeromorphic Woodland, Scrub & Herb Vegetation)
		Polar & High Montane Scrub, Grassland & Barrens (Cryomorphic Vegetation)
		Aquatic Vegetation (Hydromorphic Vegetation)
		Open Rock Vegetation (Cryptogam - Open Mesomorphic Vegetation)
	Cultural vegetation	Agricultural & Developed Vegetation (Anthro-morphic Vegetation)
Nonvegetated	Not included (see Table 2b).	

Table 2b—Optional non-vegetated categories from land cover classifications (FAO Land Cover Classification System). See also Appendix B.

Category 1	Category 2	Level 1 FAO (1996)
Non-vegetated	Natural	Terrestrial: Bare Areas
		Aquatic: Natural Waterbodies, Snow & Ice
	Cultural	Terrestrial: Artificial Surfaces & Associated Areas
		Aquatic: Artificial Surfaces & Associated Areas

The Hierarchy

The eight levels of the hierarchy for both cultural and natural vegetation are provided in Table 3. The EcoVeg approach treats natural vegetation distinct from cultural vegetation; thus, each has similar but differently defined hierarchical levels. This allows for a dynamic portrait of all existing vegetation in a way that reflects ongoing changes driven by land use, climate change, invasive species and natural processes. Tables 4a and 4b provide examples of natural (4a) and cultural (4b) types across all levels of the two hierarchies.

Development of the Upper Levels

The upper levels of the classification were based on the formation concept, which is prominent in the history of vegetation classification (Appendix F). The definition provided by Whittaker (1962 pg. 150) is typical: "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." The UNESCO (1973) definition guided much of the earlier work on the EcoVeg approach. The formation is "basically physiognomic-structural in character with supplementary ecological information integrated into its various categories and applicable to natural and semi-natural vegetation." Physiognomy can be defined as "the visible structure or outward appearance of a plant community as expressed by the dominant growth forms, such as their leaf appearance or deciduousness"(Fosberg 1961). Structure is the horizontal and vertical spatial pattern of growth forms in a plant community, especially with regard to their height, abundance, coverage or biomass within the individual layers (Gabriel and Talbot 1984).

Table 3—Hierarchy levels for natural and cultural vegetation.

Natural Hierarchy Level	Cultural Hierarchy Level
L1 – Formation Class	L1 – Cultural Class
L2 – Formation Subclass	L2 – Cultural Subclass
L3 – Formation	L3 – Cultural Formation
L4 – Division	L4 – Cultural Subformation
L5 – Macrogroup	L5 – Cultural Group
L6 – Group	L6 – Cultural Subgroup
L7 – Alliance	L7 – Cultural Type
L8 – Association	L8 – Cultural Subtype

Table 4a—Hierarchical classification for natural vegetation with examples.

Natural Vegetation	Example
Upper Levels	
1 – Formation Class	**Scientific Name:** Mesomorphic Shrub & Herb Vegetation **Colloquial Name:** Shrub & Herb Vegetation
2 – Formation Subclass	**Scientific Name:** Temperate & Boreal Shrub & Herb Vegetation **Colloquial Name:** Temperate & Boreal Grassland & Shrubland
3 – Formation	**Scientific Name:** Temperate Shrub & Herb Vegetation **Colloquial Name:** Temperate Grassland & Shrubland
Mid Levels	
4 – Division	**Scientific Name:** *Andropogon – Stipa – Bouteloua* Grassland & Shrubland Division **Colloquial Name:** Central North American Grassland & Shrubland
5 – Macrogroup	**Scientific Name:** *Andropogon gerardii – Schizachyrium scoparium – Sorghastrum nutans* Grassland & Shrubland Macrogroup **Colloquial Name:** Central Lowlands Tallgrass Prairie
6 – Group	**Scientific Name:** *Andropogon gerardii – Sporobolus heterolepis* Grassland Group **Colloquial Name:** Northern Tallgrass Prairie
Lower Levels	
7 – Alliance	**Scientific Name:** *Andropogon gerardii – Sorghastrum nutans – Sporobolus heterolepis* Grassland Alliance **Colloquial Name:** Northern Mesic Tallgrass Prairie
8 – Association	**Scientific Name:** *Andropogon gerardii – Hesperostipa spartea – Sporobolus heterolepis Grassland* **Colloquial Name:** Northern Bluestem Mesic Tallgrass Prairie

Table 4b—Hierarchical classification for cultural vegetation with examples.

Cultural Vegetation	Example
Upper Levels	
1 – Cultural Class	Anthromorphic Vegetation
2 – Cultural Subclass	Herbaceous Agricultural Vegetation
3 – Cultural Formation	Row & Close Grain Crop
4 – Cultural Subformation	Graminoid Row Crop
Mid Levels	
5 – Cultural Group [optional]	*Tropical & Temperate Corn Crop*
6 – Cultural Subgroup	Temperate Corn Crop
Lower Levels	
7 – Cultural Type	Maize Corn
8 – Cultural Subtype [optional]	*Corn for silage*

We define growth form[1] as the shape or appearance of a plant reflecting growing conditions and genetics (see Appendix C for a glossary of terms). Growth form is usually consistent within a species, but may vary under extremes of environment (Mueller-Dombois and Ellenberg 1974). A list of growth forms is provided in Appendix D as a first approximation for defining upper level types.[2] This list is structured into two levels: general growth forms and specific growth forms. These lists were adapted from Whittaker (1975, pg. 359) and Box (1981), and may reflect a western hemisphere perspective, but the intent is to provide a method for characterizing the growth form composition of all formations. For comparison, an extended list of "eco-physiognomic" growth form types developed by Box and Fujiwara (2005) is presented in Appendix E. This extended list could provide a stronger basis for the approach proposed here but needs further review. Introducing a combination of morphological, anatomical and physiological adaptations could allow for finer classification distinctions. Instead, however, we proposed adding diagnostic species at the mid-levels of the classification, in addition to growth form descriptors.

By characterizing the growth forms as part of a vegetation plot, it becomes possible to empirically describe the growth form components of a vegetation type and relate them to ecological factors. Thus, combinations of growth forms can define xeromorphic (desert) vegetation or hydromorphic (aquatic) vegetation. Some growth forms, however, such as "flowering forb" do not show particularly strong ecological relationships, at least not as currently defined. They may be constant growth forms rather than diagnostic ones.

As with species in lower level units, a growth form is rarely restricted to one upper level formation type. Too often, a single physiognomic criteria has been used alone to define a formation (e.g., defining a formation by 25 to 60 percent tree canopy cover). Although such criteria may be helpful in a diagnostic key or for particular mapping applications, we suggest that in an integrated classification, the use of differential growth forms is more helpful. The same growth forms may appear in multiple units, but it is the relative abundance of that growth form, in combination with ecological processes and consideration of broad floristic-biogeographic patterns at lower levels, that define formation types (Table 5). Thus, tree covered lawns are separated from natural forests because of differences in the combination of shrub, herb and tree growth forms and in ecological processes, though both may have 25 to 60 percent tree canopy. Just as a specified presence and abundance of one or more differential species are primary criteria for defining vegetation types at lower levels, the presence and abundance levels of one or more growth forms are primary criteria for defining vegetation types at upper levels.

---

[1] A similar term, life form, is defined as the ecological strategy that a plant uses to complete its life cycle, e.g., Raunkiaer life forms are defined on the position of the bud or organs from which new shoots or foliage develop after an unfavorable season. Different life forms may not always exhibit clear outward structural differences (e.g., hemicryptophytes and geophytes).

[2] The growth form list in the FGDC standard is published as a "normative list," which may require a formal approval process for amending it. In the mean-time, all additions or changes could be treated as optional.

Table 5—Characters used to distinguish Tropical Lowland Humid Forest from Tropical Montane Humid Forest (after Whitmore 1984, Table 18.1).

	Formation	
Formation Criteria	**Tropical Lowland Humid Forest**	**Tropical Montane Humid Forest**
Canopy height	25-45 m	1.5-33 m
Emergent trees	Characteristic, to 60 (80) m tall	Often to usually absent, to 37 m tall
Pinnate leaves	Frequent	Rare to very rare
Principle leaf size class of woody plants[a]	Mesophyll or Macrophyll (or Megaphyll)	Mesophyll or microphyll
Buttresses	Usually frequent and large	Uncommon, small or absent
Cauliflory	Frequent	Rare to absent
Big woody climbers	Abundant	Usually none
Bole climbers	Often abundant	Very few to to abundant
Vascular epiphytes	Frequent	Frequent to abundant
Nonvascular epiphytes	Occasional	Occasional to abundant

[a] For definition of leaf-sizes see Mueller-Dombois and Ellenberg (1974, page 453).

Finally, growth forms are closely related to plant functional types (PFTs), a grouping of organisms that respond in a similar way to a suite of environmental factors (Gitay and Noble 1997). A comparison of PFTs used for broad scale assessments shows a very close relationship to the growth forms presented here, and leads to aggregations of functional types that are similar to formations (Leemans 1997). This opens up the possibility of modeling responses of formations to disturbances and to climate change (Cramer 1997), as earlier developed by Box (1981) who formulated climatic envelopes for each of his growth form/plant functional types (Appendix E). See also Gillison (2013) for a recent treatment of plant functional types.

The upper levels were not developed in a strictly top down manner. Rather, members of the HRWG had access to draft mid and lower level units (from Division to Association) for the United States and parts of Canada and Latin America. In addition, comparisons were made with other classifications in which physiognomic or formation types were used to organize floristic types, such as the European vegetation types published in Rodwell and others 2002 (see other examples in Appendix F). To test relationships between upper and lower levels, a comprehensive master spreadsheet of draft units was organized under the upper levels and was used to critique the overall “naturalness” of the formation units. The HRWG reevaluated formation concepts where formations introduced undesirable splits in lower units that were otherwise ecologically and floristically similar. Our goal was to make splits between types that had good ecological and vegetation support for them. Still, inevitably, given the multidimensional and continuous gradients affecting vegetation, some criteria for upper levels require splitting otherwise closely related floristic types (e.g., open woodland from grassland, floodplain forest from upland forest).

In summary, the upper levels of the hierarchy are based on dominant and diagnostic growth forms that reflect ecological and anthropogenic drivers at global and continental scales, and their concepts are influenced by consideration of vegetation patterns at lower levels. The comprehensive set of formation types for all 3 levels (L1–L3) are provided in Appendix B.

Ecological Approach to Organizing Formation Class Types:

Formation Class is a vegetation classification unit of high rank (1st level) defined by broad combinations of dominant general growth forms adapted to basic ranges of moisture, temperature, and/or substrate or aquatic conditions (FGDC 2008; cf. Beard 1973; cf. "major physiognomic types" of Whittaker 1975).

A primary concern of the HRWG was to consider the ecological relationships among vegetation types rather than simply growth forms alone. We asked ourselves what fundamental ecological/environmental and anthropogenic processes order global vegetation patterns. Can we identify the characteristics of vegetation that reflect those processes? Our concern is a familiar one to those seeking an ecological basis for developing vegetation classifications. For example, Warming (1909, pg. 143) wrote:

> *"Why not use each growth form [lichen, moss, herb, dwarf-shrub, shrub, tree] as a foundation upon which to build a special class? The following classes could then be distinguished: that of forest formations, of bush-formations of shrub-formations, of dwarf-shrub formations, or perennial-herb formations, of moss-formations, and of alga-formations… From a morphological standpoint this would possess a certain interest, but from a phytogeographical one it must be dismissed, because it would involve the separation of formations that are oecologically closely allied."*

He goes on to state that formations can be based on either a single or compound growth forms, where many growth forms are combined to form a single whole. This approach has been echoed by others over the years (Box and Fujiwara 2005, 2013; Whittaker 1962, 1975) and was adopted by the HRWG. Here we rely strongly on multiple growth forms to define formations types (e.g., including needle-leaved and cold deciduous broad-leaved trees together within a temperate and boreal forest subformation; aseasonal or drought deciduous herbaceous growth forms with evergreen or drought-deciduous shrubs to define topical grassland, savanna and shrubland subformation), wherever these combination of growth forms reflected a more natural vegetation unit with respect to macro-ecological gradients.

Terminology for Formation Names:

Because our growth forms emphasize primarily morphological adaptations we use the term "morphic" to name formation types, as in hydromorphic, mesomorphic, xeromorphic (see also Table 4 in Ellenberg 1988). Other researchers have used terms such as hydrophyte, mesophyte, and xerophytes (e.g., Warming 1909). But these terms are often applied to species, where the combination of morphology, anatomy, physiology, and even life history strategy define the forms. These terms may be better applied in the mid and lower levels of the classification where species are part of the criteria. Compounding the issue in North America is use of the term "hydrophyte" or "helophyte" species that depend, to varying degrees, on wet habitats, irrespective of any obvious morphologic or anatomical adaptations. For example, Tiner (1998) defines hydrophytes as "plants growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content." Hydrophytic vegetation is defined as "the sum total of macrophytic plant life that occurs in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controlling influence on the plant species present" (U.S. Army Corps of Engineers 1987). By contrast, hydromorphic vegetation in our approach is defined by types where rooted and floating aquatic growth forms are dominant (i.e., aquatic vegetation).

Zonal and Azonal Vegetation

Zonal vegetation refers to vegetation that reflects a close relation to the current climatic conditions of a region and that develop, without significant human interference, on soils with non-extreme properties (Mueller-Dombois and Ellenberg 1974). For example, mesic mixed beech-maple forests with *Fagus grandifolia* (American beech) and *Acer saccharum* (sugar maple) in the northeastern United States and southeastern Canada. Azonal vegetation is found on sites subject to "excessive" moisture or drought within that climatic region or strong anthropogenic influence; for example, sedge meadows, forested swamps and rocky woodlands, as well as corn fields and orchards. From the perspective of existing vegetation, we treat zonal and azonal vegetation together as part of extended environmental gradients. Thus, although climate is a strong contributor to global environmental gradients, other factors are also notable, including substrate (rock, water). The combinations of factors are used when assessing the ecological relationships among formations.

Development of Natural Formations

Formation Class

The formation class is the top level at which users enter the classification; thus, a small set of clearly defined types is helpful. The six types are defined by broad combinations of dominant general growth forms associated with basic moisture, temperature, and/or substrate or aquatic conditions, often spanning multiple climatic regions (See Appendix C for a glossary of terms).

In addition, practical applications of the classification suggest that we be as clear as possible on specifying criteria for what constitutes forest and woodlands versus various grassland and shrubland types. Concerns over the precise boundaries of these classes require careful attention and are noted in the description.

1. Forest & Woodland (Mesomorphic Tree Vegetation)

Concept Summary

Type Concept Sentence: Tropical, temperate and boreal forests, woodlands and tree savannas characterized by broadly mesomorphic (including scleromorphic) tree growth forms (including *broad-leaved, needle-leaved, sclerophyllous, palm, bamboo trees*, and *tree ferns*), with at least 10 percent cover, irregular horizontal spacing of vegetation structure, and spanning humid to seasonally dry tropical to boreal and sub-alpine climates and wet to dry substrate conditions. Includes native forests as well as managed and some plantation forests where human management is infrequent.

This class contains all mesomorphic tree-dominated vegetation (including sclero-morphic tree vegetation) down to 10 percent canopy cover. The HRWG followed the FAO recommendations (FAO 2001), which are satisfactory for ecological and floristic application in many treed biomes, in both upland and wetland formations. The appro-priate boundaries for distinguishing forest and woodland vegetation have been defined in many ways. This is further complicated by use of the term savanna (see below). However, it is also common to define Forest & Woodland as having greater than 25 percent tree cover, whereas tree savannas, commonly found in grassland regions of the world, have 10 to 25 percent tree cover (see FGDC 1997; Grossman and others 1998; UNESCO 1973). Savanna definitions vary widely, from 5 to 30 percent to 10 to 50 percent (Curtis 1959), 10 to 60 percent cover, or even higher, thus spanning the same range as used by others for woodlands. Given the commonality of a lower threshold of 10 percent tree cover, we felt it best to initially place tree savannas and woodlands together, at least in the temperate zone, then separate them at lower levels. The HRWG recognizes that this is not entirely satisfactory from some rangeland perspectives.

Further review of tropical grasslands, savannas and shrublands by Dixon and others (2014) suggests some differences in criteria are needed for tropical versus temperate grasslands and tree savannas, namely:

1. a non-wetland formation with at least 10 percent vascular vegetation canopy cover;
2. graminoids have at least 25 percent cover (but if less than 25 percent cover, graminoids exceed that of other herbaceous and shrub cover),
3. broad-leaved herbs (forbs) may have variable levels of cover and dominance,
4. shrubs have less than 25 percent canopy cover, and
5. trees:
    i. in temperate regions, typically have less than 10 percent canopy cover, are less than 5 m tall and are single-layered, or
    ii. in tropical regions, typically have less than 40 percent canopy cover, are less than 8 m tall, and are single layered.

The term “savanna” (let alone its spelling, with or without the “h”) has often engen-dered confusion and debate. In our work, the term is restricted to two broad vegetation patterns. For temperate regions, it is applied to grasslands or shrublands with scattered trees (typically 10 to 30 percent) and primarily limited to fire-maintained upland types, although these vegetation types are also referred to as woodlands, oak openings and oak barrens. Temperate grasslands without scattered trees are referred to either as grasslands or prairies. For tropical vegetation, savanna is applied in the classical sense as interchangeable with tropical grasslands, with or without scattered trees, but some-times separating out the treed tropical savanna distinct from non-treed tropical savanna (tropical grasslands *sensu stricto*).

A final comment on tree growth forms: scleromorphic tree vegetation is treated here as broadly mesomorphic and is the growth form distinctive to the warm-temperate formation (level 3) within this class.

2. Shrub & Herb Vegetation (Mesomorphic Shrub & Herb Vegetation).

Concept Summary

Type Concept Sentence: Grasslands, shrublands, open tree savannas, marshes, bogs and fens dominated by broadly mesomorphic (including scleromorphic) shrub and herb growth forms (including *broad-leaved, needle-leaved*, and *sclerophyllous* shrubs, and *forb* and *graminoid herbs*) with an irregular horizontal canopy structure, typically less than 10 percent mesomorphic tree cover (but see discussion of tropical grasslands and savannas above), tropical to boreal and subalpine climates, and wet to dry substrate conditions.

Shrub and herb vegetation is combined here because in many non-forested vegetation types, these two growth forms may occupy the same upper strata, or in some cases, grasses may even overtop shrubs (tallgrass prairie, emergent marshes). This can lead to strong floristic overlap between shrub and grass types, which supports combining them at the upper levels and separating them at lower levels.

The primary issue with this class is incorporating both upland and wetland types. See discussion on "Wetlands" below.

3. Desert & Semi-Desert (Xeromorphic Woodland, Scrub & Grassland Vegetation)

Concept Summary

Type Concept Sentence: Cool and warm semi-deserts dominated by xeromorphic growth forms, including *succulent* (e.g., cacti, euphorbias) and *small-leaved shrubs* and *trees*, desert grasses and other xeromorphic growth forms, with an irregular horizontal canopy spacing that is often open to very sparse, including very open sandy and rocky vegetation with xeromorphic growth forms.

Inclusion of Tropical Thorn Woodland with other warm-desert scrub was a late addition to the hierarchy. The decision was based on the similarity of xeromorphic trees to other desert vegetation, although some will prefer that thorn woodland be placed next to Tropical Dry Forest (indeed some authors include thorn woodlands in that concept [Pennington and others 2006]). Our logic for the placement of Tropical Thorn Woodland is based on explicitly defined xeromorophic growth forms (e.g., succulents, leafless thorn trees, etc.).

Distinguishing non-vegetated and vegetated areas in deserts will also be difficult, given that on a site where vegetation is about 1 percent cover, there may be patches that vary between greater than 1 and less than 1 percent, and unbiased plot sampling of the site could have some plots with no cover. The few plants occurring at such low percentages may also be generalists and not particularly strong diagnostic species. For that reason, desert rocky and sandy vegetation are included here, rather than the "Open Rock Vegetation" class.

4. Polar And High Montane Scrub & Grassland (Cryomorphic Scrub, Herb And Cryptogam Vegetation)

Concept Summary

Type Concept Sentence: Tundra, alpine and tropical high montane habitats dominated by cryomorphic growth forms (including *dwarf-shrubs*, krummholz, associated *herbs,* and cryptograms such as *lichens* and *mosses*) with low height and open to closed canopy.

The name of this formation class emphasizes the cryomorphic nature of the vegetation. However, in many tropical montane regions that are roughly equivalent with the temperate "alpine" zone, the vegetation is not truly cryomorphic. That is, the soils do not experience cryoturbation and the vegetation doesn't experience frost, strong winds, and short growing seasons. This is true for parts of the paramo and puna, so the HRWG placed them under Shrub & Herb Vegetation (class 2) in Tropical Montane Grassland & Shrubland. However, all temperate alpine vegetation is placed in cryomorphic. Rocky vegetation dominated by cryptogram and cryomorphic vascular vegetation (such as Arctic barrens in polar deserts) is included here.

5. Aquatic Vegetation (Hydromorphic Vegetation)

Concept Summary

Type Concept Sentence: Open freshwater and saltwater wetlands dominated by aquatic vegetation, either rooted with leaves rising up to or near the surface, or floating freely on the water surface. Stands typically have surface water, generally up to 2 m in depth, along ocean, lake, pond, and river margins in non-tidal, tidal, and intertidal habitats.

We include rooted and submerged vegetation in this formation class but treat all other emergent wetlands under mesomorphic vegetation classes 1 and 2, as many emergent wetlands share growth forms with upland vegetation. We expect that this aquatic vegetation class will be most useful in wetland situations such as ponds (i.e., bodies of water smaller than 8 ha and less than 2 m deep with no wave action; Cowardin and others 1979). Where aquatic vegetation forms a component of lakes, rivers, and oceans, other classification schemes can provide a more holistic set of types, within which various levels of aquatic vegetation types can be included. Nonetheless, it is possible to include all vegetated habitats, even seagrasses, in this classification. For example, Den Hartog (2003) developed comprehensive marine seagrass formations and lower level floristic units for the globe. From a terrestrial perspective, wetlands may seem to be sufficiently distinct from upland types in classes 1 and 2 to place them here; but, when viewed from the larger aquatic vegetation perspective that includes only floating and submerged freshwater and marine vegetation, they are more closely related to those classes (See Wetlands section below).

6. Open Rock Vegetation (Cryptogam —Open Mesomorphic Vegetation)

Concept Summary

Type Concept Sentence: *Lichen, bryophyte, alga* or *fern*-dominated rocky habitats such as cliffs, talus, scree, pavement, cobble, lava or boulderfields in association with open or sparse mesomorphic vegetation.

This formation class is restricted to cropytogamic dominated vegetation found on consolidated and unconsolidated rocks where mesomorphic vascular plant cover is less than 10 percent; there is discussion as to whether non-seed plants such as ferns or *Selaginella* spp. should be excluded from the 10 percent vascular cover limit. The typical habitat is cliff, scree, talus or rock outcrops. Desert rocky or sandy vegetation is placed in Class 3, and alpine rock, scree and fellfields are placed in Class 4. There are questions to be resolved regarding placement of sparsely vegetated boulder or cobble drainages in dry creeks, river beds, or rocky shorelines where nonvascular vegetation may be a minor component. Scree vegetation may have more direct contact with soil with higher levels of vascular plant cover. The lack of information on rock vegetation makes classification and descriptions difficult.

The concept of this class has been narrowed to regions where climates are milder and mesomorphic vegetation is more typical, and cryptogam vegetation is otherwise not a typically dominant growth form. Early pilots of this hierarchy included desert, polar, and alpine rock vegetation in this class. However, given how open the vascular vegetation can be in those habitats, it created too much of an artificial split between the very sparse vascular vegetation and the somewhat more open vascular vegetation, both of which have substantial cryptogam dominance.

Wetlands

Wetlands have international significance due to the variety of human and ecological values they provide. However, placing wetlands in the hierarchy has been challenging. Wetlands are handled in various ways by ecological and vegetation classifications. In various global schemes, they are sometimes only noted incidentally, next to the main climatically driven types (e.g., Box and Fujiwara 2005; Whittaker 1975). Others recognized them as wholly distinct from other vegetation (NWWG 1997). The HRWG integrated them more directly into the hierarchical levels, although we struggled with their placement, as described below.

Chosen option: Wetlands are placed within various classes, depending on the level of distinctiveness of growth forms and their ecological drivers, but are always segregated out at Level 3 (formation).

Alternate option: Wetlands are grouped together into a single large hydromorphic and hydrophytic (or helomorphic) vegetation group. It reflected the perspective of many who see wetlands as a distinctive set of vegetation types, as well as various wetland publications that identify "wetland" as its own higher category (see the National Wetlands Inventory/Cowardin wetland classification, Cowardin and others 1979; and the Canadian wetland classification, National Wetlands Working Group 1997).

Rationale for Chosen Option *(wetlands initially dispersed among other classes, then individual wetland types recognized at formation level):*

1. It relies more strongly on dominant growth forms rather than diagnostic ones.
2. It more strongly separates the most distinctive vegetation classes ("more orthogonal vegetation criteria"). That is, it is difficult to class all wetlands together globally due to their "relative wetness," because that depends on the context of surrounding regional climatic and vegetation patterns.

3. Wetland distinctions vary even at the species level, because many widespread species may be considered wetland in some regions but not in other regions; e.g., definitions of Facultative and Obligate wetlands differ across U.S. wetland regions.
4. It is less dependent on ecological considerations in defining the class (i.e, a wetland/non-wetland distinction).

Rationale for Alternative Option *(wetlands grouped with aquatic vegetation as a single class, then individual wetland types recognized at formation level):*

1. It identifies the wetland criteria up front, overall, rather than repeatedly across subclasses.
2. It groups closely related wetland types together.
3. It provides a set of wetland subclasses that are clearly identified in many wetland classifications (e.g., swamp, bog and fen, marsh).
4. It more strongly integrates ecologically related growth forms, even if not the dominant ones.

Rationale for either option:

1. Both do a good job of grouping vegetation patterns.
2. Both are equally amenable to mapping approaches.
3. Both provide useful categories for vegetation management.
4. Both recognize the same major wetland types at formation level (Level 3).

The HRWG decided to adopt the chosen option because it was more faithful to the criteria required for Level 1. Forested wetlands are placed in the "Forest & Woodland" class; shrub and herb wetlands are placed in the "Shrub & Herb Vegetation" class, but separated out as a subclass; aquatic wetland vegetation, which has distinctive hydromorphic growth forms, is placed in Class 5 under Aquatic Vegetation. As all major wetland types are separated out at Level 3, most users will find few disadvantages to the current approach, and they can choose to aggregate all wetlands into their own category if so desired. Our approach is a classification of all vegetation, not a classification of wetland and non-wetland, which is more concerned with legal conservation and water law issues.

Formation Subclass

Formation Subclass: A vegetation classification unit of high rank (2nd level) defined by combinations of general dominant and diagnostic growth forms that reflect global macroclimatic factors driven primarily by latitude and continental position, or that reflect overriding substrate or aquatic conditions. (cf. Box and Fujiwara 2005, 2013; FGDC 2008; Walter 1985; Whittaker 1975).

Macroclimatic factors have a strong influence on the development of the formation subclass, even among substrate-based classes. Few issues arose in developing these subclasses. The HRWG worked with vegetation patterns that often correspond to broad bioclimatic classes. The work of Rivas-Martinez and others (Rivas-Martinez and others 1999a; Rivas-Martinez and Rivas-Sáens 1996–2009) was helpful for global scale distinctions, particularly the division of bioclimates into Tropical, Temperate, Mediterranean, Boreal, and Polar (Figure 1). Here we review a few of the subclasses, where some problems in definition were encountered. In all cases, see additional "classification comments" in the type descriptions in Part II.

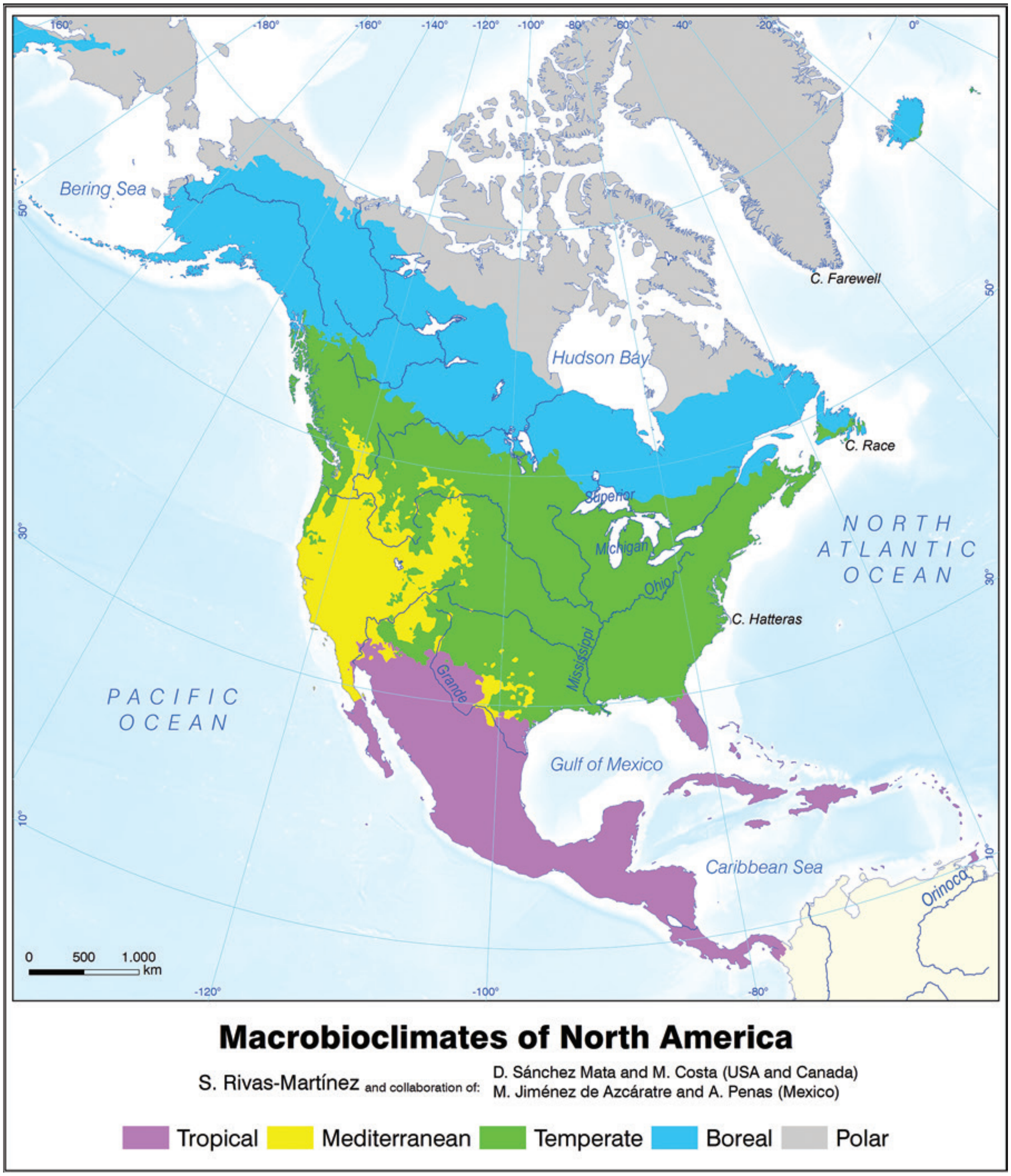

Figure 1—Bioclimatic Regions of (a) North America (Rivas-Martinez et al. 1999), (b) Europe (Rivas-Martinez et al. 2004), and (c) South America (Rivas Martinez, in press). Mapped distribution of these bioclimatic regions should not be used as definitive linework for actual formation distributions. See text for discussion of Mediterranean bioclimate. Maps used with permission (figure produced by Ángel Penas Merino).

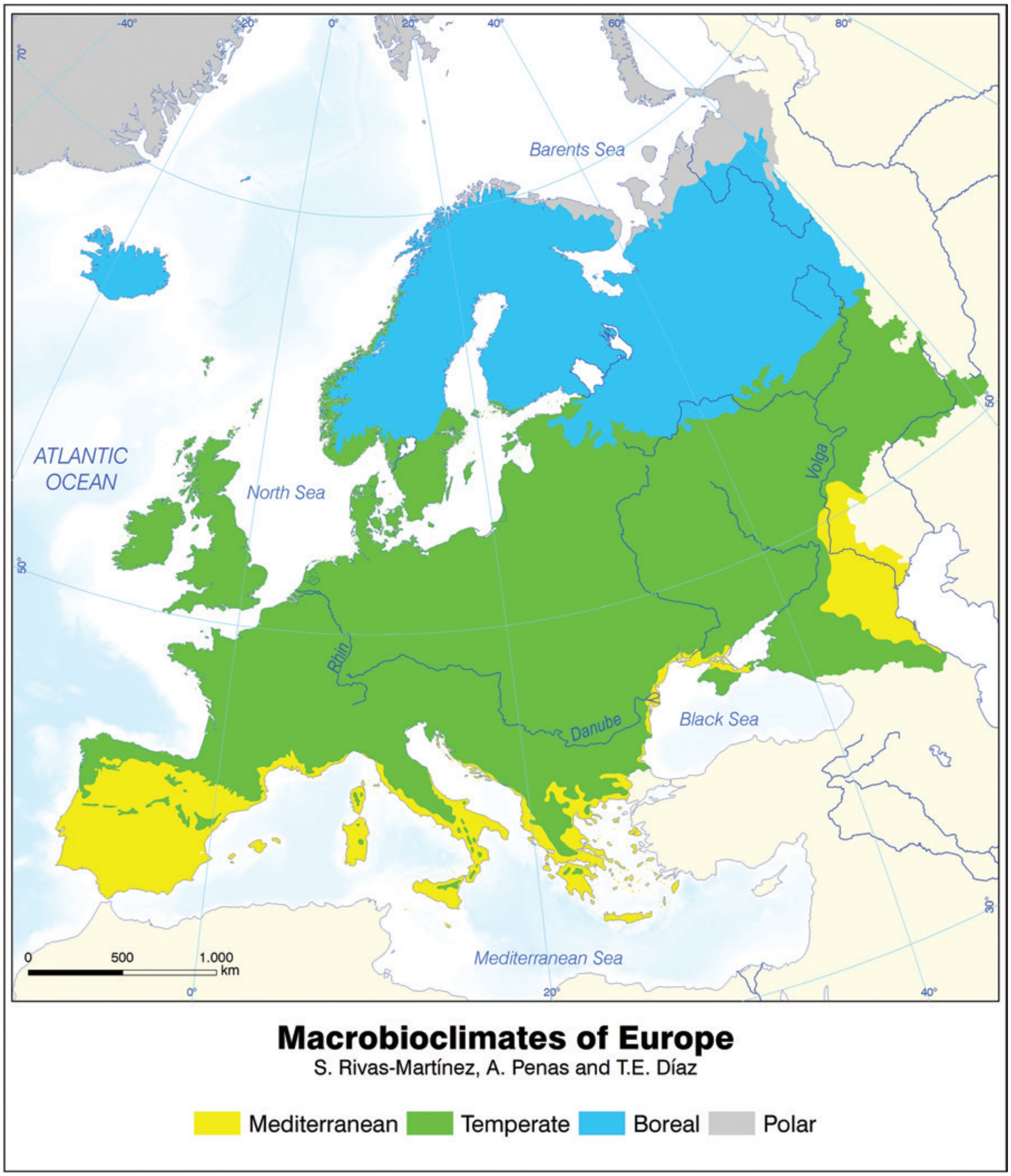
Barents Sea
ATLANTIC
OCEAN
North Sea
Black Sea
Mediterranean Sea
Volga
Rhin
Danube
0
500
1.000
km
Macrobioclimates of Europe
S. Rivas-Martínez, A. Penas and T.E. Díaz
Mediterranean
Temperate
Boreal
Polar

Figure 1b

Figure 1c

Temperate, Boreal and Montane Vegetation

Temperate & Boreal vegetation are combined at the subclass level, because they share many of the same broad growth forms. They are recognized as distinct at the formation (L3) level based on the simplified set of growth forms and distinctive climate found in the boreal forests. Montane forests, shrublands, and grasslands in the temperate and boreal regions do not contain distinctive growth forms from lower elevation vegetation until one reaches the alpine zone. Alpine vegetation shares strong growth form similarities with polar vegetation, and they are treated together at the subclass level (4.B. Temperate to Polar Alpine & Tundra Vegetation).

Temperate and Mediterranean Vegetation

The one bioclimate type of Rivas-Martinez and Rivas-Sáens (1996-2009) that does not correspond as closely to our approach is the Mediterranean bioclimate. They define this bioclimate to include not only Mediterranean scrub vegetation but also vegetation that we place in Cool Semi-Desert, (e.g., in North America, the Great Basin vegetation, in South America the Patagonian vegetation, and in Europe the Eastern European steppe) (figures 1, 2). In addition, we only use the term "Mediterranean" in reference to "Mediterranean Scrub & Grassland" (an L3 formation unit), thus restricting the vegetation concept to sclerophyllous and other Mediterranean type scrub growth forms within a broadly temperate and boreal subclass. The distinctive Mediterranean vegetation around the world has been variously treated either narrowly or broadly; here, we use the term narrowly based on growth forms. The sclerophyllous and mixed evergreen-deciduous tree growth forms of the European Mediterranean region are also found in other warm-temperate climates, and are included in the Warm-Temperate Forest class. That formation includes:

- In Europe, the European Mediterranean cork-oak forests (*Quercus suber*) of Spain and Portugal, fir forests (*Abies maroccana*) and cedar forests (*Cedrus atlantica*) in high-mountain areas in Morocco, oak woodlands broadly distributed throughout the Mediterranean Basin countries;
- In South America, the warm temperate forests of *Nothofagus macrocarpa*, *N. glauca, N. alessandrii*, *Austrocedrus chilensis* forests, etc.;
- In Australia, the many Eucalypt forests; and
- In North America, both the Mediterranean California forests and woodlands and the Southeast U.S. Coastal Plain forests.

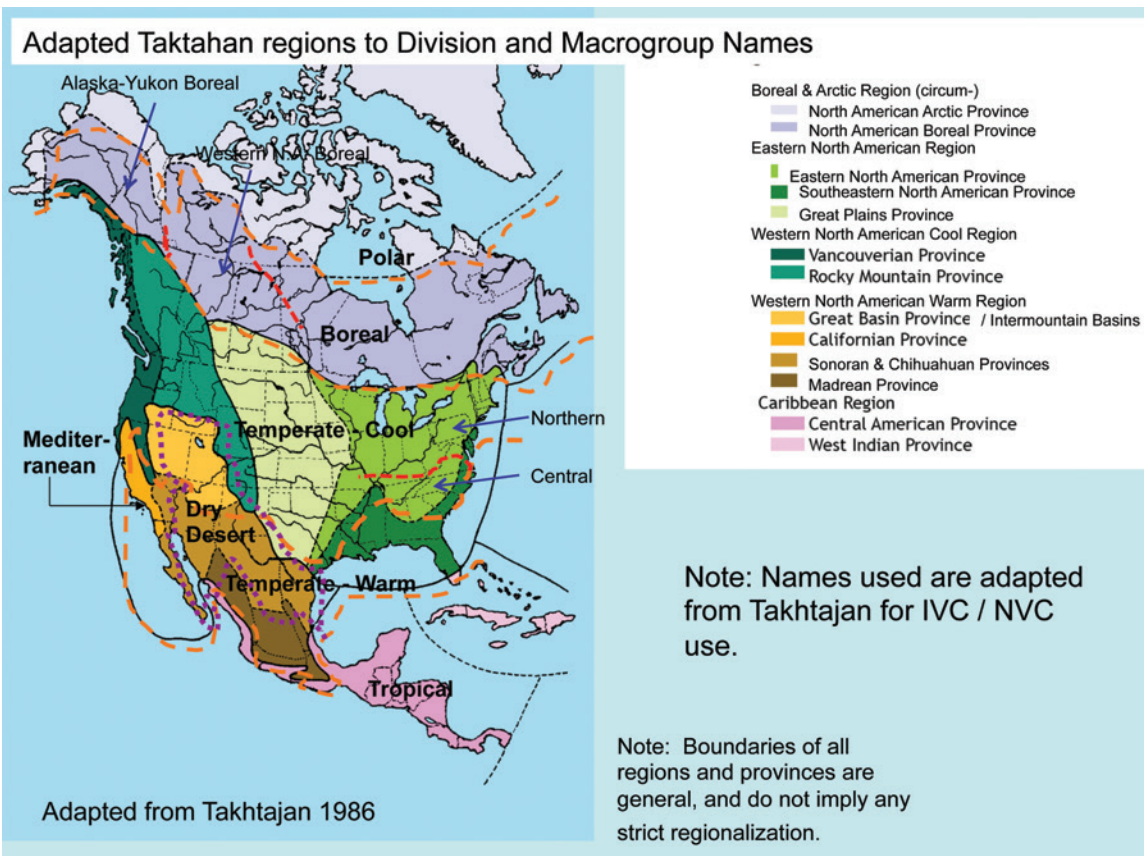

Figure 2—Bioclimatic Regions and Formations and Divisions within North America defined by climate. Less-climatically driven wetland or substrate formations are not as strongly influenced by these patterns. Mapped distribution of these biogeographic regions should not be used as definitive linework for actual formation, division or other vegetation type distributions.

Our approach here, as throughout, is to emphasize the vegetation patterns, and to assess their significance through correlations with broad ecological and biogeographic processes. For example, at the level of formation subclass, we typically combine temperate and boreal units, despite the differences in macroclimate, because of their fairly strong overlap in dominant and diagnostic growth forms, whereas tropical types are much more distinctive from either temperate or boreal. Separate temperate and boreal types are recognized at the formation level.

Formation

Formation: A vegetation classification unit of high rank (3rd level) defined by combinations of dominant and diagnostic growth forms that reflect global macroclimatic conditions as modified by altitude, seasonality of precipitation, substrates, and hydrologic conditions. (cf. "formation-type" and "biome-type" of Box and Fujiwara 2005; FGDC 2008; Walter 1985; Whittaker 1975).

The formation describes vegetation patterns that reflect the combination of macroclimates and/or substrate and topography. There is no strict parallelism among criteria in identifying formations; thus, in a few cases, a subclass is not split any further, because no major patterns of variation are evident with respect to the vegetation or ecological processes as compared to other types at that level. In addition, bottom-up information may also be considered from the Division level. For example, a formation split was avoided if it creates two Divisions with overlapping floristics within broadly similar growth forms, although tradeoffs are inevitable (e.g., wetland and upland forest formations may overlap in floristics and dominants).

Formation Issues

Tropical humid forest (1.A.2, 1.A.3)

Commonly called tropical rain forests, we chose this term to ensure that users understand that both moist and wet, or seasonal evergreen and aseasonal evergreen rain forests are included in the concept.

Temperate and boreal forest and woodland formations (1.B.1 – 1.B.5.)

The distinctive growth forms and climate relations of major forest formations draw from a variety of works, including Walter (1985) who separated boreal, cool-temperate, and warm-temperate forests and woodlands. (See the Formation subclass discussion under "Temperate and Mediterranean vegetation" for a discussion of warm temperate and Mediterranean forest vegetation.)

Placement of subalpine forests and woodlands is problematic as to whether they are more boreal-like or temperate-like in their growth forms and floristics, and corresponding climate. At this time, we treat subalpine forests within the temperate, as they often take on some of the characteristics of lower elevation forests, and we restrict boreal forests to the high latitude regions of the globe.

Mediterranean scrub and grassland formation (2.B.1)

See discussion of this vegetation under the Formation Subclass – Warm "Temperate and Mediterranean "Vegetation."

Coastal upland scrub and herb formations (2.A.3, 2.B.4)

Distinctive ecology and substrate of rocky shores, beaches and dunes, somewhat reflected in vegetation, are separated out into their own formations. This is one of the weaker formation distinctions. Note that coastal salt marshes are treated separately as a wetland formation.

Salt marsh (2.C.5)

The vast majority of salt marshes are temperate, but the formation ranges broadly enough, both along the coast and inland, that climate regime is identified with it. Inland salt marshes are typically separated from coastal salt marshes at the Division level.

Polar tundra and barrens formation (4.C)

Wet Tundra is sometimes defined to include: peaty wet tundra (bogs and poor fens), tundra meadows, and marshes. But we treat those as wetland types in 2.C. Shrub & Herb Wetland. Thus a separate "Wet Tundra" is not recognized. Cryptogam dominated barrens (polar deserts) are also placed here.

Tropical high montane and temperate alpine (4.A.1)

The Tropical Montane Grassland & Shrubland (i.e. *paramo* and *puna*) is placed under the Mesomorphic class (2.A.2), differentiating it from the Tropical High Montane Scrub & Grassland Formation that has been placed within the Cryomorphic Scrub, Herb & Cryptogam Vegetation Class. This split is a result of the key physiognomic distinctions such as the ground cover of the formation, which is continuous for the tropical montane shrubland and grasslands as compared to the low, semi-open coverage of the tropical cryomorphic formations, and the predominance of mesomorphic growth forms (predominantly tussock grasses, large rosette plants, shrubs with evergreen coriaceous and sclerophyllous – *ericoid* leaves, and cushion plants). As for environmental drivers, seasonality is related to rainfall rather than temperature. The main difference of this formation with its temperate counterpart is the diurnal fluctuation of temperature, which can be 20 °C or more in tropical high mountains (i.e., Andes, Africa) with no growth limiting season.

Cliff, scree and rock formations (6.A.1-6.B.1)

Climate and substrate combinations are used for these formations, but there is little literature available to guide us. Vascular components of these rock formations are often helpful. That is, one might find bromeliads on tropical cliffs, deciduous broadleaf shrubs on temperate cliffs, and sclerophyllous evergreen shrubs on Mediterranean cliffs. We are not aware of how the nonvascular growth forms might differ among these formations.

In early pilots of this hierarchy, additional formations existed for desert, polar, and alpine rock vegetation but these have now been moved under those classes and subclasses (see discussion above under "6. Open Rock Vegetation").

Wetland Formations

Our approach to defining wetland formations follows a widely used set of physiognomic-ecological types and terms that provide a set of wetland units corresponding to broad climatic and edaphic factors. We drew, in particular, on the Canadian Wetland Classification system for types and definitions (National Wetlands Working Group 1997; see also Mackenzie and Moran 2004) and from Mitsch and Gosselink (2000) for ecological processes and functions. The major wetland types that inform our formation distinctions are described in Table 6. Most of the wetland types are divided into tropical versus temperate wetlands based on the different kinds of dominant growth forms (e.g., broad-leaved evergreen trees and palms in tropical swamps) (see Appendix B).

Table 6—Major wetland types used to guide formation distinctions. Types, definitions, environmental features and growth forms are adapted from the Canadian National Wetlands Working Group (1997) and Mackenzie and Moran (2004), with linkage to major wetland types described by Mitsch and Gosselink (2000).

	Wetland type	Definition	Environmental features	Growth forms	Mitsch & Gosselink (2000) Type
Forest & Woodland (1)	**Flooded & Swamp Forest**	A swamp is a wooded mineral (or less often peat) wetland on sites with a flowing/flooded or fluctuating semi-permanent, near surface water table. Forested swamps have trees occurring on elevated microsites. Flooded forests occur on sites where flooding varies from temporary (<7 days) to semi-permanent (>180 days). Trees >2 m have ≥10 percent cover. We place shrub swamps with marsh and wet meadow in Class 2.	Mineral soils or well-humified peat. Temporary to semi-permanent flooding (0.1 to 2 m deep), or freshwater or oligohaline tidal inundation	Tall shrub, broad-leaved tree, needle-leaved tree, forb, graminoid, hydromorphic herb (rarely)	Freshwater swamps; Riparian ecosystems (wetland, tree)
	Mangrove	Mangroves occur in the intertidal and brackish backwater of estuarine areas in tropical regions. Mangroves include tree and shrub forms of mangrove of all heights.	Intertidal and supratidal zones, semi-diurnal to diurnal, flooding by brackish or saltwater	Mangrove, halophytic shrub, halophytic (succulent) forb, graminoids	Mangrove swamps

(continued)

Table 6—(Continued).

	Wetland type	Definition	Environmental features	Growth forms	Mitsch & Gosselink (2000) Type
Shrub & Herb Wetland (2.C.)	**Bog**	Bogs are shrubby, nutrient-poor peatlands with distinctive communities of ericaceous shrubs and hummock-forming *Sphagnum* species, sometimes with sedges, adapted to high acid and oxygen-poor soil conditions. Trees >5 m typically have <10 percent cover (raised bogs may contain some forested stands).	+/- ombrotrophic, pH < 5.5, >40 cm fibric/ mesic peat	Stunted needle-leaved tree, low shrub, dwarf shrub (ericaceous), sphagnum	Peatland
	Fen	Fens are peatlands where groundwater or stream inflow maintains relatively moderate to high mineral content within the rooting zone. Sites are characterized by non-ericaceous shrubs, sedges, grasses, reeds, and brown mosses. Trees >5 m typically have <10 percent cover. Forested fen is included under Swamp Forest.	Groundwater-fed pH > 5.0 >40 cm fibric/ mesic peat	Low shrub (often non-ericaceous), sedge (often fine), grass, reed, and brown moss, with or without sphagnum	Peatland
	Freshwater Marsh, Wet Meadow & Shrub Swamp *(non-tidal and tidal)*	A marsh-wet meadow is a shallowly flooded or saturated wetland dominated by emergent grass-like vegetation. A fluctuating water table is typical in marshes and wet meadows, with early season high water tables and some flooding dropping through the growing (or dry) season, and exposure of the substrate or drying of the profile possible in late (or dry) season or drought years. Shrub wetlands (shrub swamps, shrub carrs) occupy similar sites to wet meadows. Trees >5 m have <10 percent cover.	Mineral soils or well-humified peat. Protracted shallow flooding (0.1 to 2.0 m) or prolonged soil profile saturation, or freshwater or oligohaline tidal inundation.	Grass, sedge (often coarse), forb, low shrub, tall shrub	Freshwater marshes - emergent; Tidal freshwater marshes; Riparian ecosystem (wetland, herb/shrub)
	Saltwater Marsh	Saltwater marshes are intertidal to supratidal ecosystems that are flooded diurnally (or less), sometimes with freshwater inputs, and are dominated by salt-tolerant emergent graminoids and succulents. Trees >5 m have <10 percent cover.	Intertidal and supratidal zones, semi-diurnal to diurnal, flooding by brackish or saltwater [*n.b. inland non-tidal saline wet meadows may also be placed here]*	Grass, sedge, forb, halophytic (succulent) forb, halophytic shrub.	Tidal salt marshes

(continued)

Table 6—(Continued).

	Wetland type	Definition	Environmental features	Growth forms	Mitsch & Gosselink (2000) Type
Aquatic	**Aquatic Vegetation *(non-tidal and tidal)***	Aquatic wetlands are shallow waters dominated by rooted, submerged and floating aquatic plants. They are associated with permanent still or slow-moving waters, such as shallow potholes, ponds, rivers and lakes. Aquatic plants may occur in mineral or in well-humified sedimentary peat. Emergent growth forms <10 percent cover, hydromorphic growth forms >1 percent cover.	+/-Permanent deep flooding (0.5 – 2 m), substrate can be muck, sand, marl or rocky substrates	Hydromorphic (aquatic) herb, Emergents < 10 percent cover	Freshwater marshes - aquatic

Summary of Criteria for Natural Formations

We summarize the criteria for these three formation levels in Table 7, and compare them with the Division level, which introduces the use of both physiognomic and floristic criteria.

Development of Cultural Formations

As with the natural vegetation, physiognomic criteria represent the primary properties of cultural vegetation at the upper levels but are assessed in light of human activities that govern these properties. Thus, the arrangement and organizing criteria for these units is quite different from natural units, being largely constructed from physiognomic and structural considerations driven by human management activities. Excluded from these criteria are properties from outside the current vegetation, such as explicit habitat factors (e.g., climate, soil type) or land use activities (e.g., grazed pasture versus ungrazed pasture), except as these are expressed in the vegetation growth forms and structures. Some types are difficult to classify as natural or cultural vegetation (e.g., forest plantation, pastures), and the user may need to compare both parts of the hierarchy to determine the type's location.

The upper levels of the hierarchy are based on dominant and diagnostic growth forms that reflect anthropogenic drivers at global to continental scales. A comprehensive set of cultural vegetation units are available in pilot form for most levels of the hierarchy, based on the U.S. Natural Resources Conservation Service's National Resources Inventory (NRI) (FGDC 2008; Appendix I); thus, we deferred to that classification for most of the units but organized them into a hierarchical structure consistent with the overall framework.

Table 7—Brief summary of criteria for formation units and division.

Criteria	Formation Class	Formation Subclass	Formation	Division[a]
Diagnostic Species	--	--	--	Very large set. Many character spp., often endemic to the division. At least some of the character species are dominant in parts of the range of the type.
Growth Forms	Broad combinations of dominant general growth forms and specific growth forms	Combinations of general and specific dominant and diagnostic growth forms	Combinations of dominant and diagnostic growth forms, sometimes based on individual diagnostic growth forms (e.g. mangrove)	The same combination of growth forms as at the formation level
Range of Variation	Overlapping general growth forms (tree, shrub), but combinations of diagnostic growth forms generally non-overlapping (e.g., xeromorphic)	Combinations of diagnostic growth forms partially non-overlapping (e.g., warm temperate forests and tropical forests	Combinations of diagnostic growth forms more strongly overlapping (e.g., temperate and boreal forests), relative abundances more important	Essentially non-overlapping floristics
Ecological Gradients	Basic moisture, temperature, and/or substrate or aquatic conditions	Global macroclimatic factors driven primarily by latitude and continental position, or that reflect overriding substrate (rock vegetation) or water salinity (aquatic vegetation)	Global macroclimatic conditions in combination with landmass and edaphic factors, such as altitude, seasonality of precipitation, substrates, and hydrologic conditions	Continental scale biogeographic differences in composition, reflecting macroclimate patterns modified by the continents. Divisions within a formation are often geographically separated.

[a]A character species in a Division shows a distinct maximum concentration, either in constancy and/or abundance, in one well-defined vegetation type as compared to all others and recognizable at general/global geographic scales (Mueller-Dombois and Ellenberg 1974).

Cultural Class

Cultural Class: A vegetation classification unit of high rank (1st level) defined by broad combinations of dominant general growth forms determined by global scale human activities

Cultural Subclass

Cultural Subclass: A vegetation classification unit of high rank (2nd level) defined by combinations of general dominant and diagnostic growth forms that reflect global scale human activities.

Cultural Formation

Cultural Formation: A vegetation classification unit of high rank (3rd level) defined by combinations of dominant and diagnostic growth forms that reflect global scale human activities.

Type Description

Many details of type description especially for natural vegetation, are provided in FGDC (2008) and Jennings and others (2009), including from plot data preparation and data collection, data analysis, interpretation, documentation and archiving, and type description, nomenclature, and peer review. That work, however, was focused on the lower floristic levels of the natural types, alliances and associations. Additional guidance is needed for application across all levels of the hierarchy. Here we summarize our approach to type description of the formations (See also Faber-Langendoen et al. 2014).

Upper Level Nomenclatural Rules

The HRWG has adopted and advocated for the approach taken in FGDC (2008) and Jennings and others (2009), whereby a scientific name, a translated scientific name (from the vernacular plant names available from widely accepted standard taxonomic references), and a colloquial name are all provided. Translated names and colloquial names are provided in English and a variety of other common languages. The names can include both physiognomic terms (forest, grassland, bog, tundra) and species names, and may also include a biogeographic term. The HRWG recommends development of a glossary of nomenclatural terms to guide ongoing naming of types.

Formation types at Levels 1-3 are named, defined, and organized by vegetation structure and physiognomy, as these are reflected in broad climatic and site factors. A convenient aid for naming the formations, and consistent with the goal of using common terminology (FGDC 2008), is to use terms based on the habitats that they occupy; it should be re-emphasized that habitat factors are not typically used in defining formations (Whitmore 1984, pg. 155). To avoid tendencies towards making the name too descriptive, we also provide a one-sentence descriptive summary of the type. The result is a set of easily recognized formations with memorable colloquial names that communicate the most distinctive vegetation and ecological characteristics of the formation. Currently, we apply only English terms to the three formation levels, and distinguish scientific and common names only for Level 1.[3]

Overall Style

All first letters of English words in a vegetation type name are capitalized and, as needed, additional words are separated by either a hyphen with spaces (-), a comma and space (,) or the “and” symbol with spaces (&).

---

[3] These approaches to nomenclature do not rule out the option of adding a formal Latinized name for types at these three levels, as done by Rübel (1930-1931, see Appendix B in Shimwell 1971). For example, following Rübel, the scientific names for the Desert and Semi-Desert class could be “*Deserta,*” the Warm Semi-Desert subclass could be named “*Siccadeserta,*” and the Cool Semi-Desert subclass named “*Frigorideserta.*”

Level 1 (Formation class)

Class names are based on the very broad growth forms that correspond to global moisture/temperature regimes. The single name helps identify the broad grouping of growth forms that correspond to particular moisture/temperature conditions. A parenthetical set of names is included to guide general users to the main kind of vegetation included in the class. The class level is organized by decreasing complexity and cover of the vegetation, reflecting increasingly stressful site factors. Given the wide overlap in use of the terms "Forest" and "Woodland" we use both terms to indicate that the class definition encompasses all mesomorphic (i.e. broad-leaved or needle-leaved) trees of varying height and canopy spacing.

Examples:

- Mesomorphic Tree Vegetation (Forest & Woodland)
- Mesomorphic Shrub & Herb Vegetation (Shrub & Herb Vegetation)
- Xeromorphic Woodland, Scrub & Herb Vegetation (Desert & Semi-Desert)
- Hydromorphic Vegetation (Aquatic Vegetation)

Level 2 (Formation subclass)

The subclass name reflects the structure, physiognomy and environmental factors that characterize the subclass. The primary environmental factor is macroclimate. Physiognomic terms are sometimes more specific than the class name (e.g., scrub versus shrubland where the vegetation may include tall xeromorphic tree-like plants such as tall cacti). All such terms, if used, should be defined.

Examples:

- Tropical Forest & Woodland
- Temperate & Boreal Grassland & Shrubland
- Cool Semi-Desert Scrub & Grassland
- Saltwater Aquatic Vegetation

Level 3 (Formation)

The formation name reflects the structure, physiognomy and environmental factors that characterize the formation. The primary environmental factors are macroclimate in combination with soil moisture conditions, elevation and substrate. Physiognomic terms are sometimes more specific than the class or subclass name. All physiognomic terms should be defined in the vegetation type description.

Examples:

- Tropical Lowland Humid Forest
- Mediterranean Scrub & Grassland
- Cool Semi-Desert Scrub & Grassland
- Marine & Estuarine Saltwater Aquatic Vegetation

Description Template

The official template for describing types is provided in FGDC (2008) and Jennings and others (2009), and is appropriate to all levels of the hierarchy (see also FGDC 2008, Section 3.2.3). An expanded set of instructions on completing the template is available on request from the authors. Following are a few general observations on the format of these descriptions:

- A standard template is used, supplemented with a few additional fields.
- Concepts for Level 1 types were developed from the expertise of the HRWG members. Other levels are more commonly used by other classifications and appropriate citations and synonyms are provided (See Appendix F).
- A standard set of growth forms is used (see Appendix D; see also Appendix E in FGDC 2008). Growth forms types are placed in italics to remind the reader that the terms have specific meanings. Additional growth forms that may be useful to add to the list and that are included in the descriptions can also be placed in italics, with an asterisk.

These descriptions are a first preliminary effort at global descriptions for formation types, and are provided to give some guidance to our concepts. Undoubtedly even these preliminary descriptions are biased by our western hemisphere perspective. We look forward to engaging with a broader set of ecologists around the globe to continue improving both the concepts and the descriptions. We hope such collaboration can develop, in part, by identifying vegetation types at the Division level around the globe.

Peer Review

We follow the approach of FGDC (2008) and Jennings and others (2009) for peer review. Those documents outline a process based on a dynamic classification standard, whereby peer review is an open process conducted by professional organizations in collaboration with other interested parties. It is administered by a peer review board under the aegis of an institution capable of providing independent reviewers of appropriate experience in vegetation classification. In this case, the ESA Vegetation Classification Panel will solicit review of the current set of formations. It is desirable to have a panel of international vegetation ecologists oversee the ongoing peer review of these global formation types.

A Key to the Formations

An introduction and key to the Formation Class (Level 1) is provided in Appendix I. We note in the introduction to the key, that keying out formations requires attention to vegetation strata and growth forms. Many species have only a single or primary growth form. Therefore, if a species list and vegetation strata or general growth forms are part of the plot description, detailed recording of specific growth forms may not be needed (e.g., Mucina and others 2000; Peet and others 1998; Tart and others 2005b). If a flora or species list for a state, province, or nation also identifies the species growth form(s), then a rollup of species to growth forms will simplify the standard field methods. The user need only be aware of those species that have multiple growth forms, and which growth form is present on the plot. In the United States, the U.S. Department of Agriculture (USDA) PLANTS database (2002 version; see http://plants.usda.gov) lists the general growth form ("growth habit") of all plant species in the United States This list could be supplemented with the specific growth forms (Appendix D) of each species.

Synopsis

We have introduced an ecological vegetation classification approach (the EcoVeg approach) by which vegetation ecologists can organize global vegetation patterns at multiple scales (Faber-Langendoen and others 2014), and also provide rationale and detailed descriptions for each of the upper level units. We believe this framework is an important contribution to what is currently available to vegetation ecologists, land managers, and conservationists. Many global classifications deal with only broad structural patterns, others with only floristics. We provide an introduction to formations, along with the descriptions and key, as a basic synopsis of the world's vegetation structured by specific growth form criteria. Sufficient detail is given to encourage consistent application anywhere in the world and within a hierarchical structure that includes both floristic and growth form criteria, ultimately at the levels of alliance and association. The formations descriptions are not detailed; they rely on a large tradition of description and classification for their support, and they seek to provide as concise an overview as possible. They are presented here in draft form, and we are aware that we have not been able to invest as much effort across all of them. More work is needed to reference the many publications that support or improve these concepts. In addition, our work is only one, among many, and so establishing crosswalks to other classification will increase our understanding of how others have defined and described the vegetation.

A real test of these concepts is whether they provide any value in moving to the next step, which is supporting description and classification of Divisions and Macrogroups within the formations. It is these types that force us to specify very clearly in which continents and regions these formations are found and whether the summaries of variability so simply described here can account for the variation observed around the globe. Our expertise has primarily come from Western Hemisphere vegetation ecologists, though we have also considered vegetation in Africa and Europe. We look forward to helping vegetation ecologists achieve consensus on these "mid-level" units (see Appendix J for examples of Cool Temperate Forest and Grassland Divisions). Such collaboration can help us better understand the ecological processes, biogeographic and historical relationships, current threats, and conservation status of vegetation types.

PART II: DESCRIPTION OF WORLD FORMATION TYPES

1. Forest & Woodland (C01)

Overview

Database Code: 1 (C01)

Scientific Name: Mesomorphic Tree Vegetation Class

Common Name (Translated Scientific Name): Mesomorphic Tree Vegetation Class

Colloquial Name: Forest & Woodland

Hierarchy Level: Class

Lower Level Hierarchy Units:

1.A. Tropical Forest & Woodland (S17)

1.B. Temperate & Boreal Forest & Woodland (S15)

Concept Summary

Type Concept Sentence: Tropical, temperate and boreal forests, woodlands and tree savannas characterized by broadly mesomorphic (including scleromorphic) tree growth forms (including *broad-leaved, needle-leaved, sclerophyllous, palm, bamboo trees*, and *tree ferns*), typically with at least 10 percent cover (but tropical tree savannas up to 40 percent cover, when trees are less than 8 m tall), irregular horizontal spacing of vegetation structure, and spanning humid to seasonally dry tropical to boreal and subalpine climates and wet to dry substrate conditions. Includes native forests, as well as managed, and some plantation forests where human management is infrequent.

Classification Comments: Plantations, ruderal, and native forest and woodland stands are typically placed in this class. Some plantation forests can be placed here rather than in the *Agricultural & Developed Vegetation Class (CCL01)* despite having a canopy layer that may be very regular (spaced in planted rows), if the tree regeneration, shrub and ground layers develop spontaneously with irregular horizontal spacing, similar to native forests (i.e., regular human intervention does not occur for these layers). However, where plantations have highly regular horizontal structure, with regular human intervention in all layers (e.g., through cutting, spraying, ground-layer mowing), they may better be placed in the *Agricultural & Developed Vegetation Class (CCL01)*.

Similarly, tree-dominated vegetation that has a natural, irregular horizontal spacing in the tree layer, but highly regular shrub or herb layers because of human intervention, should be placed in the *Agricultural & Developed Vegetation Class (CCL01)*. For example, shade coffee, cacao, and other woody agricultural crops grown under native (or exotic) tree species and in which all non-treed strata layers are subject to regular human intervention should be placed in that class.

Included in this class are low-statured trees that overtop other growth forms. These include tree sapling and seedling stands with trees less than 2 m, where the tree growth form is at least 10 percent cover and overtops other growth forms. These include subarctic woodlands, and coastal dwarf-tree woodlands that are less than 2 m but are single-stemmed with definite crowns. Conversely, treed bogs and fens, with low stunted trees and conical canopies, and otherwise sharing the moss and dwarf-shrub layers of open bogs and fens, are placed with those types. Where trees share the same strata as grasslands and shrublands (e.g., tallgrass brush prairie of 1 to 3 m, with trees less than 2 m), the vegetation is placed in the shrub- and herb-dominated classes.

Tree cover ranges from 10 to 100 percent, and is inclusive of what are called forests, woodlands, and tree savannas, at least in the non-tropical regions. The class limit of 10 percent tree cover (for mesomorphic tree growth forms) follows that of FAO's Global Forest Resources Assessment 2000 (FAO 2001). We exclude stands of trees planted primarily for agricultural production (such as fruit tree or forest plantations) and typically agroforestry, as well as those in developed lands, such as cities and roadsides (they are placed in Class 7, formation 7.A.2). However, unlike FAO, we do not include what FAO calls "temporarily unstocked areas" (such as clearcuts, burnt areas) unless the tree growth form is actually present at 10 percent cover—even if in seedling or sapling form—and exceeds the height of other growth forms.

Other classifications may limit forests and woodland to a narrower range of tree cover. For example, forests and woodlands are sometimes defined as 25 to 100 percent cover, and distinguished from tree savannas with 10 to 25 percent cover, which included under broadly defined grassland and shrubland classes (Driscoll and others 1984; FGDC 1997; Grossman and others 1998; Minnesota DNR 2005). UNESCO (1973) required that tree savannas also have a strong herbaceous layer (greater than 50 percent graminoid cover). Still, a variety of definitions of tree savanna have been published, from the 10 to 25 percent cover noted above, to 10 to 30 percent cover in Nelson (2005), 10 to 40 percent in UNESCO (1973), and 10 to 50 percent cover in Curtis (1959). Blue oak, Engelmann oak, and other woodlands in California Mediterranean woodlands are typically between 10 and 60 percent cover, and California State ecologists place these in the Forest & Woodland (Barbour and others 2007). However, apart from tree savannas, there are many other forest and woodland types and regions where the degree of canopy closure plays less of a role in defining types, for example, forested swamps and bogs, longleaf pine woodlands (Peet 2006), eastern pine barrens, and subarctic woodlands.

Thus, given the variety of situations, we have chosen a more inclusive definition of forest and woodland that encompasses most tree savanna concepts, and rely on lower levels of the hierarchy to make distinctions based on a combination of biogeography, ecology, and floristics. For example, in the context of the eastern Great Plains tallgrass prairie-forest border, it is common to recognize oak savannas, based on open tree cover levels (e.g., 5 to 30 percent tree cover in Nelson 2005), as separate from oak woodlands (30 to 80 percent cover) and oak forests (80 to 100 percent cover). Savannas may be distinguished from forests or woodlands, but these structural distinctions often correspond to lower level units of the NVC hierarchy (e.g., group, alliance, and association). Still, Dixon and others (2014) suggest that there may be good ecological reasons to treat upland tropical tree savannas, with 10 to 40 percent tree cover, trees less than 8 m tall, and a substantial graminoid layer as part of *2. Shrubland & Grassland (C02)*, and we allow for that option here.

Similar NVC Types:

2. Shrubland & Grassland (C02): When grasses and shrubs dominate the ground layer and tree cover is near but greater than 10 percent, is clumped, or overtopped by grasses and shrubs, there may be cases where assignment to this class is preferable. Short mesomorphic trees that do not overtop shrubs and herbs are placed in this class. However, in tropical upland savanna regions, stands may have 40 percent tree cover, where trees are less than 8 m tall, tree regeneration is sparse to absent, and there is a substantial graminoid layer.

3. Desert & Semi-Desert (C03): Occasionally xeromorphic trees may be sufficiently dense to form woodland stands (e.g., saguaro, Joshua tree, microphyllous-leaved mesquite woodlands, tropical thorn woodlands). The dominance of xeromorphic growth forms places these stands in the Desert & Semi-Desert class rather than Forest & Woodland.

7. Agricultural & Developed Vegetation (CCL01): Forests found in urban parks and lawns may have an irregular horizontal spacing but a highly regular or mowed understory and are placed in this developed vegetation class. Forests, such as orchards and forest plantations, typically have either a very regularly spaced tree canopy (often pruned or trained) and/or plowed or regularly manipulated ground layer (e.g., tree-shaded shrub or herb crops).

Diagnostic Characteristics: Mesomorphic *tree* growth forms (*broad-leaved, needle-leaved*, and *sclerophyllous trees, palms, bamboo trees*, and *tree ferns*) have greater than 10 percent canopy cover, a spontaneous, irregular horizontal canopy spacing, and overtop other growth forms, except in tropical upland regions, where trees typically have greater than 40 percent cover, are greater than 8 m tall, and the vegetation lacks a substantial graminoid layer.

Vegetation

Physiognomy and Structure: *Growth Forms*: Stands are dominated by mesomorphic trees, including *broad-leaved deciduous* (including mostly deciduous, winter-deciduous, facultatively deciduous), *broad-leaved evergreen* (including mostly evergreen), *needle-leaved* (deciduous and evergreen), *sclerophyllous trees, palms, bamboo trees*, and *tree ferns*. Tree growth forms generally have a single main stem and more-or-less definite crowns, and may be as low as 2 m (scrub trees) (e.g., tropical cloud elfin forest, mesquite woodland). Where growth forms are not easily defined, woody plants equal to or greater than 5 m at maturity are considered trees (FGDC 2008).

Structure: Typical stands have one or more of the tree growth forms exceeding 5 m in height, and the canopy has irregular horizontal tree stem spacing, with a minimum of 10 percent canopy cover (8 m in height and minimum of 40 percent in tropical forests and woodlands, as low as 2 m in subarctic woodlands). A tree regeneration layer is often present, along with various associated growth forms (shrubs, herbs, nonvasculars). Stands of trees where the tree growth form is short (<5 m) in height but overtopping shrub and herb growth forms, may also be placed in this class.

Environment

Environmental Description: *Climate*: Climates range from humid tropical to boreal and subalpine, with fairly moderate moisture and temperature conditions. See details under the various forest and woodland subclasses.

Soil/substrate/hydrology: Dry to wet soils, including those found in swamp forests and mangroves.

Distribution

Geographic Range: Forest and Woodland occurs on all continents, mostly in the following ecoregions (Bailey 1989, 1996): the Humid Tropical and Humid Temperate Domains, the Subarctic Division of Polar Domain, and Mountain Divisions of Dry Domain. It is less common in other divisions of Polar and Dry domains.

Citations

Synonymy:
= Forest (FAO 2001) [Approximately equivalent. Xeromorphic scrub woodlands are probably included here, but otherwise the concepts are very similar.]
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: Hierarchy Revisions Working Group
Acknowledgments:
Version Date: 26 Aug 2014

1.A. Tropical Forest & Woodland (S17)

Overview

Database Code: 1.A (S17)
Scientific Name: Tropical Forest & Woodland Subclass
Common Name (Translated Scientific Name): Tropical Forest & Woodland Subclass
Colloquial Name: Tropical Forest & Woodland
Hierarchy Level: Subclass
Placement in Hierarchy: 1. Forest & Woodland (C01)
Lower Level Hierarchy Units:
1.A.1. Tropical Dry Forest & Woodland (F003)
1.A.2. Tropical Lowland Humid Forest (F020)
1.A.3. Tropical Montane Humid Forest (F004)
1.A.4. Tropical Flooded & Swamp Forest (F029)
1.A.5. Mangrove (F006)

Concept Summary

Type Concept Sentence: Tropical forests found at lowland and montane elevations including tropical dry forests, and lowland to montane humid forests (tropical rainforests) and tropical forested wetlands, where frost is essentially absent at sea level.

Classification Comments: Review of tropical monsoon forests is needed, as they can vary from dry to moist.

Similar NVC Types:

1.B. Temperate & Boreal Forest & Woodland (S15): Broad-leaved evergreen trees may be common in warm temperate forests, comparable to tropical dry forests (i.e., evergreen leaves are typically small), but deciduousness is caused by frost, and types are found where a hard frost occurs annually.

2.A. Tropical Grassland, Savanna & Shrubland (S01): Where tree cover exceeds 10 percent, stands are typically placed in the Tropical Forest & Woodland (S17). However, in tropical upland savanna regions, stands may have 40 percent tree cover, where trees are less than 8 m tall, tree regeneration is sparse to absent, and there is a substantial graminoid layer.

3.A. Warm Desert & Semi-Desert Woodland, Scrub & Grassland (S06): Thorn woodlands, with xeromorphic characteristics (aphyllous or very small-leaved trees, with succulents), are placed in this subclass, and rainfall is more typically between 25 and 100 cm.

7.A. Woody Agricultural Vegetation (CCL01): Tropical Forest & Woodland (S17) long-rotation plantations or woody restoration plantings with an irregular structure and a largely spontaneous ground layer may initially be similar to Woody Agricultural Vegetation (CCL01) in their early stages of development, especially if planted in rows and the understory is strongly manipulated.

Diagnostic Characteristics: Tropical Forest & Woodland is dominated by broad-leaved, often megaphyll, evergreen trees, broad-leaved drought-deciduous or semi-deciduous trees, or small-leaved (micro- to mesophyll evergreen trees). Evergreen needle-leaved trees may occur in association with these other growth forms. Climates are consistently warm (seasonal daily temperatures with minimal variation), and annual rainfall is typically greater than 100 cm.

Vegetation

Physiognomy and Structure: Tropical Dry Forest (typically called Tropical Dry Forest or Tropical Seasonally Dry Forest) range in canopy types, including evergreen, semi-evergreen (needle-leaved or broad-leaved), or largely or wholly deciduous Canopy heights decrease and canopy coverage tends to decrease as the climate dries until the forests are reduced to open, short-statured (5 - 15 m) woodlands (Whittaker 1975). Tree growth forms predominate, with micro- to mesophyll leaves, but succulent species may be present. They occur in humid dry tropical climates, typically with a pronounced dry season, during which some or all of the trees may lose their leaves, or leaves may be moderately small and evergreen sclerophyllous. Some tropical forests have a more sustained dry period, with less seasonality.

Tropical humid forests (including moist and wet forests) occur in the humid tropics where rainfall varies from abundant and well-distributed throughout the year to somewhat seasonal. Tree growth forms predominate, are tall, often of numerous species, some with buttressed bases, often smooth bark, and evergreen meso- to macrophyll leaves. Also present may be tree ferns, large woody climbers or lianas, and both vascular and nonvascular epiphytes, often of greater diversity than the ground layer. Heights may exceed 30 m (Whittaker 1975).

Tropical forested wetlands include swamps and mangroves, with hydrophytic plants and, in the case of mangrove, distinctive hydromorphic growth forms adapted to saline conditions.

Environment

Environmental Description:

Climate: In general, the tropical humid forest has a fairly consistent average annual temperature, ranging from 26 to 27 degrees C, and a more variable daily temperature, with changes up to 5 degrees C. In the tropical dry forest, average annual temperatures range between 20 and 30 degrees C, and daily temperatures change from between 26 to 28 degrees C. At sea level, frost is essentially absent from the Tropical Forest & Woodland (Holdridge 1967). Rainfall ranges from 100 to 450 cm (400 to 180 inches), with the rainfall becoming increasingly more seasonal in tropical dry climates, where the dry season may extend for 4 to 7 months (Holzman 2008).

Soil/substrate/hydrology: Soils in humid regions are often highly weathered ancient soils with high acidity and low nutrient and organic matter content; however, many tropical forests occur on rich volcanic or limestone soils. The major soil orders in the U.S. system include Oxisols, Ultisols, Inceptisols, and Entisols (Soil Survey Staff 1999) (see Brady and Weil 2002 for comparison of U.S. soil orders with Canadian and FAO systems). Younger and richer soils are found in alluvial habitats or in areas influenced by ashes from volcanic activity (Holzman 2008).

Distribution

Geographic Range: Tropical Forest & Woodland is concentrated around the equator with tropical humid forest most common between 0 and 10 degrees N and S latitude, and tropical dry forest between 10 and 23 degrees N and S, with latitudinal limits shaped by frost and drought. Tropical Forest & Woodland is found in three major regions: South and Central America and the Caribbean Islands; Africa (west, central, and interior) and Madagascar; and the Indo-Asian Pacific (India, Southeast Asia, Indonesia, New Guinea, Pacific Islands, and northeastern Australia).

Citations

Synonymy:

= Tropical Forest & Woodland (Holzman 2008)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen and E. Helmer

Acknowledgments:

Version Date: 26 Aug 2014

1.A.1. Tropical Dry Forest & Woodland (F003)

Overview

Database Code: 1.A.1 (F003)

Scientific Name: Tropical Dry Forest & Woodland Formation

Common Name (Translated Scientific Name): Tropical Dry Forest & Woodland Formation

Colloquial Name: Tropical Dry Forest & Woodland

Hierarchy Level: Formation
Placement in Hierarchy: 1.A. Tropical Forest & Woodland (S17)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical Dry Forest & Woodland is dominated by broad-leaved drought-deciduous, semi-deciduous, and small-leaved or sclerophyllous evergreen trees where rainfall is lower, often associated with more strongly seasonal, tropical climates, rainshadows, or drying winds. At continental scales, the largest areas occur between 10 and 23 degrees N and S latitude.

Type Concept: Tropical Dry Forest & Woodland, including most monsoon forests, occurs in extensive areas near the equator around the globe between about 10 and 23 degrees N and S latitude, though it is also be found near windward coasts and on the leeward sides of mountains or islands. These forests are dominated by broad-leaved drought-deciduous trees or small-leaved (micro- to mesophyll) evergreen trees or broad-leaved (meso- to macrophyll) sclerophyllous-leaved trees. Evergreen needle-leaved trees may occur in association with these other growth forms. It is a medium to high forest varying on average from 15 to 25 m tall, typically with several structural levels as complex upper canopy, several subcanopy levels of treelets and shrubs, woody vines, and an irregular low herbaceous plant stratum. Canopy heights decrease and canopy coverage tends to decrease as the climate dries until the forests are reduced to open, short-statured (5 - 15 m) woodlands (more rarely shorter). Included are semi-evergreen, partially sclerophyllous, semi-deciduous and deciduous, mostly dense to semi-dense forests adapted for a distinct period of seasonal winter drought, resulting in 4 to 7 months of drought (rainfall 60 mm or less), during which some or all of the trees lose their leaves. Annual rainfall ranges from 100 to 200 cm. The considerable diversity of dry tropical forests and woodland types are related to the topographic, hydric and edaphic variations as well as with the floristic composition and different biogeography.

Classification Comments: Mooney and others (1995) suggest that Tropical Dry Forest & Woodland may be defined as forest occurring in tropical regions characterized by pronounced seasonality in rainfall distribution, resulting in several months of drought. The forests that develop under such climatic conditions share a broadly similar structure and physiognomy; they mainly occur on oligotrophic, reddish soils (Oxisols, Ultisols), but may also occur on mesotrophic soils. Beyond that, they note that these shared characteristics are difficult to define with precision. They may either be deciduous or evergreen, though typically small-leaved, and either open- or closed-canopy. There are sclerophyllous evergreen broad-leaved (mesophyllous to macrophyllous-leaved) Tropical Dry Forest & Woodland in the Brazilian-Bolivian Cerrado. But we include here only the most closed form of cerrado (i.e. the cerradão) and the more typical cerrado is placed in *2.A. Tropical Grassland, Savanna & Shrubland (S01)*.

Many authors include thorn woodlands as part of a broadly defined "tropical dry forest" or "seasonally dry tropical forest" (SDTF). For example, Pennington and others (2006) use a wide interpretation of SDTF in the Neotropics, including formations as diverse as tall forest on moister sites to cactus scrub on the driest, but they exclude the Chaco of Argentina, Paraguay and Bolivia because it receives frost. See also Oliveira-Filho and others (2006) who include caatingas and carrascos within their broad definition of SDTF, but exclude cerrados and chaco. Here we treat *3.A.1 Tropical Thorn Woodland Formation (F039*) as a separate xeromorphic growth form-based formation that includes, in the Neotropics, caatingas, carrascos, and chaco.

Tropical monsoon forests are sometimes grouped with *1.A.2 Tropical Lowland Humid Forest Formation (F020)* as "tropical moist forest," but being deciduous with pronounced drought periods, they are better included here with *1.A.1 Tropical Dry Forest & Woodland Formation (F003)* (Whitmore 1998). Further review of the range of variation in tropical monsoon forests is needed, to clarify the transition to Tropical Lowland Humid Forest.

Similar NVC Types:

1.A.2. Tropical Lowland Humid Forest (F020): As seasonality increases, the abundance of drought-deciduous trees increases, and semi-evergreen humid forests more closely resemble Tropical Dry Forest & Woodland (F013). Tropical monsoon forests are sometimes grouped with Tropical Lowland Humid Forest as "tropical moist forest" (Whitmore 1998), but they are here included with Tropical Dry Forest & Woodland.

1.B.1. Warm Temperate Forest & Woodland (F018): Broad-leaved evergreen trees may be common in this formation, comparable to Tropical Dry Forest & Woodland (i.e., evergreen leaves are typically small), but deciduousness is caused by frost, and types are found north or south of around 23 degrees N and S latitude.

3.A.1. Tropical Thorn Woodland (F039): Thorn woodlands, with xeromorphic characteristics (aphyllous or very small-leaved trees, with succulents) are placed in this xeromorphic woodland formation (F039). Rainfall is between 25 and 100 cm. Tropical Dry Forest & Woodland grades to Tropical Thorn Woodland in areas with lower annual rainfall and increasing period of seasonal drought (in xeric warm bioclimates), while the trees and shrubs become fully deciduous and with a considerable increase of distinct xeromorphic adaptations such as thorns, succulency and clearly microphyllous species that instead are scarce or absent in Tropical Dry Forest & Woodland.

7.A.2. Intensive Forestry Plantation & Agroforestry Crop (F043): Tropical Dry Forest & Woodland (F003) long-rotation plantations or woody restoration plantings with an irregular structure and a largely spontaneous ground layer may initially be similar in their early stages of development, especially if planted in rows and the understory is strongly manipulated.

Diagnostic Characteristics: Tropical Dry Forest & Woodland is dominated by broad-leaved drought-deciduous trees or, more rarely, small-leaved (micro- to mesophyll) evergreen trees or broad-leaved (meso- to macrophyll) sclerophyllous-leaved trees. Thorn forest scrub, and scrubby cerrado are excluded. Evergreen needle-leaved trees may occur in association with these other growth forms. Climates are consistently warm (seasonal daily temperatures with minimal variation), and annual rainfall is strongly seasonal, but average annual rainfall is typically greater than 100 cm.

Vegetation

Physiognomy and Structure: Tropical Dry Forest & Woodland is dominated by broad-leaved drought-deciduous trees or, more rarely, small-leaved (micro- to mesophyll) evergreen trees or broad-leaved (meso- to macrophyll) sclerophyllous-leaved trees (Lugo and others 2006). Evergreen needle-leaved trees may occur in association with these other growth forms. It is a medium to high forest varying on average from 15 to 25 m tall, typically with several structural levels as complex upper canopy, several subcanopy levels of treelets and shrubs, woody vines, and an irregular low herbaceous plant stratum. Canopy heights decrease and canopy coverage tends to decrease as the climate dries until the forests are reduced to open, short-statured (5 - 15 m) woodlands (more rarely shorter). Included are semi-evergreen, partially sclerophyllous, semi-deciduous and deciduous, mostly dense to semi-dense forest (Whittaker 1975).

In the Neotropics the lower forest level is often dominated by colonies of clumping terrestrial bromeliads. Overall, there is predominance in the canopy of medium-sized leaves (mesophyllous) that fall partially or almost completely in the dry season. Tall arborescent cacti can be frequent in dry semi-deciduous forest of the Neotropics and physiognomically similar arborescent succulent euphorbias in the Paleotropics. In western Brazil, eastern Bolivia, and Paraguay, this formation includes large stands of medium-low and partially sclerophyllous semi-evergreen forests or “cerradão,” with characteristic adaptations to drought and fire, such as very corky bark on twisted trunks and xylopodiums (but we exclude the more typical cerrado, which is placed with *2.A. Tropical Grassland, Savanna & Shrubland (S01)*.

Environment

Environmental Description: *Climate*: Tropical Dry Forest & Woodland occurs in areas where the air subsides near the tropics of Cancer and Capricorn and the Intertropical Convergence Zone (ITCZ) migrates north and south seasonally, producing the alternating pattern of rainfall and dryness. The average drought season varies in length from 3 to 6 months and is generally coincident with the annual lowest temperatures. Annual rainfall ranges from 100 to 200 cm (Whitmore 1998), or where the annual rainfall is less than 160 cm, with a period of at least 5 to 6 months receiving less than 10 cm, during which some or all of the trees lose their leaves (Pennington and others 2006). The climate is warm tropical pluviseasonal, subhumid to humid.

Soil/substrate/hydrology: The substrate often includes large areas of highly weathered reddish soils with high iron and aluminum content and low mineral nutrients content, as well as frequent development of laterization. The main soil orders in the U.S. system associated with Tropical Dry Forest & Woodland are Oxisols, Ultisols and Alfisols (Soil Survey Staff 1999) [see Brady and Weil (2002) for comparison of U.S. soil orders with Canadian and FAO systems]. More rarely, they occur on mesotrophic soils. This type also occurs on limestone substrates in the Caribbean and Mesoamerica (Lugo and others 2006).

In most areas, Tropical Dry Forest & Woodland supports seasonal regimes of fire, both natural and characteristically human induced, which can cause frequent pyrogenic secondary savannized or woodland physiognomies. Fires, in conjunction with climate, are likely to partially explain the distribution of Tropical Dry Forest & Woodland (Bond and others 2005).

Tropical Dry Forest & Woodland tends to occur at lower elevations. However, in South America, large more-or-less isolated pockets occur in several valleys of the eastern slopes of the Andes, particularly in southern Peru and Bolivia, where they can reach altitudes up to approximately 1,200 m.

Distribution

Geographic Range: Tropical Dry Forest & Woodland is concentrated near the equator, primarily between 10 and 23 degrees N and S latitude. It is found in three major regions: South and Central America and the Caribbean Islands; Africa (west, central and interior) and Madagascar; and the Indo-Asian Pacific (India, Southeast Asia, Indonesia, New Guinea, Pacific Islands, and northeastern Australia).

In the Neotropics, this formation occupies large areas in central South America, mainly in eastern Bolivia, central and western Brazil, and eastern Paraguay. Also, in the Neotropics, these forests extend across northern South America (Venezuela) and in western Mesoamerica (Mexico to Panama), with minor extensions in western Ecuador and Peru.

In the Paleotropics, Tropical Dry Forest & Woodland potentially occupies large areas in Africa (Sudano-Zambezian and Madagascan regions), India and Southeast Asia (Indochinese region), northeastern Australia, and the Pacific Islands, but generally has been extensively degraded by human activity to semi-open woodlands and treesavannas.

Citations

Synonymy:

= Seasonally Dry Tropical Forests (Mooney and others 1995)
= Tropical Dry Forest (Miles and others 2006)
= Tropical Seasonal Forest (Holzman 2008)
= Tropical broadleaf woodland: biome type 8 (Whittaker 1975)
= Tropical seasonal forest: biome type 2 (Whittaker 1975)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: G. Navarro, D. Faber-Langendoen and E. Helmer

Acknowledgments:

Version Date: 26 Aug 2014

1.A.2. Tropical Lowland Humid Forest (F020)

Overview

Database Code: 1.A.2 (F020)

Scientific Name: Tropical Lowland Humid Forest Formation

Common Name (Translated Scientific Name): Tropical Lowland Humid Forest Formation

Colloquial Name: Tropical Lowland Humid Forest

Hierarchy Level: Formation

Placement in Hierarchy: 1.A. Tropical Forest & Woodland (S17)

Lower Level Hierarchy Units

See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical Lowland Humid Forest is dominated by broad-leaved evergreen trees, often with multiple complex strata and growth forms in lowland to submontane or premontane elevations with aseasonal to moderately seasonal rainfall and warm temperatures.

Classification Comments: Heath forests are a striking variant within this formation, as described by Richards (1996) and Whitmore (1998). They occur on podsolized soils developed from siliceous sand, either coastal alluvium or weathered sandstones. Although typically found in a rainforest climate and retaining basic growth forms characteristic of *1.A.2 Tropical Lowland Humid Forest Formation (F020)*, the nutrient-poor, acidic conditions produce a strikingly distinct physiognomy. Here are found dense, often pole-sized trees, a stronger predominance of microphylls over mesophylls, with some sclerophylly, and woody climbers that are more often slender. The most extensive heath forests are found in the upper reaches of the Rio Negro and Rio Orinoco of South America, also in Guyana (wallaba forests of *Eperua falcata*), coastal forests of southeastern Madagascar, Gabon, Cameroon and Ivory Coast, and in Kalimantan, Sarawak and Brunei in Borneo (referred to as kerangas), and parts of Malaya (Whitmore 1998).

Tropical montane forests may resemble heath forests to some degree (Whitmore 1998). Tropical monsoon forests are sometimes grouped with Tropical Lowland Humid Forest as "tropical moist forest" (Whitmore 1998), but by and large, they are included with *1.A.1 Tropical Dry Forest & Woodland Formation (F003)*. Further review is needed of the transition between monsoon forests and humid forests or rainforests.

Similar NVC Types:

1.A.1. Tropical Dry Forest & Woodland (F003): As climate becomes more seasonal, increasing numbers of deciduous trees are found. Stands are placed in Tropical Dry Forest & Woodland when greater than 25 percent cover of trees are deciduous during a dry period, or where small-leaved (micro- to mesophyll) trees dominate. These forests also share some characteristics with the heath forest variant of Tropical Lowland Humid Forest.

1.A.3. Tropical Montane Humid Forest (F004): Montane rainforests at highest elevations are considerably smaller and heavily covered with bryophytes, but lower elevation montane forests (towards 1000 m) share similarities with Tropical Lowland Humid Forest.

1.A.4. Tropical Flooded & Swamp Forest (F029): Soils are typically saturated to flooded, but many of the growth forms are shared with Tropical Lowland Humid Forest.

Diagnostic Characteristics: Tropical Lowland Humid Forest is dominated by meso- to megaphyll, broad-leaved evergreen trees (up to 25 percent deciduous trees), with a complex multi-layer structure, often exceeding 30 m in height. Climates are consistently warm (seasonal daily temperatures with minimal variation), and annual rainfall is relatively aseasonal and typically greater than 100 cm, with any given month rarely less than 60 mm.

Vegetation

Physiognomy and Structure: Tropical Lowland Humid Forest is a dense, multi-layered forest, with broad-leaved evergreen trees that can exceed 45 m in height. The tree layer is minimally divided into a top stratum with giant emergent trees, over a main stratum between 25 and 35 m tall, under which a stratum of shorter trees between 10 and 25 m occurs. Ground vegetation may be sparse, commonly with small trees (treelets). Herbs may be patchy. Individual trees may be deciduous or semi-deciduous, but overall comprise less than 25 percent of the main stratum. Evergreenness varies from completely evergreen to evergreen seasonal forest (which is mainly evergreen but individual trees may lose their leaves) to semi-evergreen seasonal forest (in which up to about 25 percent of the main canopy may be deciduous) (Richards 1996). Whitmore (1998) notes the following features: buttresses are common, cauliflory and ramiflory are occasional to common, pinnate leaves are frequent, leaf blades of mesophyll size predominate, big woody climbers (mostly free-hanging) are frequent to abundant, bole climbers, shade and sun epiphytes are occasional to frequent, and bryophytes are rare (Table 5). These characteristics are lost as forests become drier or as elevation increases.

Environment

Environmental Description: *Climate*: Tropical Lowland Humid Forest (including semi-evergreen rainforest) occurs in aseasonal, humid climates where water stress is low to absent, with no regular annual dry season (Whitmore 1998). In general, a tropical rainforest climate can be defined as one with monthly mean temperatures of at least 18 degrees C throughout the year, and an annual rainfall of at least 170 cm (and usually above 200 cm) and either no dry season or a short one of fewer than 4 consecutive months with less than 10 cm rainfall (Richards 1996; Whitmore 1998).

African rainforests are primarily semi-evergreen (where deciduous trees may comprise up to 25 percent of the main canopy), as are Australian rainforests, and various parts of other regional rainforest blocks (Whitmore 1998).

Soil/substrate/hydrology: These forests generally occur from sea level to approximately 1,200 m elevation, but the boundary between lowland and montane forests occurs at different elevations depending on the "Massenerhebung effect" (Collins 1990; Richards 1996). This is a phenomenon whereby large mountains and the central parts of large ranges are warmer at given elevations than small mountains and outlying spurs. Thus Collins (1990) mapped the boundaries in the Caribbean, Central America, Madagascar, Australia and Southeast Asia at 910 m, whereas in West Africa the boundary was set at 1200 m, in New Guinea at 1,400 m and in South America at 1800 m.

Soils are often ancient and deeply weathered, with little organic darkening of the topsoil and with bright reddish or yellowish colors throughout the subsoil. Few of the original rock minerals remain in the upper horizon. Organic content may vary. Soils are often clay-like, but weathered sands also occur. Other more recent soils include those found on recent volcanic deposits, colluvial and alluvial soils (Richards 1996).

Distribution

Geographic Range: Tropical Lowland Humid Forest is concentrated around the equator, between the Tropic of Cancer (23 degrees N latitude) and Tropic of Capricorn (23 degrees S latitude). It is found in three major regions: South and Central America; Africa (west, central and interior) and Madagascar; and the Indo-Asian Pacific (India, Southeast Asia, Indonesia, New Guinea, Pacific Islands, and northeastern Australia). In the United States, it is found in Hawaii and in several territories, including Puerto Rico and many of its Pacific island territories.

Citations

Synonymy:
= Lowland tropical rain forest: biome type 1 (Whittaker 1975)
= Tropical Rain Forest (Richards 1996)
> Tropical heath forest (Whitmore 1998) [Heath forests occur on podsolized soils developed from siliceous sand, either coastal alluvium or weathered sandstones. The nutrient-poor, acidic conditions produce a strikingly different physiognomy of dense, often pole-sized trees, stronger predominance of microphylls over mesophylls, with some sclerophylly. Woody climbers are more often slender.]
> Tropical lowland evergreen rain forest (Whitmore 1998) [Whitmore separates out tropical semi-evergreen rainforest, which is here combined at the formation level.]
> Tropical semi-evergreen rain forest (Whitmore 1998) [Whitmore separates out tropical lowland evergreen rainforest, which is here combined at the formation level.]
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen
Acknowledgments:
Version Date: 26 Aug 2014

1.A.3. Tropical Montane Humid Forest (F004)

Overview

Database Code: 1.A.3 (F004)
Scientific Name: Tropical Montane Humid Forest Formation
Common Name (Translated Scientific Name): Tropical Montane Humid Forest Formation
Colloquial Name: Tropical Montane Humid Forest
Hierarchy Level: Formation
Placement in Hierarchy: 1.A. Tropical Forest & Woodland (S17)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical Montane Humid Forest is dominated by broad-leaved evergreen trees, with increasingly small leaves and stems, often gnarly, with dense crowns as elevations increase. These forests are generally found within 23 degrees N and S latitude of the equator between 1,000 and 3,500 m in elevation.

Classification Comments: The proportion of precipitation that is from clouds is a defining factor, but is difficult to assess. Tropical Montane Humid Forests resemble heath forests to some degree (Whitmore 1998), with their wet climate, but have smaller stems and leaves.

Similar NVC Types:

1.A.2. Tropical Lowland Humid Forest (F020): These rainforests are typically much taller, with multiple strata and growth forms, but as elevations increase (up to 1,000 m), a transition occurs to lower elevation Tropical Montane Humid Forest.

Diagnostic Characteristics: Tropical Montane Humid Forest is dominated by micro- to mesophyll, broad-leaved evergreen trees (up to 25 percent deciduous trees), with a simple or two-layer structure, ranging from 5 to 30 m in height. Climates are more often cool, but without frost, with seasonal daily temperatures with minimal variation. Annual rainfall is relatively aseasonal and typically greater than 100 cm, with any given month rarely receiving less than 60 mm. The proportion of precipitation that is from clouds is a defining factor, but is difficult to assess. Better defining characteristics are the amounts of epiphytes and ferns and where the epiphytes occur as well as canopy structure.

Vegetation

Physiognomy and Structure: Tropical Montane Humid Forest is dominated by broad-leaved evergreen trees, with increasingly small leaves and stems, often gnarly, with dense crowns as elevations increase. Lower elevations represent a transition from *1.A.2 Tropical Lowland Humid Forest Formation* (F020) [see Table 5]. At the highest elevations, the trees may be less than 10 m tall (sometimes referred to as elfin woodland), and covered in bryophytes, ferns, and other epiphytic plants. Peat may form, sometimes with sphagnum mosses (*Sphagnum* spp.). These in turn may be replaced by a kind of "tropical subalpine forest" with very tiny leaves (nanophylls), as found in New Guinea and the Andes (Whitmore 1998). Treeline is typically reached between 3500 and 4000 m, where the vegetation transitions to "tropical high montane grassland and shrubland" (tropical "alpine" vegetation).

Environment

Environmental Description: *Climate*: Climates are more often cool, but without frost, with seasonal daily temperatures with minimal variation. Annual rainfall is relatively aseasonal and typically greater than 100 cm, with any given month rarely receiving less than 60 mm. The proportion of precipitation that is from clouds is a defining factor, though this is difficult to know in the field. Better defining characteristics are the amounts of epiphytes and ferns and where the epiphytes occur as well as canopy structure.

Soil/substrate/hydrology: Tropical Montane Humid Forest is typically found between elevations of 1,000 to 3,500 m, with the treeline typically reached between 3,500 and 4,000 m. But the boundary between lowland and montane forests occurs at different elevations depending on the "Massenerhebung effect" (Collins 1990; Richards 1996). This is a phenomenon whereby large mountains and the central parts of large ranges are warmer at given elevations than small mountains and outlying spurs. Thus Collins (1990) mapped the boundaries in the Caribbean, Central America, Madagascar, Australia, and Southeast Asia at 910 m, whereas in West Africa the boundary was set at 1,200 m, in New Guinea at 1,400 m, and in South America at 1,800 m.

Distribution

Geographic Range: Tropical Montane Humid Forest is generally found around the globe within 23 degrees N and S latitude of the equator, typically between 1000 and 3500 m in elevation. It is found extensively in Central and South America, especially the Andes and parts of the Caribbean, and is uncommon in Africa (Cameroon and the eastern fringe of the Congo basin) and many mountain regions throughout the Indo-Malayan region.

Citations

Synonymy:
= Elfinwoods: biome-type 7 (Whittaker 1975)
= Tropical montane rain forests (Whitmore 1998) [Whitmore (Table 2.2) discusses the range of variation between lower and upper montane rainforests.]
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen, E. Helmer and J. Sawyer
Acknowledgments:
Version Date: 26 Aug 2014

1.A.4. Tropical Flooded & Swamp Forest (F029)

Overview

Database Code: 1.A.4 (F029)
Scientific Name: Tropical Flooded & Swamp Forest Formation
Common Name (Translated Scientific Name): Tropical Flooded & Swamp Forest Formation
Colloquial Name: Tropical Flooded & Swamp Forest
Hierarchy Level: Formation
Placement in Hierarchy: 1.A. Tropical Forest & Woodland (S17)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical Flooded & Swamp Forest is a forested or wooded wetland and peatland found in margins of freshwater lakes, alluvial plains, rivers and depressions around the globe.

Classification Comments: Forests may vary from deciduous to evergreen. Further review is needed of the degree of variation in evergreen versus deciduous-leaved trees between floodplains and swamps in tropical dry versus moist-wet climates.

Similar NVC Types:

1.A.2. Tropical Lowland Humid Forest (F020): Overall dominant growth forms are similar, but forest structure is more complex in Tropical Lowland Humid Forest, and the soils are not saturated or inundated. Tree palms and lianas are more common.

1.A.5. Mangrove (F006): As concentrations of salts decline, Mangrove (F006) may grade into Tropical Flooded & Swamp Forest.

Diagnostic Characteristics: This formation is dominated by mesophyll, broad-leaved, evergreen trees, with soils saturated to flooded for all or parts of the year, varying from peat to mineral soil textures. Climates are consistently warm (seasonal daily temperatures with minimal variation).

Vegetation

Physiognomy and Structure: Tropical Flooded & Swamp Forest is a forested or wooded wetland and peatland. Structural characteristics that recur in flooded forests are presence of monospecific stands such as palm swamp, even-canopied forests, and sharp vegetation zonations. It is common to find that trees in flooded tropical forests develop sclerophylly (firm, thickened leaves) due to poor nutrition or water limitations, or gas exchange structures (e.g. pneumatophores, lenticels, knees, aerial roots, swelling of base of trees, surface or aerial roots) in order to overcome poor soil aeration, or support structures (e.g. plank buttresses and stilt roots) to provide stability in muddy or steep conditions. Tree heights can vary greatly, from 1 to 50 m.

Based on the type of dominant species, swamp forests can be conveniently divided into two types: forests dominated by broad-leaved evergreen hardwood species and those dominated by palms. Dominance by palms becomes stronger with increasing hydroperiod or soil moisture conditions. Species richness generally decreases with increasing hydroperiod. One formation that covers large areas in western Amazonia and in the Orinoco River basin is the often monodominant “aguajales” or *Mauritia flexuosa* stands. These palm swamps may be regularly affected by riverine floods, but they mostly occur farther from current river channels, the water-logged condition then being maintained by a combination of high precipitation and poor drainage in depressional terrain. Other palm-associated (*Raphia, Manicaria*) swamps are typical of the coastal regions of Central America and northern South America along estuarine channels, sometimes in mixed stands with a few mangrove species.

Environment

Environmental Description: *Soil/substrate/hydrology*: Tropical swamp forests can be divided into freshwater or brackish swamp or floodplain forest (along rivers and lakes) and peat swamp forest (formed behind natural floodplain levees), where peat layers may be well in excess of 1 m thick (Whitmore 1984). The floodplain forests are found along rivers, streams, coasts and lakes. They have a dynamic water table, with seasonal flooding inundating the vegetation for short (<7 days) to long (>1 month) periods, leading to an influx of sediment and mineral enrichment during high water periods. Information about underlying soils is scarce.

Many floodplain swamp forests are potentially peat-accumulating, but, although studies on this subject exist in Southeast Asia, they have apparently never been published for the Amazon basin (Whitmore 1998). Swamps and other types of wetlands in the Neotropics have been described in terms of their vegetation composition, structure, and geomorphology, but studies have failed to deal with peat formation or detailed descriptions of the underlying soils. There is evidence that at least the *Mauritia* swamps frequently accumulate peat of some kind.

The lowland tropical peat swamps are formed from layers of woody debris too waterlogged to fully decompose. Slowly deposited over thousands of years, the carbon-rich peat strata have been known to reach a thickness of up to 20 m. In Indonesia the ombrogenous peatlands are mostly formed on the inward edge of the mangroves. They are usually dome-shaped and several meters thick overlying the mangrove mineral soil; the whole sequence taking several thousand years. Periods with rising sea levels promote the formation of very deep peat layers up to 20 m thickness with the alluvial soil far below present sea levels. Peat domes younger than 3,000 years do have the alluvial soil at about present mean sea level.

The initial rate of vegetation growth and peat build up is rapid, as the alluvial mangrove soils are nutrient rich. As the peat accumulates, it builds up above the level of the nutrients in the alluvial soils that are accessible for the plant roots. In that case, the mineral supply to the vegetation depends on the minerals in the rainwater and available nutrients of the decaying vegetation in the surface layer. As the swamp ages and the peat layer increases, nutrients become increasingly scarce, tree growth and litter production are reduced, and growth of the whole formation slows down.

Besides its association with mangroves, the lowland Neotropical peatlands are associated with palm swamps and open herbaceous marshes. The latter apparently are relatively nutrient rich, since surface runoff water easily reaches all parts of the swamps. Furthermore, the layer of organic material is usually thin enough for the roots of the plants to have direct contact with the underlying mineral soil. In the case of palm swamps, they may be regularly affected by riverine floods, but for most of their extent they occur farther from current river channels, the water-logged condition then being maintained by a combination of high precipitation and poor drainage, which makes them ombrogenous types of peatlands.

Distribution

Geographic Range: Flooded forest systems are a regular feature of the low-lying coastal areas in the West Indies, southern Mexico, Central America, and northern South America. In South America, the greatest extent of flooded forest occurs in Amazonia, and in the basins of other important rivers, such as the Orinoco and the Atrato. However, the most complex mosaics of wetlands, savannas, and flooded forests are maybe those of the Beni in Bolivia and the Brazilian Pantanal, on very extensive flat basins subject to a strong seasonality in the precipitation. Some of the extensive floodplains of South America include treed and shrub swamps that are located off the direct influence of the main river channels, usually occupying past, silted up river arms or depressed areas with inflows product of runoff and seepage or only sporadic, extreme river floods.

Citations

Synonymy:
> Freshwater swamp forest (Whitmore 1998) [Whitmore divides the Tropical Swamp & Flooded Forest into two formations based on peat or mineral soils.]
> Peat swamp forest (Whitmore 1998) [Whitmore divides the Tropical Swamp & Flooded Forest into two formations based on peat or mineral soils.]
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: C. Josse and G. Navarro
Acknowledgments:
Version Date: 26 Aug 2014

1.A.5. Mangrove (F006)

Overview

Database Code: 1.A.5 (F006)
Scientific Name: Mangrove Formation
Common Name (Translated Scientific Name): Mangrove Formation
Colloquial Name: Mangrove
Hierarchy Level: Formation
Placement in Hierarchy: 1.A. Tropical Forest & Woodland (S17)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Mangroves are dominated by broad-leaved evergreen trees, with complex aerial root systems, found in estuarine and coastal marine habitats that form a typically narrow fringe along the coasts of tropical latitudes worldwide.

Similar NVC Types:

1.A.4. Tropical Flooded & Swamp Forest (F029): As concentrations of salts decline, Mangrove (F006) may grade into this formation.

2.C.5. Salt Marsh (F035): Dwarf mangroves may grade into tropical salt marshes.

Diagnostic Characteristics: Broad-leaved evergreen trees, with complex aerial root systems (including aerial “stilt” roots and pneumatophores), found in tropical estuarine and coastal marine habitats.

Vegetation

Physiognomy and Structure: Physiognomically, mangroves vary in size from shrubby dwarf trees to tall trees, with mesophyll, evergreen leaves. They have a complex set of aerial roots. Roots may diverge from the tree as much as 2 m above ground and penetrate the soil away from the main stem. Secondary roots may branch off, creating a “stilt root” structure. They also may contain pneumatophores (root extensions growing up above the water surface) emerging 30 cm or more above the muddy surface. Their adaptations to cope with seawater include methods of salt secretion, exclusion and accumulation.

Environment

Environmental Description: *Soil/substrate/hydrology*: Mangroves (mangal, mangle) are tidal, estuarine forested wetlands that occur along the (sheltered) coasts of tropical latitudes of the Earth. They are commonly found on the intertidal mudflats along the shores of estuaries, usually in the region between the salt marshes and seagrass beds. Where tidal amplitude is relatively low, they form narrow bands along the coastal plains, and rarely penetrate inland more than several kilometers along rivers. Where tidal amplitude is greater, mangroves extend farther inland along river courses forming extensive stands in the major river deltas. Mangrove cays occur also within the lagoon complex of barrier reefs (Stoddart and others 1982). In general, mangroves fall within two categories: mangroves of oceanic islands and inland mangroves. The latter need to adapt to a pronounced variation in salinity due to the variations in freshwater carried from the interior streams, while the former owe the salinity gradient to the rate of evaporation in the shallow ponds and mudflats and the rainfall on site, especially in the case of small to very small islands.

Gilmore and Snedaker (1993) described five distinct types of mangrove forests based on water level, wave energy, and pore water salinity: (1) mangrove fringe forests, (2) overwash mangrove islands, (3) riverine mangrove forests, (4) basin mangrove forests, and (5) dwarf mangrove forests. Dwarf forests are most commonly observed in south Florida, around the vicinity of the Everglades, but occur in all portions of the range where physical conditions are suboptimal, especially in drier transitional areas.

Rainfall plays an important role in distribution and species composition because rainfall regulates salt concentrations in soils and plants, as well as providing a source of freshwater for the mangroves. This is an important factor when propagules begin to take root and when mature individuals bloom and fruit. If high rainfall occurs over a short period and other months of the year are prone to drought, the conditions can be considered unfavorable for the growth and distribution of mangroves.

Mangroves provide habitats for commercially important crustaceans; are important nursery grounds for juvenile fish; filter and trap pollutants and sediments from land runoff thus maintaining estuarine water quality; provide barriers and buffer zones to stabilize shorelines and prevent coastal erosion; and are also a major producer of organic material. Mangroves protect the coast against erosion, but monsoons and storms cause large waves and winds to erode the coast, destroying many mangrove areas. Sea level rise, together with monsoons or hurricanes and storms, accelerates the speed of mangrove coastal erosion.

Mangroves cannot tolerate frost, especially in the seedling stage, but mangroves are also regulated by sea temperatures, rarely occurring outside the range delimited by the winter position of the 20 degree C isotherm (Hogarth 2007). It is not entirely clear why mangroves are limited to the tropics. Given their pan-tropical distribution and the wide availability of muddy, saline habitats in temperate regions, there would seem to be many suitable opportunities to spread into these latitudes. Hogarth (2007) suggests that perhaps the combination of being a tree, tolerating salt, and coping with waterlogging creates a metabolic cost that is difficult to sustain in lower temperatures and shorter day lengths.

Distribution

Geographic Range: Mangroves occur along the (sheltered) coasts of tropical latitudes of the Earth, typically between the equator and 23 degrees N and S, but mangroves occur considerably southward in southeastern Australia. Mangrove distribution appears to be limited by both frost and sea temperatures, rarely occurring outside the range delimited by the winter position of the 20 degree C isotherm (Hogarth 2007). They are estimated to cover 18 million ha (Spalding and others 1997, in Hogarth 2007).

Citations

Synonymy:
= Mangrove vegetation (mangal) (Richards 1996)
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: C. Josse
Acknowledgments:
Version Date: 26 Aug 2014

1.B. Temperate & Boreal Forest & Woodland (S15)

Overview

Database Code: 1.B (S15)
Scientific Name: Temperate & Boreal Forest & Woodland Subclass
Common Name (Translated Scientific Name): Temperate & Boreal Forest & Woodland Subclass
Colloquial Name: Temperate & Boreal Forest & Woodland
Hierarchy Level: Subclass
Placement in Hierarchy: 1. Forest & Woodland (C01)
Lower Level Hierarchy Units:
1.B.1. Warm Temperate Forest & Woodland (F018)
1.B.2. Cool Temperate Forest & Woodland (F008)
1.B.3. Temperate Flooded & Swamp Forest (F026)
1.B.4. Boreal Forest & Woodland (F001)
1.B.5. Boreal Flooded & Swamp Forest (F036)

Concept Summary

Type Concept Sentence: Temperate & Boreal Forest & Woodland is typically dominated by broad-leaved deciduous and needle-leaved trees, with some broad-leaved evergreens in warmer regions, and a climate that varies from warm temperate with only rare frosts to very cold subarctic conditions. It is found across the globe in the mid latitudes, typically between 25 and 60 to 70 degrees N and S latitude, and includes boreal, cool temperate, and warm temperate/Mediterranean forests.

Classification Comments: Warm temperate forests and woodlands are defined here to include both the classic Mediterranean forests and woodlands and the more humid warm temperate forests. Both share increasing levels of broad-leaved evergreen trees, including sclerophyllous-leaved trees, as well as evergreen shrubs and herbs, as compared to other temperate forests and woodlands. Walter (1985) recognizes two warm temperate biomes, the “Zonobiome of the Winter-Rain Region with an Arid-Humid Climate and Sclerophyllic Woodlands” (Zone IV) and the “Zonobiome of the Warm-Temperate Humid Climate” (Zone V), distinct from the cool-temperate biome “Zonobiome of the Temperate-Nemoral Climate” (Zone VI) and the boreal biome “Zonobiome of the Cold-Temperate Boreal Climate” (Zone VIII). Schultz (1995) also recognizes the two warm-temperate regions, which he refers to as: “Mediterranean-Type subtropics” (with world distribution shown in his Figure 129) and “Humid subtropics” (with world distribution shown in his Figure 171).

Similar NVC Types:

1.A. Tropical Forest & Woodland (S17): There is a strong dominance by broad-leaved evergreen trees, and deciduousness is caused by drought rather than forest composition.

2.B. Temperate & Boreal Grassland & Shrubland (S18): Tree cover is less than 10 percent.

7.A. Woody Agricultural Vegetation (CCL01): Long-rotation plantations or woody restoration plantings of Temperate & Boreal Forest & Woodland (S15) with an irregular structure and a largely spontaneous ground layer may initially be similar in their early stages of development to Woody Agricultural Vegetation (CCL01), especially if planted in rows and the understory is strongly manipulated.

Diagnostic Characteristics: Temperate & Boreal Forest & Woodland is typically dominated by broad-leaved deciduous and needle-leaved trees, with some broad-leaved evergreens in warmer regions (See Table 8). Climate varies from warm temperate with only rare frosts and snow to cold subarctic conditions. It is found across the globe typically between 25 and 60 to 70 degrees N and S latitude.

Table 8—Characteristics of Boreal and Temperate Forests.

Criterion	Boreal Forest & Woodland (upland and wetland)	Cool Temperate Forest & Woodland (upland and wetland)	Warm Temperate Forest & Woodland (upland and wetland)
Dominant Growth Forms	Needle-leaved (usually evergreen) conifer, often strongly conical-shaped, and simple, broad-leaved, small mesophyll deciduous hardwoods.	Broad-leaved deciduous or evergreen needle-leaved conifer, alone or in mixes, variable leaf and crown shapes, and leave sizes typically mesophyll with a seasonal green understory of herbs. The tall-shrub layer is variable, and is often broad-leaved deciduous, but the short-shrub layer may be heath. The moss layer is often sparse, but more dominant in cold, rainy and/or high montane needle-leaved evergreen stands.	Broad-leaved evergreen trees, microphyll to small mesophyll leaves, sometimes dwarfed stems, sclerophyllous or small-leaved trees (e.g., eucalypts, sclerophyllous oaks); or various combinations of broad-leaved deciduous, broad-leaved evergreen or evergreen needle-leaved conifer trees.

(continued)

Table 8—(Continued).

Criterion	Boreal Forest & Woodland (upland and wetland)	Cool Temperate Forest & Woodland (upland and wetland)	Warm Temperate Forest & Woodland (upland and wetland)
Location	Northern Hemisphere south of the arctic treeline.	Middle latitudes of North America, western and far-eastern Eurasia, and an isolated small area in the middle latitude of South America.	Mediterranean Basin and Mediterranean and warm temperate regions in North America (California, Southeast Coastal Plain), Chile, South Africa, Australia, India and Southeast Asia.
Climate Type	Cold snow climates, with extended cold winters and short mild summers, frozen soils in winter.	Humid temperate climates with distinctive spring, summer, autumn, and cool to cold winter seasons, with freezing temperatures.	Mild (mostly frost-free) winter, temperate humid spring, hot-dry summer, and mild, often dry autumn seasons. Rainy season in winter and dry summers (Mediterranean).
Temperature	Lengthy periods of freezing temperatures with the coldest month isotherm –3 ^{o}C, with the growing season generally averaging less than 100 days, occasionally interrupted by nights of below-freezing temperatures.	Freezing temperatures usually of moderate duration, although of frequent occurrence during winter months. Potential growing season generally from 100 to 200 days and confined to late spring and summer when freezing temperatures are infrequent or absent.	Freezing temperatures of short duration but generally occurring every year during winter months. Potential growing season more than 200 days with less than an average of 150 days a year subject to temperatures below 0 ^{o}C or chilling fog.
Precipitation Controls	Seasonal shift of polar front.	Summer convectional storms, Atlantic hurricanes, Asian monsoons.	Stationary high-pressure cells in summer.
Precipitation (annual)	38–50 cm (15–20 inches)	50–125 cm (20–50 inches).	25–100 cm (10–40 inches) (Mediterranean).
Dominant Soil-Forming Process	Podzolization	Podzolization.	Severe weathering.
Major Soil Orders (Soil Survey Staff 1999)	Gelisols, some Spodosols in south.	Alfisols and Ultisols, some Spodosols in north.	Various, Ultisols and Alfisols common.
Soil Characteristics	Sandy ash-colored A horizon; accumulation of minerals in B horizon; generally low in natural fertility.	Gray forest soils with accumulated silicate clay minerals in B horizon; some (Alfisols) with relatively high natural fertility; more leached soils in southern areas (Ultisols) due to higher precipitation levels.	Naturally productive soils, some regions worn by thousands of years of human use.
Biogeographic History	Recent-post Pleistocene migration of plants and animals.	Recent-post Pleistocene to ancient Tertiary origins.	Recent to more ancient, some regions influenced by thousands of years of human use.

Vegetation

Physiognomy and Structure: Temperate forests and woodlands include temperate rainforest, temperate deciduous forest, and temperate evergreen forests and woodlands. They are dominated by broad-leaved or needle-leaved growth forms. Trees typically range in height from 10 to 30 m, but rainforest trees may attain great height, exceeding 50 m. Temperate broad-leaved deciduous and needle-leaved forests and wooodlands grow in cool temperate continental climates, with summer rainfall and cold winters, during which the broad-leaved trees lose their leaves, extending to high montane regions, where they resemble boreal forests and woodlands. Temperate broad-leaved evergreen forests and woodlands, often mixed with broad-leaved deciduous and needle-leaved trees, occur in warm-temperate climates, with either mild winters and moist, warm summers, or winter-rain winters and dry, warm summers (Mediterranean). Tree species diversity is low in temperate forests and woodlands (Whittaker 1975).

Boreal Forest & Woodland contains primarily needle-leaved evergreen trees, with or without boreal broad-leaved deciduous trees. Structure varies from tall, closed canopy (but rarely exceeding 15 m) to open, low (<5 m) subarctic woodlands. Nonvascular mosses and lichens may predominate in the ground layer. Winters are very cold and vary from arid to moist. Temperate high montane forest may resemble Boreal Forest & Woodland (Whittaker 1975).

Environment

Environmental Description: Soil orders in Table 8 are described using the U.S. soil orders (Soil Survey Staff 1999). See Brady and Weil (2002) for comparison of U.S. soil orders with Canadian and FAO systems.

Distribution

Geographic Range: Temperate forests and woodlands range from the giant forests of the Pacific Coast of North America, or the Australian temperate rainforests, to New Zealand and Chile, to montane forests in various locations. Temperate forests and woodlands occur across much of the United States and southern Canada, in limited parts of Mesoamerica, Western Europe, Mediterranean regions, Southeast Asia, southern Australia, and limited parts of Chile. Boreal forests and woodlands occur in the northern regions of North America and Eurasia. A few isolated areas may occur in the Southern Hemisphere.

Citations

Synonymy:

= Temperate Forest Biomes (Kuennecke 2008) [Kuennecke includes boreal, cool temperate, and warm temperate (Mediterranean) formations as part of his "temperate forest biomes" concept.]

= Temperate and boreal woodlands & scrub (Mucina 1997) [Mucina created this type as an organizational category for Braun-Blanquet classes and did not define it as a formal type.]

> Temperate broad-leaved forests and scrub (Rodwell and others 2002) [European cool and warm temperate forests and floodplain forests are included in the subclass, but boreal forests are excluded.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen
Acknowledgments:
Version Date: 26 Aug 2014

1.B.1. Warm Temperate Forest & Woodland (F018)

Overview

Database Code: 1.B.1 (F018)
Scientific Name: Warm Temperate Forest & Woodland Formation
Common Name (Translated Scientific Name): Warm Temperate Forest & Woodland Formation
Colloquial Name: Warm Temperate Forest
Hierarchy Level: Formation
Placement in Hierarchy: 1.B. Temperate & Boreal Forest & Woodland (S15)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Warm Temperate Forest & Woodland is dominated by broad-leaved evergreen trees, sometimes with dwarfed stems and small, sclerophyllous leaves (in Mediterranean climates), or various combinations of broad-leaved deciduous, broad-leaved evergreen and needle-leaved evergreen conifer trees. Winters are mild (mostly frost free) and may be the rainiest season, springs are temperate-humid, summers are hot-dry, and autumn is often dry.

Classification Comments: The warm-temperate Mediterranean regions around the world typically contain both the classic Mediterranean scrub (*2.B.1. Mediterranean Scrub & Grassland Formation (F038)*), and the forests and woodlands included here. Cool-temperate and warm-temperate forests may be difficult to distinguish, but cool-temperate forests are more strongly dominated by broad-leaved deciduous trees, and broad-leaved evergreen trees are essentially absent. Braun (1950) includes at least parts of these warm-temperate forests in her "Deciduous Forest Formation" (the "Southeastern Evergreen Forest Region"), but briefly notes a "Subtropical Broad-leaved Evergreen Forest" that includes central Florida southward.

Various ecoregional treatments recognize the distinct vegetation and climate of the warm-temperate region, e.g., Brown and others (1998) separates cool-temperate from warm-temperate vegetation. Walter (1985) recognizes two warm-temperate biomes, the "Zonobiome of the Winter-Rain Region with an Arid-Humid Climate and Sclerophyllic Woodlands" (Zone IV) and the "Zonobiome of the Warm-Temperate Humid Climate" (Zone V), distinct from the cool-temperate biome "Zonobiome of the Temperate-Nemoral Climate" (Zone VI) and the boreal biome "Zonobiome of the Cold-Temperate Boreal Climate" (Zone VIII). Similarly, Schultz (1995) recognizes the two warm temperate regions, which he refers to as: "Mediterranean-Type subtropics" (with world distribution shown in his Figure 129) and "Humid subtropics" (with world distribution shown in his Figure 171). We prefer the term warm temperate to subtropics. Schultz states that "apart from the driest sites and those with lowest nutrient contents, all the regions of the Mediterranean Type subtropics were originally covered by forests of mostly evergreen sclerophyllous species of trees" and in the European Mediterranean region, these were mostly evergreen oak, such as *Quercus ilex*. Today, many of these regions are more typically dominated by sclerophyllous shrub formations, as described in 2.B.1 Mediterranean Scrub & Grassland Formation (F038).

Similar NVC Types:

1.A.1. Tropical Dry Forest & Woodland (F003): Broad-leaved evergreen trees may be common in Warm Temperate Forest & Woodland (F018), comparable to Tropical Dry Forest & Woodland (F003) (i.e., evergreen leaves are typically small), but deciduousness in Warm Temperate Forest & Woodland is caused by frost, and types are found north or south of 23 degrees N and S latitude.

1.B.2. Cool Temperate Forest & Woodland (F008): More strongly dominated by broad-leaved deciduous trees; broad-leaved evergreen trees essentially absent. Frost regularly occurs, with snow common in the northern parts of the regions.

1.B.3. Temperate Flooded & Swamp Forest (F026): Warm Temperate Forest & Woodland (F018) typically contains well-drained soils and lacks any aquatic vegetation, peat or muck layer.

2.B.1. Mediterranean Scrub & Grassland (F038): The vegetation is more commonly scrub-shrub, typically sclerophyllous, or with open (sometimes annual-dominated) grasslands and forb meadows. Combinations of dwarf scrubby trees less than 2 m tall with low shrubs may grade into Warm Temperate Forest.

2.B.2. Temperate Grassland & Shrubland (F012): Open woodlands or tree savannas, with grassy or shrubby understories, and with trees 10 percent cover or more, are placed in Warm Temperate Forest & Woodland (F108), but may have strong floristic similarities to grasslands.

Diagnostic Characteristics: Broad-leaved evergreen trees, sometimes with dwarfed stems, microphyll to small mesophyll leaves, sclerophyllous (Mediterranean); or various combinations of broad-leaved deciduous, broad-leaved evergreen or needle-leaved evergreen conifer trees. Mild (mostly frost-free) winter, temperate humid spring, hot-dry summer, and mild, often dry autumn seasons. Rainy season in winter and dry summers (Mediterranean).

Vegetation

Physiognomy and Structure: The vegetation varies from (a) dominance by broad-leaved evergreen trees, sometimes with dwarfed stems, and microphyll to small mesophyll leaves, with varying levels of sclerophylly (Mediterranean) to (b) various combinations of broad-leaved deciduous, broad-leaved evergreen or needle-leaved evergreen conifer trees. Natural disturbances include wind and fire.

Environment

Environmental Description: *Climate*: Freezing temperatures of short duration are expected, generally occurring every year during winter months. The potential growing season is more than 200 days with less than an average of 150 days a year subject to temperatures below 0 degrees C or chilling fog (Brown and others 1998). Spring is mild, summers are hot-dry, and autumns are mild and often dry. Rainy season in winter is most strong in Mediterranean climates. Average annual precipitation varies from 25 to 100 cm (10 to 40 inches).

Soil/substrate/hydrology: Soils are often strongly weathered. Soils are various, with Ultisols and Alfisols most common, and productive, but in some regions the soils are worn by thousands of years of human use (Soil Survey Staff 1999) (see Brady and Weil, 2002, for comparison of U.S. soil orders with Canadian and FAO systems).

Distribution

Geographic Range: Warm Temperate Forest & Woodland is found in the Mediterranean Basin and Mediterranean and warm temperate regions in North America (California, Southeast Coastal Plain), Chile, South Africa, Australia, India and Southeast Asia.

Citations

Synonymy:

= Warm Temperate Forest and Woodland (Brown and others 1998)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

1.B.2. Cool Temperate Forest & Woodland (F008)

Overview

Database Code: 1.B.2 (F008)

Scientific Name: Cool Temperate Forest & Woodland Formation

Common Name (Translated Scientific Name): Cool Temperate Forest & Woodland Formation

Colloquial Name: Cool Temperate Forest

Hierarchy Level: Formation

Placement in Hierarchy: 1.B. Temperate & Boreal Forest & Woodland (S15)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Cool Temperate Forest & Woodland includes temperate deciduous forest and woodland, temperate needle-leaved forest and woodland, and temperate rainforest, dominated by broad-leaved or needle-leaved tree growth forms.

Classification Comments: This formation includes a range of conifer and broad-leaved hardwood growth forms. The formation is sometimes restricted to "temperate broadleaf forest regions," but even there, pure conifer stands can occur, (e.g., in temperate eastern North America, there are pure conifer stands of *Tsuga canadensis* and *Pinus strobus)*. Inclusion of western North American conifer forests in this cool-temperate formation rather than the Boreal Forest & Woodland follows that of Brandt (2009) and others. Warm-temperate and cool-temperate forest and woodland formations are very similar, but differences are driven by broad climatic patterns. Overlap with boreal forests in the western montane region also presents conceptual challenges.

Various ecoregional treatments recognize the distinct vegetation and climate of the cool-temperate region, e.g., Brown and others (1998) separate cool-temperate from warm-temperate vegetation. Walter (1985) recognizes the cool-temperate biome "Zonobiome of the Temperate-Nemoral Climate" (Zone VI) distinct from two warm-temperate biomes, the "Zonobiome of the Winter-Rain Region with an Arid-Humid Climate and Sclerophyllic Woodlands" (Zone IV) and the "Zonobiome of the Warm-Temperate Humid Climate" (Zone V), and from the boreal biome "Zonobiome of the Cold-temperate Boreal Climate" (Zone VIII).

Our approach treats the subalpine forests of the Rocky Mountain region as part of *1.B.2 Cool Temperate Forest & Woodland Formation (F008)*, rather than as part of *1.B.4 Boreal Forest & Woodland Formation (F001)*, such as done by Whittaker (1975) and Brown and others (1998). Our decision is in line with a more biogeographic approach for divisions, and corresponds to that of Rivas-Martinez and others (1999b), but is debatable from a structural and climatic perspective. As Chris Lea (pers. comm. 2012) notes, one could retain lowland and lower montane western coniferous forests in Cool Temperate, but move high montane and subalpine to the Boreal formation, to which they also have strong floristic and environmental similarities (this would require a name change of the latter to something like "Boreal & High Montane" or "Boreal & Subalpine" formation). This would have minimal impact on lower level units, requiring only a transfer of two current western North America groups (G020 and G025) to F001, under a new (western North American) division of F001 and eastern North America group G024 (requires a new macrogroup and division, but the description of these would be identical with the existing group description). The only major new description for Forests and Woodlands would be a new division description for "Western North America High Montane & Subalpine Forest," within formation F001. These forests, fairly simply, contain quaking aspen and lodgepole pine on up through the Engelmann spruce-fir types. In the Sierra Nevada, Ponderosa pine, Douglas-fir, "mixed conifers" (white fir, etc.) represent the upper limits of *1.B.3 Temperate Flooded & Swamp Forest Formation (F026*). The Shrubland & Grassland class needs no formation-level adjustments, but some lower level adjustments might be needed for consistency. We will continue to review this issue as we compare our work with that of Eurasian treatments of boreal and cool temperate (nemoral) forests.

Similar NVC Types:

1.B.1. Warm Temperate Forest & Woodland (F018): Has increasing prominence of evergreen broad-leaved trees, and shrubs, and evergreen herb ground layer. Snow virtually absent, frost is relatively rare.

1.B.3. Temperate Flooded & Swamp Forest (F026): Cool Temperate Forest & Woodland (F008) typically contains well-drained soils and lacks any aquatic vegetation, peat or muck layer.

1.B.4. Boreal Forest & Woodland (F001): Greatly simplified set of growth forms, primarily more conical-shaped spruce, fir and larch, and simple-leaved boreal hardwoods of *Betula* spp. and *Populus* spp. Moss layer often very prominent. Persistence of snow typically greater than 5 months of the year. Frost possible in almost any season. These conditions also closely describe North American subalpine and high montane forests, but those are treated here with Cool Temperate Forest & Woodland because of the floristic, biogeographic and ecological similarities with lower elevation forests. See Brown and others (1998) who recognize a "Boreal and Subalpine Forest & Woodland" type.

2.B.2. Temperate Grassland & Shrubland (F012): Open woodlands or tree savannas, with grassy or shrubby understories, and with trees 10 percent cover or more, are placed in Cool Temperate Forest & Woodland (F008), but may have strong floristic similarities to grasslands.

7.A.2. Intensive Forestry Plantation & Agroforestry Crop (F043): Long-rotation plantations or woody restoration plantings of Cool Temperate Forest & Woodland (F008) with an irregular structure and a largely spontaneous ground layer may initially be similar in their early stages of development, especially if planted in rows and the understory is strongly manipulated.

Diagnostic Characteristics: This formation contains pure or mixed stands of broad-leaved deciduous or needle-leaved evergreen tree growth forms, with a seasonal green understory of herbs. The tall shrub layer is variable, and is often broad-leaved deciduous, but the short shrub layer may be heath. The moss layer is often sparse, but more dominant in cold, rainy and/or high montane needle-leaved evergreen stands. Snow may be on the ground between 1 to 6 months of the year (8 months in high montane temperate examples).

Vegetation

Physiognomy and Structure: In moist climates and habitats, there are commonly five strata: (1) a tree stratum, 15 to 35 m (60 to 100 feet) tall, dominated by broad-leaved deciduous and/or needle-leaved evergreen forest, often with a substratum of small trees (5 to 15 m tall); (2) a small tree and tall sapling layer (between 2 to 5 m); (3) a short shrub layer (<2 m); (4) an herb layer of perennial forbs, including an ecological group that bloom primarily in early spring (in deciduous broadleaf-dominated examples); and (5) a ground layer of lichens, clubmosses, and true mosses. Lichens and mosses also grow on the trunks of trees. Woody vines (lianas) are not common. In dry, and fire-dependent climates and regions, the structure may be simple, with a tree layer (>10 percent) and a strong grassy or shrubby ground layer. In western North America, structure is more variable, reflecting the range of ecological sites, from high mountains and valleys, to coastal rainforests with a variety of mesoclimates. Structural variability ranges from short-statured conifers, with a sparse understory and heavy duff layer, to the tallest and largest trees in the world in moist to wet climates, with shrub, herb and moss growth forms prominent (Whittaker 1975).

Many of the genera, previously part of an Arcto-Tertiary Geoflora, are common to all three of the disjunct Northern Hemisphere broadleaf expressions of this biome. Included among these genera are *Quercus* (oak), *Acer* (maple), *Fagus* (beech), *Castanea* (chestnut), *Carya* (hickory), *Ulmus* (elm), *Tilia* (basswood or linden), *Juglans* (walnut), and *Liquidambar* (sweetgum). Different species of these genera occur on each continent. In the Southern Hemisphere different sets of genera and species are found. Western North America contains a much reduced set of hardwood genera and expanded conifer diversity (*Abies, Picea, Pinus, Pseudotsuga, Thuja, Tsuga*). Transitions to the boreal forests are also apparent.

The temperate regions of the Southern Hemisphere differ from their northern counterparts. Distinctions between warm temperate and cool temperate are much contracted (e.g., in parts of the evergreen southern beech *Nothofagus* forests in South America, Australia and New Zealand).

Environment

Environmental Description: *Climate:* This formation is associated with cooler continental and oceanic temperate climates (Koeppen Dca, Dcb, and Do, and Cfb). There is a growing season of approximately 100 to 200 days, confined to late spring and summer when freezing temperatures are infrequent or absent. The 50 to 250 cm (20 to 100 inches) of precipitation are distributed evenly throughout the year. The non-growing season is due to temperature-induced drought during the cold winters.

Soil/substrate/hydrology: Soils are sometimes referred to as "gray forest soils," where silicate clay minerals accumulate in the B horizon. Some soils (Alfisols) have relatively high natural fertility; others are more leached, due to higher precipitation levels (Ultisols) and more common in the warmer parts of the region. Other orders in the U.S. system include Spodosols in the more northern regions and Inceptisols (Soil Survey Staff 1999) (see Brady and Weil 2002 for comparison of U.S. soil orders with Canadian and FAO systems).

Distribution

Geographic Range: This formation is most prominent in the Northern Hemisphere, where it occurs in four major, disjunct expressions in (1) western and central Europe, (2) eastern Asia, including Korea and Japan, (3) eastern North America, and (4) western North America. Cool temperate forests may occur as minor components of southern and montane New Zealand and in Australia, especially Tasmania. Cool temperate forests also occur in Chile.

Citations

Synonymy:

- > Cool Temperate Forest (Brown and others 1998) (Brown and others place the subalpine forests of the montane regions in their "Boreal and Subalpine Forest and Woodland" type.)
- < Taiga or Subarctic - Subalpine needle-leaved forests (biome type 6) (Whittaker 1975) [Whittaker combines the subalpine forests of the temperate region with boreal forests.]
- > Temperate deciduous forests (biome type 4) (Whittaker 1975)
- > Temperate evergreen (needle-leaved) forest (biome type 5) (Whittaker 1975) [Whittaker includes both temperate evergreen broadleaf and temperate evergreen needle-leaved forest in this biome type, but notes the distinction between the two in Plate 4.]
- > Temperate rain forests (biome-type 3) (Whittaker 1975)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012) after R.H. Whittaker (1975)

Author of Description: D. Faber-Langendoen

Acknowledgments: Todd Keeler-Wolf, Ken Baldwin, Chris Lea

Version Date: 26 Aug 2014

1.B.3. Temperate Flooded & Swamp Forest (F026)

Overview

Database Code: 1.B.3 (F026)

Scientific Name: Temperate Flooded & Swamp Forest Formation

Common Name (Translated Scientific Name): Temperate Flooded & Swamp Forest Formation

Colloquial Name: Temperate Flooded & Swamp Forest

Hierarchy Level: Formation

Placement in Hierarchy: 1.B. Temperate & Boreal Forest & Woodland (S15)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Temperate Flooded & Swamp Forest is a tree-dominated wetland influenced by minerotrophic groundwater, either on mineral or organic (peat) soil, found in mid latitudes of the globe.

Classification Comments: No distinction is made between warm versus cool temperate floodplain and swamp forests, because they do not have the same degree of change from broad-leaved evergreen to broad-leaved deciduous trees observed in uplands. Separation of temperate wetland from upland forests requires consideration of soils, vegetation and hydrology. At the wettest extremes, these forests are continuously flooded and aquatic vegetation growth forms may dominate the herb or field layer. Otherwise, these forests may be saturated and a peat layer may form. There are also practical user and ecological benefits to distinguishing wetland forests from upland forests at the formation level.

Similar NVC Types:

- *1.B.1. Warm Temperate Forest & Woodland (F018)*: These typically contain well-drained soils, and lack any aquatic vegetation, peat or muck layer.
- *1.B.2. Cool Temperate Forest & Woodland (F008)*: These typically contain well-drained soils, and lack any aquatic vegetation, peat or muck layer.
- *1.B.5. Boreal Flooded & Swamp Forest (F036)*: Temperate Flooded & Swamp Forest (F026) less often contains a sphagnum peat layer and is more commonly dominated by hardwood species.
- *2.C.4. Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland (F013)*: Tall shrub swamps share many structural and habitat similarities to hardwood tree swamps, especially during the tree regeneration stage.

Diagnostic Characteristics: Temperate Flooded & Swamp Forest is defined as a tree-dominated wetland in a temperate climate that is influenced by minerotrophic groundwater, either on mineral or organic soils. The vegetation is dominated by broad-leaved or needle-leaved trees, generally over 10 percent cover, and the substrate is either a wood-rich peat or a mineral soil on floodplains.

Vegetation

Physiognomy and Structure: Temperate Flooded & Swamp Forest is a forested wetland and peatland. These swamps are defined as tree-dominated wetlands that are influenced by minerotrophic groundwater. The vegetation is dominated by either broad-leaved or needle-leaved trees generally over 10 percent cover, and a wood-rich peat or a mineral soil on floodplains (National Wetlands Working Group 1997).

There are three general physiognomic variants of forested swamps: coniferous swamps, broad-leaved deciduous (hardwood) swamps, and broad-leaved evergreen (hardwood) swamps. Mixtures of the above can also be described. Shading of the understory tends to favor shade-tolerant species. In cool-temperate regions, hardwood swamps generally occur in somewhat richer conditions, giving way to shrub swamps and marshes in somewhat wetter locations. Coniferous swamps occur across a wider range of trophic levels from rich to poor (National Wetlands Working Group 1997).

Environment

Environmental Description: *Soil/substrate/hydrology:* In swamp forests, the water table is often below the major portion of the ground surface, and the dominant ground surface is at the hummock ground surface, that is; 20 cm or more above the average summer groundwater level. It is the aerated (or partly aerated) zone of substrates above the water that is available for root growth of trees. These temperate swamps are not as wet as marshes, fens and the open bogs. The drier treed swamps grade into upland forest on mineral soil, and the wettest treed swamps grade into scrubby treed fen, which is wetter with less tree canopy cover. Scrubby tree fens may grade into tall shrub swamps, but they are somewhat drier and have at least 10 percent tree canopy cover (National Wetlands Working Group 1997).

Flooded forests (sometimes called riverine or riparian swamps) have a more dynamic water table, with seasonal flooding inundating the vegetation for short (<7 days) to long (>1 month) periods. They are found along rivers, streams, and lakes. They are subject to dramatic water fluctuations, seasonal flooding, and an influx of sediment and mineral enrichment during high water periods. Peat accumulation is usually shallow, often less than 40 cm, but depths of 1 m can exist (National Wetlands Working Group 1997).

The temperate flooded and swamp forest occurs on mineral soils as well as on peat. In the cool temperate regions, the texture of underlying mineral soils is variable, ranging from clays to sands, and they frequently are Gleysols. On sands, iron-rich ortsteins or fragipans are often present, acting as impermeable layers that impede water drainage. Swamps on mineral soils tend to accumulate peat by paludification. When organic soils develop, they are Histosols (U.S. system) or Mesisols or Humisols (Canadian system) that are rich in woody peat, at least in the surface layers [see Brady and Weil (2002) for a comparison of U.S. soil orders with Canadian and FAO systems]. Swamps on peat have developed either by a basin-filling process or by paludification of previously drier mineral soils. In the basin-filling process, the previous ecosystem was a marsh or fen, whereas in paludification the swamp has developed over an older, dry upland forest on mineral soil (National Wetlands Working Group 1997).

The nutrient regime in swamps is highly variable, ranging from base-rich conditions with pH above 7.0, to base-poor conditions where pH can be in the range of 4.5 or lower. Temperate swamp forms may be recognized based on the base-rich/pH gradient, i.e., calcareous rich (eutrophic), intermediate (mesotrophic), and poor (oligotrophic) (National Wetlands Working Group 1997).

Distribution

Geographic Range: These forested wetlands are widely distributed throughout the mid-latitudes around the globe.

Citations

Synonymy:
\> Cold Temperate Swamp & Riparian Forest (Brown and others 1998) [Cool- and warm-temperate forested wetlands are distinguished, based on climate.]
\>< Swamp (National Wetlands Working Group 1997) [This type includes tree swamps with greater than 30 percent cover, boreal and temperate swamps, and both tree and tall-shrub (>1 m) swamps.]
\> Warm Temperate Swamp & Riparian Forest (Brown and others 1998) [Cool- and warm-temperate forested wetlands are distinguished, based on climate.]
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen, after National Wetlands Working Group (1997)
Acknowledgments:
Version Date: 26 Aug 2014

1.B.4. Boreal Forest & Woodland (F001)

Overview

Database Code: 1.B.4 (F001)
Scientific Name: Boreal Forest & Woodland Formation
Common Name (Translated Scientific Name): Boreal Forest & Woodland Formation
Colloquial Name: Boreal Forest
Hierarchy Level: Formation
Placement in Hierarchy: 1.B. Temperate & Boreal Forest & Woodland (S15)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Boreal Forest & Woodland (or taiga) is dominated by needle-leaved (usually evergreen, conical-shaped) conifers, and broad-leaved deciduous hardwoods that cover the northern regions of North America and Eurasia, with extended cold winters and short mild summers.

Classification Comments: The Braun-Blanquet approach generally recognizes the *Vaccinio-Piceetea* class of vegetation as synonymous with Eurasian and North American boreal and sub-boreal coniferous forests, including both upland boreal forests and forested swamps (Peinado and others 1998; Spribille and Chytrý 2002; Kolbek and others 2003); however, Rivas-Martinez and others (1999b) separated the North American Boreal Forest & Woodland into a separate class, distinct from both European boreal forests and western temperate forests.

Various ecoregional treatments recognize the distinct vegetation and climate of the boreal region, compared to the temperate region. Brown and others (1998) separates arctic-boreal from both cool-temperate and warm-temperate vegetation. Walter (1985) recognizes the boreal biome "Zonobiome of the Cold-temperate Boreal Climate" (Zone VIII), distinct from the cool-temperate biome "Zonobiome of the Temperate-Nemoral Climate" (Zone VI) and two warm-temperate biomes, the "Zonobiome of the Winter-Rain Region with an Arid-Humid Climate and Sclerophyllic Woodlands" (Zone IV) and the "Zonobiome of the Warm-Temperate Humid Climate" (Zone V).

Some authors extend the North American Boreal Forest & Woodland southward into the southern Rocky Mountains and/or Appalachian Mountains (e.g., Brown and others 1998; Kuennecke 2008; Whittaker 1975), primarily because of the spruce-fir zones that occur in those ranges. But the more temperate climate, increasingly diverse conifer and hardwood growth forms, biogeographic patterns and distinctive species suggest that they can satisfactorily be placed in a temperate formation, where they extend up to the treeline in the subalpine regions (see also Rivas-Martinez and others 1999b). However, biogeographic comparisons across larger regions, including biome or formation scales, and which can be done at the genus level and above (e.g., McLaughlin 2007), suggest a greater similarity of high-elevation Engelmann spruce-fir in the Rocky Mountains with that of the boreal. But similarities are less strong in the eastern deciduous region, where red spruce-fir forests share more species with the eastern temperate region. Chris Lea (pers. comm. 2012) notes that there are a number of subdominant species common to North American high montane/subalpine forests, North American boreal forests, and Eurasian boreal forests (a number of *Vaccinium* spp., *Linnaea borealis, Carex aquatilis, Carex utriculata*, etc.), and at least one dominant tree species (*Populus tremuloides*) that is common to North American high montane/subalpine and North American boreal forests. Additionally, many fauna species (lynx, pine marten, pine grosbeak, golden-crowned kinglet, crossbills, etc.) show similar species distribution patterns. But many of these species also have considerable overlap in the temperate zone. We will continue to review this issue with North American and Eurasian colleagues.

Similar NVC Types:

1.B.2. Cool Temperate Forest & Woodland (F008):

1.B.5. Boreal Flooded & Swamp Forest (F036):

7.A.2. Intensive Forestry Plantation & Agroforestry Crop (F043): Long-rotation plantations or woody restoration plantings of Boreal Forest & Woodland (F001) with an irregular structure and a largely spontaneous ground layer may initially be similar in their early stages of development, especially if planted in rows and the understory is strongly manipulated.

Diagnostic Characteristics: Boreal Forest & Woodland is dominated by needle-leaved (usually evergreen, conical-shaped) conifers, and broad-leaved deciduous hardwoods, with extended cold winters and short mild summers. Tree height rarely exceeds 15 m, and may be as low as 2 m in subarctic conditions. Lichens and mosses frequently dominate the ground layer.

Vegetation

Physiognomy and Structure: Boreal Forest & Woodland is dominated by needle-leaved (usually evergreen, conical-shaped) conifers, and broad-leaved deciduous hardwoods. Lichens and mosses often dominate the ground layer. The structure of Boreal Forest & Woodland varies from closed forest to lichen woodland and forest-tundra. Closed forests dominate the southern boreal zone; lichen woodlands dominate the northern regions; and isolated forest-tundra patches occur in the tundra zone near or just above treeline (Elliott-Fisk 2000). Boreal forests are a disturbance-based forest, with fires and insect outbreaks as primary disturbances. Tree species diversity is very low. Evergreen spruce (*Picea*), fir (*Abies*), and deciduous larch (*Larix*) are common distinctive genera, as are broad-leaved deciduous aspen (*Populus*) and birch (*Betula*) (Whittaker 1975).

Environment

Environmental Description: According to Brandt (2009), the boreal zone's northern boundary in both North America and Eurasia is generally the southern limit of the tundra; its southern boundary generally coincides with the northern limit of temperate forests, or grasslands (steppes).

Climate: There are lengthy periods of freezing temperatures with the coldest month isotherm of 3 degrees C, and the growing season generally averaging less than 100 days, occasionally interrupted by nights of below freezing temperatures. Snow may be present for extended periods (7 to 10 months) and soils are typically frozen in winter. Annual precipitation is 38 to 50 cm (15 to 20 inches). In North America, the northern boundary of the forest corresponds to the July isotherm of 13 degrees C, with departures due to montane or maritime influences (Elliott-Fisk 2000). The southern boundary in central and eastern Canada corresponds approximately with the 18 degree C July isotherm, but in the west the forest border shifts to slightly cooler regions with higher precipitation (Elliott-Fisk 2000). These broad-scale climatic factors are modified by local and regional topography, climates and soils.

Brandt (2009, and Table 2 therein) characterizes the limits of boreal forests based on their dominance by "cold-tolerant" trees species, i.e., tolerant of temperatures of minus 80 degrees C or lower (primarily within *Abies, Larix, Picea*, or *Pinus* but also *Populus* and *Betula*). Temperate forests are characterized by "cold-intolerant" species, i.e., they require temperatures above minus 45 degrees C to survive. A number of temperate species have "intermediate cold-tolerance," common to the cool-temperate forest. Regions of the landscape where both species co-occur is sometimes referred to as the "hemiboreal subzone," that is, the northern parts of the cool-temperate zone where cold-intolerant tree species, cold-tolerant tree species, and species with intermediate cold-tolerance co-occur, and with the cold-tolerant species contributing substantially to the forest cover. Brandt's information provides the cold-tolerance limits of these species, but equally valuable in understanding the temperate versus boreal distinction would be the warm-tolerance limits. For example, in North America, *Picea mariana* appears to be less warm tolerant than *Pinus banksiana*, but both have the same cold tolerance.

Soil/substrate/hydrology: Most boreal soils were subject to extensive glaciations (excluding parts of the Yukon Territory, the Northwest Territories, and Alaska). Soils are somewhat poorly to excessively drained. They are the result of podzolization, which is a consequence of low temperatures and excess precipitation above that of evapotranspiration. Soils often contain a sandy ash-colored A horizon, with an accumulation of iron and aluminum with organic matter in the B horizon. Soils are generally of low fertility, as nutrients are also removed from the upper horizons. With the low temperatures, organic matter decomposes slowly, resulting in acidic soil conditions and low nitrogen and mineral levels (Elliott-Fisk 2000; Kuennecke 2008). Permafrost is absent or typically occurs less than 100 cm below the surface in the Boreal Forest & Woodlandzone. Spodosols are most common; Inceptisols, Histosols, and Entisols occasional (Soil Survey Staff 1999) (see Brady and Weil 2002 for a comparison of U.S. soil orders with Canadian and FAO systems).

Distribution

Geographic Range: Boreal Forest & Woodland is found in North America from Greenland to Newfoundland and across northern Canada into Alaska, and in Eurasia, throughout most of Scandinavia and Russia, and parts of China, Kazakhstan, and Mongolia (Brandt 2009). It is absent from the Southern Hemisphere.

Citations

Synonymy:

= *Linnaeo americanae-Piceetea marianae* (Rivas-Martínez and others 1999b) [The concept of Boreal Forest & Woodland as applied within North America closely corresponds to the concept here. The authors also appear to be the first in the Braun-Blanquet tradition to recognize a distinct North American Boreal Forest & Woodland class.]

< *Vaccinio-Piceetea* (Peinado and others 1998) [The authors discuss the full diagnostic floristic composition of boreal forests across the Northern Hemisphere, and then focus on North America. They extend the Boreal Forest & Woodland further south (into the temperate-montane and cool-temperate regions of western and eastern North America) than the concept provided here.]

< Boreal Forest & Woodland Biome (Kuennecke 2008) [The author provides a general introduction to the entire boreal forest, but in North America extends the concept into the Southern Rockies and Appalachian Mountains.]

= Taiga and Boreal Forest & Woodland (Elliott-Fisk 2000) [The treatment is restricted to North America.]

< Taiga or Subarctic-Subalpine needle-leaved forests (biome-type 6) (Whittaker 1975) [Whittaker combines the subalpine forests of the temperate region with boreal forests.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments: Ken Baldwin, Chris Lea

Version Date: 26 Aug 2014

1.B.5. Boreal Flooded & Swamp Forest (F036)

Overview

Database Code: 1.B.5 (F036)

Scientific Name: Boreal Flooded & Swamp Forest Formation

Common Name (Translated Scientific Name): Boreal Flooded & Swamp Forest Formation

Colloquial Name: Boreal Flooded & Swamp Forest

Hierarchy Level: Formation

Placement in Hierarchy: 1.B. Temperate & Boreal Forest & Woodland (S15)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Boreal Flooded & Swamp Forest is a tree-dominated wetland influenced by minerotrophic groundwater (rarely ombrotrophic), either on mineral or organic (peat) soil, found in northern, high latitudes of North America and Eurasia, with extended cold winters and short mild summers.

Classification Comments: Subarctic and arctic (polar) flooded and swamp forests, including willow swamps (though these may not exceed 2 m), belong in this formation. Forested bogs and fens (>10 percent canopy) are also included here.

Similar NVC Types:

1.B.3. Temperate Flooded & Swamp Forest (F026): These forests less often contain a sphagnum peat layer and are more commonly dominated by hardwood species.

1.B.4. Boreal Forest & Woodland (F001): These typically contain better drained soils, lack any aquatic vegetation or muck layer, and, if a peat layer is present, it is shallow (<40 cm).

2.C.2. Temperate to Polar Bog & Fen (F016): Boreal Flooded & Swamp Forest (F036) includes forested bogs with greater than 10 percent tree cover, along with poor swamps.

Diagnostic Characteristics: Boreal Flooded & Swamp Forest is defined as a tree-dominated wetland in a boreal climate that is influenced by minerotrophic groundwater, either on mineral or organic (peat) soils; less commonly, they occur in transitional floodplain habitats. The vegetation is dominated by over 10 percent cover from needle-leaved trees and the wood-rich (less commonly sphagnum-rich) peat that this vegetation lays down.

Vegetation

Physiognomy and Structure: These swamps are defined as tree-dominated wetlands that are influenced by minerotrophic groundwater, either on mineral or organic soils. The vegetation is dominated by over 10 percent cover by mostly needle-leaved trees and the wood-rich peat that this vegetation lays down; less commonly, they occur in transitional floodplain habitats (National Wetlands Working Group 1997).

There are two general physiognomic variants of boreal swamps: coniferous (needle-leaved) swamps and hardwood (broad-leaved deciduous) swamps. Mixtures of the above can also be described. The understory contains shade-tolerant forest species. Generally in boreal regions, deciduous hardwoods occur in somewhat richer conditions and the deciduous swamps in drier wetland locations. Coniferous swamps occur across a wider range of trophic levels from rich to poor (National Wetlands Working Group 1997).

Environment

Environmental Description: *Soil/substrate/hydrology:* The water table is below most of the ground surface, and the dominant ground surface is at the hummock, that is, 20 cm or more above the average summer groundwater level. It is the aerated (or partly aerated) zone of substrates above the water that is available for root growth of trees and/or tall shrubs. Boreal swamps are not as wet as marshes, fens, and the open bogs. The drier treed swamps grade into upland forest on mineral soil, and the wettest treed swamps include tree fen, which is wetter with less tree canopy cover. Tree bogs can form on raised bogs, where the sphagnum mat may be relatively dry (National Wetlands Working Group 1997).

Boreal Flooded & Swamp Forest occurs on mineral soils as well as on peat. In the boreal region, the texture of underlying mineral soils is variable, ranging from clays to sands, and they frequently are Gleysols. On sands, iron-rich ortsteins or fragipans are often present, acting as impermeable layers that impede water drainage. Swamps on mineral soils tend to accumulate peat by the paludification process. When organic soils develop, they are Histosols (U.S. system) or Mesisols or Humisols (Canadian system) that are rich in woody peat, at least in the surface layers [see Brady and Weil 2002 for comparison of U.S. soil orders with Canadian and FAO systems]. Swamps on peat have developed by a basin-filling process or by paludification of previously drier mineral soils. In the basin-filling process, the previous ecosystem was a marsh or open fen, whereas in paludification, the swamp has developed over an older, dry upland forest on mineral soil (National Wetlands Working Group 1997).

The nutrient regime in swamps is highly variable, ranging from base-rich conditions with pH above 7.0, to base-poor conditions where pH can be in the range of 4.5 or lower. Swamp forms may be recognized based on the base-rich/pH gradient, i.e., calcareous-rich (eutrophic), intermediate (mesotrophic), and poor (oligotrophic to ombrotrophic) (National Wetlands Working Group 1997).

There are two general physiognomic variants of Boreal Swamp & Flooded Forest: coniferous (needle-leaved) swamps and hardwood (broad-leaved deciduous) swamps. Mixtures of the above can also be described. The understory contains shade-tolerant forest species. Generally in boreal regions, deciduous hardwood swamps occur in somewhat richer conditions, giving way to shrub swamps and marshes as conditions get wetter. Coniferous swamps occur across a wider range of trophic levels from rich to poor (National Wetlands Working Group 1997).

Distribution

Geographic Range: Boreal Flooded & Swamp Forest is found in North America, from Greenland to Newfoundland and across northern Canada into Alaska, and in Eurasia throughout most of Scandinavia and Russia, and parts of China, Kazakhstan, and Mongolia (Brandt 2009). It is absent from the Southern Hemisphere.

Citations

Synonymy:
= Boreal Swamp and Riparian Forest (Brown and others 1998)
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen, after National Wetlands Working Group (1997)
Acknowledgments: Ken Baldwin
Version Date: 26 Aug 2014

---

2. Shrub & Herb Vegetation (C02)

Overview

Database Code: 2 (C02)
Scientific Name: Mesomorphic Shrub & Herb Vegetation Class
Common Name (Translated Scientific Name): Mesomorphic Shrub & Herb Vegetation Class
Colloquial Name: Shrub & Herb Vegetation
Hierarchy Level: Class
Lower Level Hierarchy Units:
2.A. Tropical Grassland, Savanna & Shrubland (S01)
2.B. Temperate & Boreal Grassland & Shrubland (S18)
2.C. Shrub & Herb Wetland (S44)

Concept Summary

Type Concept Sentence: Grasslands, shrublands, open tree savannas, marshes, bogs and fens dominated by broadly mesomorphic (including scleromorphic) shrub and herb growth forms (including *broad-leaved, needle-leaved,* and *sclerophyllous shrubs*, and *forb* and *graminoid herbs*) with an irregular horizontal canopy structure, mesomorphic trees typically less than 10 percent cover (but tropical tree savannas typically less than 40 percent), tropical to boreal and subalpine climates, and wet to dry substrate conditions.

Classification Comments: This class includes both non-treed grasslands and shrublands, and open tree savannas, where tree canopy cover is typically less than 10 percent. Non-tropical tree savannas, defined by a strong graminoid layer (>50 percent in UNESCO 1973) and some level of open tree cover (10 to 25 percent cover in UNESCO (1973), 10 to 30 percent cover in Nelson (2005), 10 to 50 percent cover in Curtis (1959)), often closely resemble open upland grasslands and shrublands, especially in grassland regions. Thus, in this particular realm of vegetation, the open tree canopy, in combination with the ground layer, helps define savanna vegetation, distinct from forests or woodlands (e.g., Nelson 2005). But in many other regions and vegetation types (e.g. forested swamps and bogs, longleaf pine woodlands (Peet 2006), California oak woodlands (Barbour and others 2007), subarctic woodlands), the role of canopy closure varies. Thus, in non-tropical regions, we place generally tree savannas where trees > 5 m have > 10 percent cover with woodland and forest. However, Dixon and others (2014) suggest that there may be good ecological reasons to treat upland tropical tree savannas with up to 40 percent tree cover, trees less than 8 m tall, and a substantial graminoid layer as part of *2. Shrub & Herb Vegetation (C02)*, and we allow for that option here.

Croplands with a spontaneous ground layer of "weeds," where the annual rotation of crops prevents a persistent ground layer of herbs, are treated in *7. Agricultural & Developed Vegetation Class (CCL01)*. If agricultural practices are abandoned, these sites may succeed to more persistent "ruderal" grasslands and shrublands (and forests) and would be placed in this class.

Where grasses and shrubs overtop low trees ("brush prairie"), the stands are placed here in Shrub & Herb Vegetation. These situations may often occur in grassland or cool semi-desert regions (e.g., North American Great Plains or Great Basin). Also challenging are some scrub trees, such as juniper (*Juniperus* spp.) or mesquite (*Prosopis* spp.), which can form shrub-like stands, and are typically less than 5 m tall at maturity in parts of their range. Where forms are not easily defined, woody plants equal to or greater than 5 m at maturity are considered trees (FGDC 2008). In the United States, there are shrubby junipers (*Juniperus communis, Juniperus pinchotii*) that should be treated as shrubs. But pygmy conifers can potentially make 5 m and are treated as trees (*Pinus edulis, Juniperus scopulorum, Juniperus monosperma, Juniperus occidentalis, Juniperus osteosperma*).

There is a group of ephemerals that are generally mesomorphic, which can, under optimal rainfall conditions, grow on sand, including desert sands and pavement. They are adapted to deserts through their seed characteristics. Typically they do not occupy extensive deep shifting sands, only margins of sandsheets and more stable sands. They rely on seedbanks that may persist for decades in the sand and germinate under optimal winter or summer episodes of heavy rains. These are treated here as part of the mesomorphic shrub and herb class. Examples of psammophytic species include some sand verbenas (*Abronia* spp.) and several Asteraceae (e.g., *Dicoria canescens, Palafoxia* spp., etc.).

Similar NVC Types:

3. Desert & Semi-Desert (C03): Desert grassland growth forms currently are not distinguished from temperate (mesomorphic) grasslands, and, where these grasslands lack xeromorphic shrubs, there may be no growth forms that provide xeromorphic criteria. In addition, the transition from dry temperate grassland to cool or warm semi-desert may be challenging, and rely more on floristics than growth forms. Desert grasslands lacking many xeromorphic associates in the sense of those in the southwestern United Staters (New Mexico, Texas, or Arizona) may be considered monsoonal and, could be considered mesomorphic grasslands. Further review is needed.

4. Polar & High Montane Scrub, Grassland & Barrens (C04): Distinguishing cryomorphic vegetation from mesomorphic can be a challenge in both arctic and alpine regions. Here we allow mesomorphic extensions into the cryomorphic climatic zone to be retained in the mesomorphic class (e.g., boreal mesomorphic tall willow shrublands along arctic drainageways are excluded from Cryomorphic Vegetation), whereas prostrate or dwarf willow species are treated as part of the cryomorphic class.

6. *Open Rock Vegetation (C06)*: Sparsely vegetated sand dunes are similar to this class, but the vascular species present are typically mesomorphic, with adaptations to rooting in sand (psammophytic); crustose lichens and ferns are typically absent. Unstable scree may also contain scattered mesomorphic herbs and little to no nonvascular vegetation, but for now are retained in this class.
7. *Agricultural & Developed Vegetation (CCL01)*: Agricultural grasslands in this class may be regularly mowed, hayed or grazed, and have an atypical "cut" structure periodically throughout the season, and may be dominated by exotic grasses. Developed grasslands in this class have a very regularly, often very low, cropped structure because of regular cutting or mowing (even weekly during the growing season).

Diagnostic Characteristics: Shrubs and herbs in non-tropical savanna regions are at least 10 percent cover, mesomorphic trees less than 10 percent cover, and the majority of cover is comprised of mesomorphic shrub (*broad-leaved, needle-leaved, sclerophyllous*, and *rosette shrubs*) and herb (*forbs* and *graminoids*) growth forms compared to xeromorphic or cryomorphic shrub and herb growth forms. The vegetation structure has irregular horizontal canopy spacing. In tropical upland savanna regions, trees typically have up to 40 percent cover, are less than 8 m tall, and the vegetation has a substantial graminoid layer.

Vegetation

Physiognomy and Structure: *Growth Forms*: Stands are dominated by any broadly mesomorphic (including scleromorphic) herb or shrub growth form, with or without a layer of nonvascular growth form (i.e., lichen, moss). Mesomorphic shrubs include *broad-leaved, needle-leaved, sclerophyllous,* and *palm shrubs*. Semi-shrubs are typically absent. Mesomorphic herbs include forbs (including *flowering forbs, ferns,* and *succulent forbs*) and *graminoids.* These herbaceous growth forms are not exclusive to the mesomorphic class, and more work is needed to assess whether additional herbaceous growth form types should be recognized that may be distinctive for this class.

Structure: Stands have irregular shrub or herb horizontal stem spacing, typically with a moderately open to closed shrub or herb layer. There is less than10 percent mesomorphic tree cover (less than 40 percent in tropical tree savannas), and the majority of shrub and/or herb growth forms are mesomorphic, typically exceeding 10 percent cover (but may be as low as 1 to 10 percent cover). Nonvascular and dwarf-shrub growth forms may vary from 0 to 100 percent, and tree seedlings or saplings may be present at any level of cover if they are below the predominant heights of the shrubs and herbs. At maturity, dominant shrubs and herbs are typically greater than 0.3 m (sometimes over 5 to 10 m).

Environment

Environmental Description: *Climate:* Shrublands and grasslands occur in the following Trewartha Climatic zones:(Aw = Tropical wet-dry; Am = Tropical wet-dry ("monsoon"); BS = Semiarid [BSh, hot semiarid]; BW = Arid Specifically BWh (hot Subtropical High desert); BWn (or Bn)) Climates (cool coastal deserts) *"n" for nebel = fog; Cs = Subtropical dry summer "Mediterranean";Do = Oceanic "Marine West Coast";BS = Semiarid (BSk, cool semiarid);Dc = Continental.*

Soil/substrate/hydrology: Dry to moist soils. Sand dune, including psammophytic, vegetation is placed here in mesomorphic shrub and herb vegetation. Kudryashov (2010) describes the characteristics of "psammophyte" (i.e., plants that thrive in shifting sands, primarily in deserts, and that have a number of adaptations that enable them to exist on wind-blown sands).

Distribution

Geographic Range: In non-tropical regions, this type is most common in the Bailey (1989) Steppe Divisions of the Dry Domain, the Subarctic Divisions of the Polar Domain, and is less common in other divisions of Polar or Dry Domains. In the tropics, this type is uncommon in Humid Tropical and Humid Temperate Domains, but common in semi-humid Tropical Domains (savannas).

Citations

Synonymy:

= Grassland Biomes (Woodward 2008) [Approximately equivalent. Although only grasslands are mentioned in the name, shrublands are considered as part of the concept.]

> Range Land (Anderson and others 1976) [The authors exclude wet grasslands and shrublands, treating them as part of their "Wetlands" category.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: Hierarchy Revisions Working Group

Acknowledgments:

Version Date: 26 Aug 2014

2.A. Tropical Grassland, Savanna & Shrubland (S01)

Overview

Database Code: 2.A (S01)

Scientific Name: Tropical Grassland, Savanna & Shrubland Subclass

Common Name (Translated Scientific Name): Tropical Grassland, Savanna & Shrubland Subclass

Colloquial Name: Tropical Grassland, Savanna & Shrubland

Hierarchy Level: Subclass

Placement in Hierarchy: 2. Shrub & Herb Vegetation (C02)

Lower Level Hierarchy Units:

2.A.1. Tropical Lowland Grassland, Savanna & Shrubland (F019)

2.A.2. Tropical Montane Grassland & Shrubland (F017)

2.A.3. Tropical Scrub & Herb Coastal Vegetation (F024)

Concept Summary

Type Concept Sentence: Tropical Grassland, Savanna & Shrubland is dominated by mesomorphic grasses and shrubs, with or without scattered trees (but trees typically less than 40 percent cover), ranging from tropical coastal to inland lowland and montane grasslands and shrublands. Stands are found in warm tropical continental climates, typically from the equator to about 23 degrees N and S latitude, with low or pronounced rainfall seasonality, with either one or two short dry seasons, or one long dry season, but frost virtually absent.

Classification Comments: Dixon and others (2014) and others suggest that there may be good ecological reasons to treat upland tropical tree savannas, with up to 40 percent tree cover, trees greater than 8 m tall, and a substantial graminoid layer, as part of *2. Shrub & Herb Vegetation (C02)*, and we allow for that option here. By contrast, in non-tropical regions, we place tree savannas with woodland and forest.

Similar NVC Types:

1.A. Tropical Forest & Woodland (S17): Where tree cover exceeds 10 percent, stands are typically placed in Tropical Forest & Woodland (S17). However, in tropical upland savanna regions, stands more typically exceed 40 percent tree cover, trees are greater than 8 m tall, tree regeneration is abundant, and there is no substantial graminoid layer.

2.B. Temperate & Boreal Grassland & Shrubland (S18): Tropical Grassland, Savanna & Shrubland (S18) growth forms have a phenology driven by rain and drought, but not frost.

Diagnostic Characteristics: Tropical Grassland, Savanna & Shrubland is dominated by grasses and shrubs, with or without scattered trees (which may have up to 40 percent cover). Some occur in climates too dry for forest; others depend on soil conditions or fire, or both, rather than climate, but frost is typically absent throughout the growing season. The structure is a single, major grass or shrub stratum, or a mix of the two, exceeding 10 percent cover, rarely with bare ground (Whittaker 1975).

Vegetation

Physiognomy and Structure: Tropical Grassland, Savanna & Shrubland is dominated by grasses and shrubs, with or without scattered trees (but tree cover less than 40 percent). Some occur in climates too dry for forest; others depend on soil conditions or fire, or both, rather than climate. The structure is a single, major grass or shrub stratum, or a mix of the two, exceeding 10 percent cover, rarely with bare ground (Whittaker 1975). The range of variation in upland formations corresponds to Lowland versus Montane versus Coastal patterns of variation.

Environment

Environmental Description: Stands are found in warm tropical continental climates, with low or pronounced rainfall seasonality, with either one or two short dry seasons, or one long dry season, but in all cases frost virtually absent.

Distribution

Geographic Range: This subclass is found widely throughout lowland and montane upland habitats of the tropical latitudes, from the equator to about 23 degrees N and S.

Citations

Synonymy:

= Tropical Savanna Biome (Woodward 2008) [Woodward includes upland lowland and montane grassland.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

2.A.1. Tropical Lowland Grassland, Savanna & Shrubland (F019)

Overview

Database Code: 2.A.1 (F019)

Scientific Name: Tropical Lowland Grassland, Savanna & Shrubland Formation

Common Name (Translated Scientific Name): Tropical Lowland Grassland, Savanna & Shrubland Formation

Colloquial Name: Tropical Lowland Grassland, Savanna & Shrubland

Hierarchy Level: Formation

Placement in Hierarchy: 2.A. Tropical Grassland, Savanna & Shrubland (S01)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical Lowland Grassland, Savanna & Shrubland is characterized by a ground layer with a more-or-less continuous grass or graminoid layer, or mixed forb layer that may have up to 80 to 90 percent shrub cover and/or typically less than to 40 percent tree cover, and less than 8 m tall. Shrubs are predominantly broad-leaved evergreen and deciduous, but sclerophyllous growth forms are also included. Stands are found in warm tropical continental climates, with low or pronounced rainfall seasonality, with either one or two short dry seasons, or one long dry season.

Classification Comments: "Savanna" refers to a type of vegetation where grasses form a complete ground cover but there may also be an upperstory of scattered trees, shrubs, or palms. The word *savanna* comes from a Carib word for a treeless plain covered with grass (i.e., a grassland). The Spanish adopted the term when they colonized the West Indies, and they introduced it to other western languages. Today, among vegetation scientists, the meaning has changed somewhat: "savanna" refers to a type of vegetation where grasses form a complete ground cover; an upperstory of scattered trees, shrubs, or palms is usual (thus tropical grasslands, with or without scattered trees, are referred to as savannas). The term is mostly reserved to describe tropical vegetation, and the popular image of tropical savanna comes from the African part of the biome, where vast grasslands dotted with umbrella-shaped deciduous trees and thorny shrubs are inhabited by herds of large grazing animals. But it can also include low-statured woody vegetation with a strong graminoid layer, such as the Neotropical cerrado, or scrubby forms of African savanna.

The term savanna has also been applied to vegetation of similar structure in temperate zones, but there the term grassland or prairie is used for non-treed grasslands, and savanna is only used when scattered trees are present (between 10 and 30 percent);

these stands are placed in *1. Forest & Woodland Class (C01)*. Some scientists use the term *savanna landscape* to describe a group of interrelated grassland, gallery or riparian forest, swamps, and/or marsh vegetation.

Savannas in tropical Asia are most likely "derived" and not natural savannas. This means that they are the result of human activities such as logging, burning, and the grazing of livestock, any or all of which altered tropical dry (or deciduous) forests that once grew in the area. Since they are not considered natural, the tropical savannas of India and Southeast Asia are not described in this report (Woodward 2008).

The Caribbean pine savannas, like other treed savannas, should be placed according to the percent coverage of the tree layer. Where grasses and shrubs overtop low trees ("brush prairie"), the stands are placed here in Shrub & Herb Vegetation. In the tropics, the separation between the lowland shrubland and grassland and warm semi-desert thorn woodland/shrubland should be guided by the presence of succulents, small-leaved and thorny shrubs and trees, and other xeromorphic growth forms, characteristic of the latter.

Savannas that flood seasonally are common in the tropics, especially in South America (the Llanos, Beni, and Pantanal). The extensive hydrologic network combined with topographic complexities and precipitation gradients cause a complex spatial mosaic of upland and seasonally flooded types that might be challenging to classify, with waterlogged soils grading into drained soils within very short distances.

This type may extend to nearly treeline (3000 m elevation), covering the lower montane region. See description for *2.A.2. Tropical Montane Grassland & Shrubland Formation (F017)*.

Similar NVC Types:

2.A.3. Tropical Scrub & Herb Coastal Vegetation (F024): Further review is needed to describe differences between Tropical Lowland Grassland, Savanna & Shrubland (F019), and Coastal Vegetation (F024).

4.A.1. Tropical High Montane Scrub & Grassland (F022): This type is often treated broadly to include both tropical montane and high montane vegetation, i.e., all vegetation near or above the tropical treeline (e.g., Quinn 2008).

7.B.2. Pasture & Hay Field Crop (CFO05): Tropical Lowland Grassland, Savanna & Shrubland (F019) may overlap in composition with pasture grasslands, particularly in grassland regions. And in regions where a pastoral tradition has existed from 100s to 1000s of years, recognition of native versus agricultural grasslands may be challenging.

Diagnostic Characteristics: Shrubs and herbs at least 10 percent cover, mesomorphic trees less than 40 percent cover, and less than 8 m tall, and the majority of cover is comprised of mesomorphic shrub (*broad-leaved, sclerophyllous*, and *rosette shrubs*) and herb (*forbs* and *graminoids*) growth forms compared to xeromorphic or cryomorphic shrub and herb growth forms. The vegetation structure has irregular horizontal canopy spacing.

Vegetation

Physiognomy and Structure: Stands are dominated by any mesomorphic herb or shrub growth form, with or without a layer of nonvascular growth form (i.e., lichen, moss). Mesomorphic shrubs include *broad-leaved, sclerophyllous*, and *palm*.

Semi-shrubs are typically absent. Mesomorphic herbs include forbs (including *flowering forbs* and *ferns*) and graminoids. "Savanna" refers to a type of vegetation where grasses form a complete ground cover; an upperstory of scattered trees, shrubs, or palms is usual. Stands vary widely from regular shrub or herb horizontal stem spacing to irregular, typically with a moderately open shrub layer. There is less than 40 percent mesomorphic tree cover, trees are less than 8 m tall, and the majority of shrub and/or herb growth forms is mesomorphic, typically exceeding 10 percent cover (but may be as low as 1 to 10 percent). Nonvascular and dwarf-shrub growth forms may vary from 0 to 10 percent, and tree seedlings or saplings may be present at any level of cover, if they are below the predominant heights of the shrubs and herbs. At maturity, dominant shrubs and herbs are typically greater than 0.3 m (sometimes over 5 to 10 m).

The typical grasses are bunch grasses, some 2 to 4 m high. The blades are tough and contain many silica bodies. Savanna grasses use the C4 photosynthetic pathway. In addition to grasses, the herb layer of tropical savannas is often rich in sedges and forbs. Trees of the savannas, with the exception of the huge *Adansonia digitata* (baobab), are rarely taller than 12 m. Most are only 2 to 6 m tall. A thick bark often defends savanna trees against fire. Many can sprout from their roots, another survival tactic in the face of frequent burning. In Africa, where grazing by large mammals is a major factor, many woody plants are armed with thorns. These same trees and shrubs are apt to have tiny leaves and very deep taproots. Other growth forms commonly found in tropical savannas include subshrubs and annual forbs and grasses, all well-adapted to strongly seasonal environments. The subshrub dies down at the end of one rainy season and produces new woody stems at the beginning of the next. Two flowering seasons are usual in the Tropical Savanna Biome. Some plants bloom at the very beginning of the rainy season even before their leaves have fully developed. Other species bloom in the middle of the rainy season or towards its end. Ecologists recognize different types of savanna according to the spacing and frequency of trees or other woody plants (Woodward 2008). The typical grasses are bunch grasses, some 2 to 4 m high. In addition to grasses, the herb layer of tropical savannas is often rich in sedges and forbs. Many of the forbs are members of the pea or legume family (Woodward 2008).

Environment

Environmental Description: *Climate:* This formation occurs typically within an annual precipitation range of 100 to 150 cm though lower and upper extremes are around 40 and 200 cm, respectively. The rainfall is seasonal, with either a short (1 to 3 months) dry season or a long one (5 to 7 months). The wet season can be interrupted by a short period of drought that may last for 1 to 3 weeks. As distance from the equator increases, different types of savanna may form distinct zones, a pattern that results from the longer and longer dry seasons experienced, and the less and less total annual precipitation received the closer an area is to the permanent high pressure cells centered near 30 degrees latitude in both hemispheres (Woodward 2008). Mean annual temperature is about 22 to 25 degrees C, but can reach 6 degrees C in winter at the edges of the tropical distribution range (e.g., southern limit of Cerrado in Brazil, eastern southern Africa), with very occasional frosts.

Tropical savannas occur in areas with distinct annual rhythms based on alternating wet and dry seasons. Abundant precipitation during the rainy season makes this a type of tropical humid climate known as the Tropical Wet and Dry Climate (Aw in the Koeppen climate classification system), or often simply the Tropical Savanna Climate. The rains come during the high sun period, when the Intertropical Convergence Zone (ITCZ) is positioned nearby. The ITCZ is the place where the trade winds of the Northern and Southern hemispheres meet and force the air to rise and generate rainfall. Its position shifts during the year as the vertical rays of the sun migrate between the Tropic of Cancer and the Tropic of Capricorn. The low sun season, when the vertical rays strike in the opposite hemisphere, is the dry season. There may be 3 to 4 months when little or no precipitation falls. Total precipitation within the biome varies from 100 to 150 cm (40 to 60 inches) to as little as 50 cm (20 inches) a year (Woodward 2008). The tropical nature of the climate is apparent in the year-round warm temperatures, with frost being an unknown or extremely rare event. The temperature difference between the warmest month (usually at the end of the dry season) and the coolest month (during low sun) is only 2.8 to 5.5 degrees C (5 to 10 degrees F). The difference between daytime and nighttime temperatures is often greater (Woodward 2008). Even though a close correlation exists between tropical savannas and the Tropical Wet and Dry Climate, climate does not seem to be the main reason most savannas are found where they are. Repeated burning, low-nutrient soils, iron-rich hardpans close to the surface, and the impacts of large grazing and browsing mammals are also factors in the presence and maintenance of many of the world's tropical grasslands (Woodward 2008).

Soil/substrate/hydrology: Tropical savanna usually develops on nutrient-deficient, acidic soils with aluminum toxicity and pronounced alternation of wet and dry conditions (Woodward 2008).

Soils Comments: Soil formation: Soils in humid tropical climates are exposed to high rates of leaching, the dissolving and washing down into the soil column of any soluble compound. The typical soil-forming process is one of laterization. The amount of leaching that has occurred is related to the age of the land surface. The tropical savannas of Brazil and western Africa lie on very ancient surfaces (exposed continental shields) that for millions of years have been affected by high temperatures and relatively high amounts of rainfall. The bedrock has been deeply weathered, and most soluble compounds, including even silica compounds, have been removed. Since plant matter decays rapidly in constant warm, moist conditions, essentially no humus is available to help bind soluble bases (key plant nutrients) even temporarily. Left behind is a soft residue high in iron oxides and aluminum oxides and lacking most plant nutrients. The high amount of iron in the soils gives them a bright red or yellow color. Concentrations of aluminum can be high enough that the soil is mined as an ore (the ore of aluminum metal is called bauxite). In parts of the Brazilian Highlands, aluminum concentrations are so high as to be toxic to many plants. Native trees and shrubs have special adaptations to withstand these challenging conditions (Woodward 2008).

Soils developed on ancient surfaces that are composed of granitic rocks tend to be quite acidic (average pH = 4.9), further reducing the ability of the soil to hold nutrient bases. Another problem for plant life is the repeated wetting and drying of the iron-rich soils that can turn them into a brick-hard layer known as laterite. This hardpan prevents root penetration and halts the percolation of water during the rainy season, creating waterlogged soils or even temporary pools of standing water. The existence of laterite can be one reason for the lack of trees in some tropical savanna areas (Woodward 2008).

In some parts of the tropics, weathering and leaching have been neither so prolonged nor extreme. In well-drained areas and regions where the crystalline bedrock is not as old or has been more recently exposed than described above, soil-forming processes more like those of temperate regions (podzolization) are able to take place. Over much of eastern and southern Africa, for example, the savanna soils are less acidic (pH = 6.2) and somewhat more fertile than on the more ancient shield surfaces (Woodward 2008). On base-rich bedrock such as basalt or limestone, soils develop that are high in essential plant nutrients such as calcium and magnesium (both are bases). They typically have a high clay content that makes them swell during the wet season and shrink and crack during the dry season. Such soils have relatively high natural fertility and tend to be associated with grass savannas (Woodward 2008).

Soil types: The typical, iron- and aluminum-rich, low-nutrient soils of the ancient plateaus of Africa and South America are classified in the U.S. Soil Taxonomy (Soil Survey Staff 1999) as Oxisols. "Oxi" refers to the oxides of those two elements that are so concentrated by tropical soil-forming processes. Similar soils are also found in the Tropical Rainforest Biome. In other classifications, they are known as Latosols or lateritic soils (Woodward 2008). Where drainage is better or younger crystalline rock forms the parent material of the soils, the soils are Ultisols according to the U.S. Soil Taxonomy. "Ulti" means ultimate or last: the last of the nutrients have been removed by leaching (Woodward 2008). The more fertile soils developed on basalt or limestone and still containing abundant plant nutrients are among the Vertisols of the U.S. Soil Taxonomy (Soil Survey Staff 1999). "Vert" means turn. The swelling and shrinking of the clay mixes or turns the soil so that no true horizons can form. In other soil classification systems, they are more vividly named "black cracking soils" (Woodward 2008).

Distribution

Geographic Range: This formation type is found in northern South America, western and southwestern Amazon Basin, Guiana Shield, Brazilian Shield, Western Africa (Guinea-Congolia/Sudania regional transition zone), sub-Sahel (Sudanian regional center of endemism), the Central African Plateau (Guinea-Congolia/Zambezia regional transition zone and the Zambezian regional center), and Eastern Africa (Somali-Masai regional center of endemism), northern Australia and Indomalaysia. They are typically located poleward of the Tropical Rainforest and Tropical Dry Forest biomes and form a transition between those forests and the deserts of the subtropics. The boundary between forest and savanna is often abrupt.

Citations

Synonymy:

= Tropical Savanna Biome (Woodward 2008)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012) after S. Woodward (2008)

Author of Description: C. Josse and D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

2.A.2. Tropical Montane Grassland & Shrubland (F017)

Overview

Database Code: 2.A.2 (F017)
Scientific Name: Tropical Montane Grassland & Shrubland Formation
Common Name (Translated Scientific Name): Tropical Montane Grassland & Shrubland Formation
Colloquial Name: Tropical Montane Grassland & Shrubland
Hierarchy Level: Formation
Placement in Hierarchy: 2.A. Tropical Grassland, Savanna & Shrubland (S01)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical Montane Grassland & Shrubland is dominated by shrubs and herbs with mesomorphic growth forms (predominantly tussock grasses, large rosette plants, shrubs with evergreen coriaceous and sclerophyllous-*ericoid* leaves, and cushion plants).

Classification Comments: In terms of overall physiognomy, this formation is closely related to *4.A.1 Tropical High Montane Scrub & Grassland Formation (F022*) that has been placed within *4. Polar & High Montane Scrub, Grassland & Barrens Class (C04)*, and many authors would place all of the vegetation described here in that formation (e.g., Quinn 2008). The main reason for this split is that in the Tropics, the true cryomorphic vegetation, super-páramo and higher elevation puna, are treated in 4.A. They grow above 4,300 m elevation up to the permanent snowline, with mean annual temperatures lesss than 3 degrees C, and soils have cryomorphic features (such as cryoturbation). Physiognomic distinctions are mostly based on the ground cover of the formation, which is continuous as compared to the low, semi-open coverage of the tropical cryomorphic formations.

Still, as defined here, *2.A.2 Tropical Montane Grassland & Shrubland Formation (F017)* often is found at elevations above 3000 m, which means that *2.A.1. Tropical Lowland Grassland, Savanna & Shrubland Formation (F019)* extends up to 3,000 m. This may be problematic with respect to the use of Montane versus Lowland as used, though usually there is a forest band between the two. This formation is near to sometimes above the treeline, but many will associate montane with a mid-elevation forest zone, including lower and upper montane forests.

Similar NVC Types:

4.A.1. Tropical High Montane Scrub & Grassland (F022): Many authors would place what is described in Tropical Montane Shrubland, Grassland & Savanna with this formation (e.g., Quinn 2008).

Diagnostic Characteristics: Herbaceous perennials (forbs and grasses) and small woody shrubs are predominant, with small rosette and large caulirosulate plants with arborescent habit also present. The overall structure varies from semi-open to almost 100 percent coverage. The vegetation structure has irregular horizontal canopy spacing, except for the vast expanses of grassland communities in some locations.

Vegetation

Physiognomy and Structure: Tropical Montane Grassland & Shrubland is dominated by shrubs and herbs with mesomorphic growth forms (predominantly tussock grasses, large rosette plants, shrubs with evergreen coriaceous and sclerophyllous-*ericoid* leaves, and cushion plants). Vegetation structure varies from grasslands, with few short woody growth forms, to a closed canopy of shrubs usually not taller than 1 to 2 m high. Spatially patchy vegetation structure is typical due to both substrate heterogeneity and human influence characterized by periodic burning and grazing.

Environment

Environmental Description: *Climate:* The majority of the area covered by this vegetation corresponds to types that occur on tropical mountains above the limit of continuous, closed-canopy forest or forestline and below the sub-nival elevations, from 3000 to 4500 m (i.e., *páramo* and *puna*). The elevation range varies depending on the location, but it is the correlation between elevation and a decrease in temperature that, in natural conditions, generates the replacement of forested vegetation with grasslands and shrublands. There are other factors, such as the effect of recent glaciation periods, and anthropogenic disturbance as well. The variability in elevation range goes together with a great variation in climate among locations, but in general, the mean annual temperature for this type should be between 3 and 12 degrees C, with lower locations reaching a maximum of 14 degrees C average annual temperature, the greatest fluctuation in temperature occurring daily rather than seasonally. Due to the mountain setting, precipitation is highly variable as well, not only in the annual amount but its distribution, with some locales having a marked dry season and others more humid throughout the year.

Soil/substrate/hydrology: Given the volcanic origin of several tropical mountains, they have volcanic ash soils, with very high organic content and a high water-holding capacity. Other uplifts have formed metamorphic, sandstone or limestone ranges, with soils varying from shallow to deep, highly humic and forming clayish peat in locations with permanently high moisture.

Distribution

Geographic Range: Tropical Montane Grassland & Shrubland occurs in the tropical mountain regions of Central and South America, Africa, Malaysia, including New Guinea, Hawaii, lower ranges in the Caribbean, and Brazil.

Citations

Synonymy:
< Tropical Alpine Biome (Quinn 2008) [Quinn includes both the tropical montane and tropical high montane scrub band grassland in her type.]
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: C. Josse
Acknowledgments:
Version Date: 26 Aug 2014

2.A.3. Tropical Scrub & Herb Coastal Vegetation (F024)

Overview

Database Code: 2.A.3 (F024)

Scientific Name: Tropical Scrub & Herb Coastal Vegetation Formation

Common Name (Translated Scientific Name): Tropical Scrub & Herb Coastal Vegetation Formation

Colloquial Name: Tropical Scrub & Herb Coastal Vegetation

Hierarchy Level: Formation

Placement in Hierarchy: 2.A. Tropical Grassland, Savanna & Shrubland (S01)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical Scrub & Herb Coastal Vegetation is found in tropical coastal habitats, including beaches, bluffs and dunes, where wind and water are major drivers of the vegetation, from the equator to 23 degrees N and S latitude. It is dominated by prostrate perennials on the beach and foredune, and graminoids and scrub on backdunes and bluffs.

Classification Comments: This formation is only weakly defined by growth forms. It may be a more appropriate division-level distinction, but it does provide a convenient grouping of very similar divisions across the globe; thus it may be a formation, based on global scale coastal ecological processes and justified by a bottom-up perspective. See under *2.B.4. Temperate to Polar Scrub & Herb Coastal Vegetation Formation (F005)*.

There are windswept inland dunes that can appear similar to coastal environments. They may have established on more ancient coastal shorelines. Review is needed to determine whether the vegetation fits here or in *2.A.1. Tropical Lowland Grassland, Savanna & Shrubland Formation (F019)*.

In temperate coastal habitats, large perennial grasses are found, with a diversity of forbs and with higher wind and wave energy. A zone of ephemerals (such as *Cakile, Atriplex*, and *Salsola*) is perhaps more common (Barbour 1992).

Similar NVC Types:

2.A.1. Tropical Lowland Grassland, Savanna & Shrubland (F019): Found in non-coastal habitats.

2.B.4. Temperate to Polar Scrub & Herb Coastal Vegetation (F005): The strength of the tropical versus temperate distinction may be weak in these coastal habits, but annual or ephemeral herbs may be more common in temperate beaches.

Diagnostic Characteristics: The vegetation often has morphological (psammophytic) adaptations to these habitats, including prostrate herbaceous perennial growth forms, with mesomorphic leaves, neither succulent nor sclerophyllous, less commonly with annual herbs, and increasingly with perennial grasses and shrubs on the stabilized backdunes. The backdune may have more typical mesomorphic or xeromorphic scrub and herb vegetation.

Vegetation

Physiognomy and Structure: The vegetation often has morphological (psammophytic) adaptations to the beach, dune, and bluff habitats, including prostrate herbaceous perennial growth forms with mesomorphic leaves, neither succulent nor sclerophyllous, less commonly with annual herbs, and increasingly with perennial grasses and shrubs on the stabilized backdunes. The tropical coastal vegetation tends to have prostrate or low perennial grasses on the beach and foredune and woody species (favored by the long growing season) on the backdunes. In drier tropical climates, there may be a shift to xeromorphic desert species (Barbour 1992).

Environment

Environmental Description: Tropical Scrub & Herb Coastal Vegetation includes upland habitats found along the coast, including beaches, bluffs and dunes, where wind, water, and salinity are major drivers of the vegetation. Beaches include the strip of sand or gravel that extends from the mean tideline to the top of the foredune (frontal foredune). The dune extends further inland wherever the sandy/gravelly site conditions restrict tree growth (less than 10 percent cover). Unconsolidated bluffs (but not marine rock cliffs) are more stable, relatively vertical habitats (Barbour 1992).

Beach sand is typically enriched with nutrients and organic matter from the sea or lake. The permeability of the sandy substrate permits drainage and leaching, with a tendency towards arid systems. Proximity to the sea or lake induces permanently high air humidity and reduces climatic extremes. Sea-level changes constantly rework the substrate (Seeliger 1992). Winds are a constant influence.

Distribution

Geographic Range: This formation is found in tropical coastal habitats, including beaches, bluffs and dunes, from the equator to 23 degrees N and S latitude.

The beach and foredune part of the concept is most distinctive. Backdune grasslands and shrublands may be structurally similar to inland grasslands and shrublands, and floristic information may be needed to determine their placement.

Citations

Synonymy:

> Coastal foredunes of southern Brazil (Seeliger 1992) [The author uses the vegetation type as a name for a chapter in a book on Latin American coastal plant communities. Beaches are not described.]

= The Dune Plant Community (Seeliger 1992) [The author uses the vegetation type as a name for a section in a book on Latin American coastal plant communities. Beaches and dunes are included.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

2.B. Temperate & Boreal Grassland & Shrubland (S18)

Overview

Database Code: 2.B (S18)

Scientific Name: Temperate & Boreal Grassland & Shrubland Subclass

Common Name (Translated Scientific Name): Temperate & Boreal Grassland & Shrubland Subclass

Colloquial Name: Temperate & Boreal Grassland & Shrubland

Hierarchy Level: Subclass

Placement in Hierarchy: 2. Shrub & Herb Vegetation (C02)

Lower Level Hierarchy Units:

2.B.1. Mediterranean Scrub & Grassland (F038)

2.B.2. Temperate Grassland & Shrubland (F012)

2.B.3. Boreal Grassland & Shrubland (F028)

2.B.4. Temperate to Polar Scrub & Herb Coastal Vegetation (F005)

Concept Summary

Type Concept Sentence: Temperate & Boreal Grassland & Shrubland is dominated by mesomorphic grasses and shrubs, with or without scattered trees (and trees typically less than 10 percent cover), ranging from temperate coastal to inland lowland and montane grasslands and shrublands, with a strongly seasonal climate and at least some frost to extended cold seasons.

Classification Comments: Desert grasslands are treated in *3. Desert & Semi-Desert Class (C03)* based on the typical presence or abundance of xerophytic woody growth forms and, less commonly, the presence/abundance of ephemeral plants. Review of herbaceous growth forms is needed to determine if there are forms that more clearly distinguish desert grasslands from temperate grasslands. As Dixon et al. (2014) and others suggest, there may be good ecological reasons to treat upland tropical tree savannas, with up to 40% tree cover, trees <8 m tall, and a substantial graminoid layer, as part of *2. Shrub & Herb Vegetation Class (C02)*, and we allow for that option here. By contrast, in non-tropical regions, we place tree savannas with woodland and forest.

Similar NVC Types:

- *1.B. Temperate & Boreal Forest & Woodland (S15)*: Temperate & Boreal Grassland & Shrubland (S18) tree cover is less than 10 percent.
- *2.A. Tropical Grassland, Savanna & Shrubland (S01)*.
- *3.B. Cool SemiDesert Scrub & Grassland (S11)*: Temperate & Boreal Grassland & Shrubland (S18) typically lacks the microphyllous leaved shrubs, more open and short grasses, and dry soils of cool semi-desert formation (S11), but dry grasslands, such as shortgrass prairies in North America, may have many similarities to cool semi-deserts.
- *6.B. Mediterranean, Temperate & Boreal Open Rock Vegetation (S04)*: Temperate & Boreal Grassland & Shrubland (S18) contains many rocky river and lake shoreline types.

Diagnostic Characteristics: Temperate & Boreal Grassland & Shrubland is dominated by mesomorphic grasses or grasses and shrubs, with or without scattered trees (and trees typically less than 10 percent cover), ranging from temperate to coastal and inland lowland and montane grasslands and shrublands, with a strongly seasonal climate, with at least some frost and with extended strong cold seasons.

Vegetation

Physiognomy and Structure: The vegetation varies from grasslands of open to dense bunch or sod grasses, often with scattered shrubs, to low (<2 m) open to dense shrublands and sclerophyllous or soft chaparral and drought-deciduous scrub. Xeromorphic growth forms are largely absent, and the surface layer contains a thin to thick litter and duff layer in contrast to desert grassland and scrub, where the surface layer may be bare or contain a biological crust. Structure is a single, major grass or shrub stratum, or a mix of the two, with mesomorphic tree cover typically less than 10 percent, rarely with bare ground (Whittaker 1975). The range of variation in upland formations corresponds to Mediterranean, Temperate, Boreal, and Coastal climatic gradients.

Environment

Environmental Description: The vegetation occurs in areas of moderately dry to wet, continental, coastal, and Mediterranean climates (moderately dry, warm temperate, maritime climates with little or no summer rain). A number of drivers can preclude establishment of forest vegetation in these climates, including climatic characteristics, water regime (droughty soils), and fire and flooding disturbances.

Distribution

Geographic Range: This subclass occurs in the middle latitudes (between 25 and 60 to 0 degrees N and S latitude) of both hemispheres, and is most abundant in North America, Eurasia (the steppes), South America, and parts of Southern Africa and Australia. Specific latitudes depend upon the continent on which they are located.

Citations

Synonymy:

= Temperate Grassland Biome (Woodward 2008)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

2.B.1. Mediterranean Scrub & Grassland (F038)

Overview

Database Code: 2.B.1 (F038)

Scientific Name: Mediterranean Scrub & Grassland Formation

Common Name (Translated Scientific Name): Mediterranean Scrub & Grassland Formation

Colloquial Name: Mediterranean Scrub & Grassland

Hierarchy Level: Formation

Placement in Hierarchy: 2.B. Temperate & Boreal Grassland & Shrubland (S18)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Mediterranean Scrub & Grassland includes the sclerophyllous scrub that develops in Mediterranean climates found in the Mediterranean Basin, lowland California in the United States, west-central Chile, the western Cape Province of South Africa, and southwestern and southern Australia. It also includes Mediterranean grasslands, "wildflower fields," and prairies from California.

Classification Comments: Each region of Mediterranean scrub has developed unique names for the type, including in California, *chaparral* and *coastal scrub*; in Chile, *matorral* and *espinal*; in Spain, *tomillares*; in France or French-speaking countries, *maquis* or *garrigue*; in Greece, *phyrgana*; in Israel, *bath'a* or *goresh*; in South Africa, *fynbos* and *strandveld*; and in Australia, *kwongan* and *mallee* (Kuennecke 2008).

Mediterranean grassland and meadow are included in this formation. In California, they are separated from Mediterranean scrub at the division level (*2.B.1.Na. California Grassland & Meadow Division (D021))*, and the vegetation includes the Central Valley and foothill herbaceous vegetation with more pronounced summer drought. These drier Mediterranean California grasslands resemble desert grasslands. However, they have even less rain in the growing season than many desert grasslands. Although other Mediterranean regions of the world do have many annual species, California is the only region that has extensive annual-dominated herbaceous vegetation (T. Keeler-Wolf, pers. obs. 2011).

California "coastal prairies," including diagnostics such as *Festuca rubra, Festuca idahoensis, Danthonia californica*, etc., are placed in *2.B.2 Temperate Grassland & Shrubland Formation (F012)* and, within that formation, in the *2.B.2.Na Southern Vancouverian Lowland Grassland & Shrubland Macrogroup (M050)*.

Placement of montane (oro-) Mediterranean vegetation needs further review. In California, the growth forms of this vegetation are common to other, primarily cool-temperate vegetation, placed in the *2.B.2 Temperate Grassland & Shrubland Formation (F012)*. In Europe, "Oro-mediterranean grasslands and scrub" is treated as a separate formation from either "Temperate grasslands, heaths, and fringe vegetation" or "Mediterranean garrigue, maquis, mattoral, tomillar, and phrygna" vegetation (Rodwell and others 2002). Perhaps the "oroMediterranean" distinction in Europe includes a "warm temperate montane grassland and scrub" not found in other continents. Such a distinction could be made at the division level, if the flora of the montane Mediterranean vegetation was largely distinct from the lowland coastal Mediterranean vegetation.

Similar NVC Types:

1.B.1. Warm Temperate Forest & Woodland (F018): The vegetation contains tree growth forms with greater than 10 percent cover. Combinations of dwarf scrubby trees less than 2 m with low shrubs may grade into Warm Temperate Forest.

2.B.2. Temperate Grassland & Shrubland (F012): The vegetation tends to produce highest biomass in the warm to hot summers and become dormant in the winter cool or cold periods. Above-ground portions of perennial grasses dry and wither, or annuals set seed and die by late fall.

Diagnostic Characteristics: Sclerophyll-leaved shrub growth forms prevail, but soft chaparral and drought-deciduous forms may also occur. Shrub growth forms range from arborescent (2 to 5 m tall) shrubs with a closed canopy, to less than 1 m and quite open. Mixed annual and perennial grasslands may also occur, with only scattered scrub. The vegetation tends to produce the most biomass in the cool rainy winter and becomes dormant in the summer drought. Above-ground portions of perennial grasses dry and wither, or annuals set seed and die by mid-spring to early summer. The type is restricted to the Mediterranean Basin, southwestern California in the United States, west-central Chile, the western Cape Province of South Africa, and southwestern and southern Australia.

Vegetation

Physiognomy and Structure: Shrubs have adaptations to drought, nutrient-poor soils and fire. Broad-leaved evergreen, sclerophyllous shrubs dominate the vegetation of areas with higher and more predictable winter rainfall, while facultatively deciduous shrubs, or perennial or annual herbs dominate where precipitation is lowest and less predictable. Depending on the interactions of rainfall, soil texture, and type and intensity of natural processes such as fire, browzing/grazing, and bioturbation, there is a complex variation of growth forms. This ranges from woody sclerophyll to woody drought-deciduous shrubs and from perennial bunch grasses to perennial geophytes (bulbs, corms, etc., especially common in South Africa) and to ephemeral annual herbs. Generally, sclerophylls occur where winter rain is adequate and predictable and soils are well drained. Facultatively deciduous scrub occurs in areas with drier or more unpredictable rainfall patterns and often on finer textured soils than sclerophyll scrub. Perennial herbaceous vegetation such as bunch grasses occur in areas with relatively high precipitation, while annual herbs (forbs) dominate episodically following favorable winter rainfall events, but may be largely stored as seedbanks in the soil in low rainfall years. The vegetation tends to produce highest biomass in the cool rainy winter and becomes dormant in the summer drought. Above-ground portions of perennial grasses dry and wither, or annuals set seed and die by mid-spring to early summer. Small numbers of summer annuals also occur (mostly Asteraceae tribe Madiae in California), which take advantage of lingering deep soil moisture by having evolved long taproots.

Environment

Environmental Description:

Climate: The Mediterranean climate is characterized by dry summers and mild, humid, sometimes rainy winters. Annual precipitation averages 25 to 100 cm. Freezing temperatures are relatively rare. Wherever mountains and predominant wind directions cause orographic effects (for example the rainfall increases on the windward side), annual precipitation at the higher elevations may be sufficient to support a change from scrub to woodland or forest [and these would be placed in *1.B.1 Warm Temperate Forest & Woodland Formation (F018)*]. With increasing latitude, rainfall totals and length of the rainy season also increase, causing a comparable shift to woodland or forest (Kuennecke 2008). Many Mediterranean climate areas have been "invaded" by exotic annual grasses and other species that have tended to modify natural disturbance patterns such as fire (Keeley 2001).

Distribution

Geographic Range: This formation occurs in the Mediterranean Basin, and in the Mediterranean climate regions of southwestern California in the United States, west-central Chile, the western Cape Province of South Africa, and southwestern and southern Australia, at latitudes between 31 and 46 degrees N in the Northern Hemisphere and between 28 and 42 degrees S in the Southern Hemisphere. These areas form on the western or southern margins of continents where warm-season high pressure tends to settle offshore driving all precipitation to the north or south of the adjacent shore areas.

Citations

Synonymy:

> Chaparrallike Shrublands (Dallman 1998)

> Coastal Scrub (Dallman 1998)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: T. Keeler-Wolf

Acknowledgments:

Version Date: 26 Aug 2014

2.B.2. Temperate Grassland & Shrubland (F012)

Overview

Database Code: 2.B.2 (F012)

Scientific Name: Temperate Grassland & Shrubland Formation

Common Name (Translated Scientific Name): Temperate Grassland & Shrubland Formation

Colloquial Name: Temperate Grassland & Shrubland

Hierarchy Level: Formation

Placement in Hierarchy: 2.B. Temperate & Boreal Grassland & Shrubland (S18)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Temperate Grassland & Shrubland is dominated by perennial grasses, forbs and shrubs typical of moderately dry to moist habitats, and is found in the mid-latitude regions of all continents (23 to 55 degrees N and S), varying from large open grassland landscapes to droughty hillside meadows in forested landscapes.

Type Concept: Temperate Grassland & Shrubland is dominated by mesomorphic perennial grasses and forbs and is found in the mid-latitude regions across the globe. It is associated with a moist to semi-arid climate and geographically occurs between temperate forests and deserts. The present plant assemblages were strongly affected by Pleistocene glaciations, though regions close to the equator may have retained vegetation back to the Tertiary.

Grasslands are a predominant type in this formation and each continent has its own popular name for its part of this formation. In North America, it is the prairie; in Eurasia, the steppe. South Americans usually refer to pampas and South Africans to the veld. The plants (and animals) of the North American and Eurasian sections of the biome are closely related, but have been impacted differently by Pleistocene and post-Pleistocene climate changes, human occupation and use, wildfires, and grazing pressures from both wild and domesticated large mammals. The origins of South America's pampas and southern Africa's veld are still poorly understood. Fire may be implicated, as it is a necessary management tool today in preventing the encroachment of woody plants.

In addition to the larger geographic areas of grasslands and associated shrublands, scattered grassland, shrub, and forb vegetation within temperate forest formations are included.

Although mesomorphic perennial grasses and shrubs are the most common growth forms in this formation, a large number of other herbaceous plants, primarily perennial forbs, are also found. Trees are not major components of the vegetation, except as a scattered layer (typically less than 10 percent cover).

Similar NVC Types:

1.B.1. Warm Temperate Forest & Woodland (F018): Open woodlands or tree savannas, with grassy or shrubby understories, and with trees 10 percent cover or more, are placed here, but may have strong floristic similarities to grasslands.

1.B.2. Cool Temperate Forest & Woodland (F008): Open woodlands or tree savannas, with grassy or shrubby understories, and with trees 10 percent cover or more, are placed here, but may have strong floristic similarities to grasslands.

2.B.1. Mediterranean Scrub & Grassland (F038): The vegetation tends to produce highest biomass in the cool winters, and become dormant in the summer hot periods. Above-ground portions of perennial grasses dry and wither, or annuals set seed and die by late spring.

2.B.3. Boreal Grassland & Shrubland (F028): Temperate Grassland & Shrubland (F012) is currently separated based on geography and climate from boreal grassland (F028), but more specific vegetation criteria are needed.

2.B.4. Temperate to Polar Scrub & Herb Coastal Vegetation (F005): Temperate Grassland & Shrubland (F012) has similarities to coastal vegetation, especially between coastal and inland dunes in terms of growth forms and even wind-driven processes.

2.C.4. Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland (F013): Temperate Grassland & Shrubland (F012) transition, such as wet-mesic or moist grasslands and prairies, may be very similar to freshwater marshes and wet meadows (F013).

3.B.1. Cool Semi-Desert Scrub & Grassland (F033): Typically with small leaved, xerophytic shrubs (e.g., sage) and more open bare ground, sometimes with biological crust.

7.B.2. Pasture & Hay Field Crop (CFO05): Temperate Grassland & Shrubland (F012) may overlap in composition with pasture grasslands (CFO05), particularly in grassland regions. And in regions where a pastoral tradition has existed from 100s to 1000s of years, recognition of native versus agricultural grasslands may be challenging.

Diagnostic Characteristics: Mesomorphic perennial grasses and shrubs are the most common growth forms in this formation, with a variable amount of perennial forbs. Trees are scattered to largely absent (typically less than 10 percent cover). Stands are found in the mid-latitude regions of all continents, typically associated with semi-arid climates or stressful sites in moist climates in the mid latitudes (23 to 55 degrees N and S).

Vegetation

Physiognomy and Structure: Mesomorphic perennial grasses and shrubs are the most common growth forms in this formation, with a variable amount of perennial forbs. Trees are scattered to largely absent (typically less than 10 percent cover). Grasses and forbs grow to different heights at maturity. Furthermore, some grasses and most forbs are erect, while others are recumbent, creeping along the ground. Thus a distinct layering of plant foliage occurs in some temperate grasslands. Forbs and grasses may grow and bloom at different times during the growing season, so temperate grasslands may have recognizable color phases, or aspects, depending on what plants are blooming. This is especially evident in the east European steppes. Grasses and perennial forbs are well suited to withstand cold seasons and tolerate grazing and fire because of the position of their renewal buds near the ground surface. The plants are generally able to regenerate from these buds after seasonal die-downs, burns, or cropping by grazing animals (Woodward 2008). Among the grasses, both sod-forming and bunch grasses are prominent throughout, but bunch grasses become a much more frequent component of the vegetation in the drier short-grass regions.

Environment

Environmental Description: Gradation in precipitation amounts occurs in most regional expressions of the biome and is mirrored in the zonation pattern of the vegetation and animal life in each. In some instances, such as in North America, longitudinal zones dominate and replace each other in an east-west direction across the mid-continent. In other areas, latitudinal zonation is prominent and plant and animal communities change in a north-south direction. Still other natural grasslands are a consequence of rain shadows on the lee sides of major mountain ranges or of high elevation, as is the case in southern Africa (Woodward 2008).

Climate: Temperate grasslands have developed in regions having a semi-arid climate (mostly BSk in the Koeppen climate classification). Mid-latitude semi-arid climate regions receive 25 to 75 cm (10 to 20 inches) of precipitation a year. In some areas (most notably the mid-continental prairie of North America and the East European steppes of Eurasia), a significant amount falls as snow during the winter months, such that snowmelt contributes importantly to soil moisture in early spring. The interior position of grasslands on the large North American and Eurasian continents results in the wide annual range in temperatures, a temperature pattern that is considered typical for the biome. Winters see temperatures well below freezing, whereas summers can be scorchingly hot. Such a temperature pattern is described by climatologists as continental**.** Similar temperature conditions often occur in humid forested regions at the same latitudes (Woodward 2008).

North American and Eurasian grasslands owe their existence to their positions in the middle of large continents, where precipitation is reduced and temperature extremes are pronounced. The South American grasslands lie in the rain shadow east of the Andes Mountains. In Africa, elevation is a factor. According to latitude alone, these African grasslands are subtropical, but the elevated surface at the southern end of the African Plateau creates regional temperature patterns similar to middle latitude conditions (Woodward 2008).

In all regions of the formation, gradual changes in climate occur across great distances. In Eurasia, the variation occurs in a north-south direction. The wetter (subhumid) northern regions of the Temperate Grassland border the Cool Temperate Forest & Woodland and Boreal Forest & Woodland Formations, and the drier (arid) southern margins grade into the Desert formations. In the Americas, the gradation from subhumid to arid runs in an east-west direction, with progressively less precipitation the farther west one goes. In all areas a change in vegetation coincides with the change in total precipitation. Wetter areas contain taller grass species and usually a greater variety of plants and animals than do the shorter grass areas in the driest parts of the biome (Woodward 2008).

Soil/substrate/hydrology: The soils beneath prairies, steppes, pampas, and high veld are among the most fertile on Earth. Once the technology was available to break through the thick sod, many grasslands were converted to agriculture. Wheat and corn replaced native grasses, and the temperate grasslands became the breadbaskets of their respective countries (Woodward 2008).

Soils Comments:

Formation of Temperate Grassland soils: The underground portion of the grass plant is equally, if not more, important to the functioning of the ecosystem and formation of soil. Grasses develop a dense, intricate system of fine roots that not only acts to hold the plant in place but absorbs water and nutrients from the soil and stores some of the carbohydrates that the plant manufactures during photosynthesis for later use. In fact, more living plant matter (biomass) exists below ground in the temperate grasslands than above. Roots continually grow, die, and decay and thus contribute organic matter in the form of humus to the soil. The fine roots create a crumbly texture to the soil that allows water and air to penetrate to depths up to 3.5 m (12 feet) in the wetter parts of the biome, further enhancing the soil environment for plant growth. Those soluble compounds (e.g., calcium carbonate and magnesium carbonate) that might be leached to depth after rainstorms or snowmelt can be returned to the root zone during dry periods by capillary action along the tiny tunnels left by dead roots. The carbonates precipitate out near the top of the subsoil (B-horizon) when the soil moisture evaporates. The concentration of carbonates in this manner is the main feature of the soil-forming process known as calcification**,** which is characteristic of semi-arid and arid climate regions. The carbonate-rich layer forms closer to the surface the drier the climatic conditions (Woodward 2008).

Soil types: Grassland soils of temperate regions are classified in U.S. Soil Taxonomy as Mollisols. The prefix "moll" means soft and describes the friable or crumbly texture of these soils that persists even when the top layers dry out. Other parts of the world and the United Nations Food and Agriculture Organization use other names. In Canada they are called chernozemic soils; in Russia they are chernozems. Mollisols are brown in color due to the abundance of humus in both the topsoil and subsoil (A and B horizons). Color varies from dark brown and even black to chestnut brown and light brown as climate changes from subhumid to dry and grasses change from tall with deep roots to short with shallow roots. For the darkest of all, the truly black soils, the Russian name *Chernozem* (meaning black soil) is used, even in the United States. Chernozems have especially deep A and B horizons (each up to 1 m [3 feet] deep), both of which are dark with humus and humic acid stains. They have formed where semi-arid regions receive the most precipitation and where the parent material is a fine, windblown material known as loess. Loess originated as tiny particles on the newly exposed bare ground at the edge of continental glaciers when ice sheets retreated at the end of the Pleistocene ice age. Winds coming off the ice picked the dust-like material up and carried it to more humid, vegetated regions, where it accumulated. Thick deposits of loess occur in the Central Lowlands of North America, across much of semi-arid Eurasia, and in Uruguay and eastern parts of Argentina. Loess is often rich in carbonates. The soils developed on it are among the most fertile in the world, and today they produce much of the world's wheat and corn (both of which are domesticated grasses) (Woodward 2008).

Distribution

Geographic Range: Temperate grasslands and shrublands occur in the middle latitudes (25 to 55 degrees latitude) of both hemispheres. Specific latitudes depend upon the continent on which they are located. The largest areas of this formation are found in the Northern Hemisphere on the North American and Eurasian continents. Smaller but still major segments of the formation are found in the Southern Hemisphere in South America and southern Africa (Woodward 2008).

Citations

Synonymy:
= Temperate Grassland (Woodward 2008) [Despite the name, shrublands found within the grassland regions are included in Woodward's concept.]
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012) after S. Woodward (2008)
Author of Description: D. Faber-Langendoen and J. Messick
Acknowledgments:
Version Date: 26 Aug 2014

2.B.3. Boreal Grassland & Shrubland (F028)

Overview

Database Code: 2.B.3 (F028)
Scientific Name: Boreal Grassland & Shrubland Formation

Common Name (Translated Scientific Name): Boreal Grassland & Shrubland Formation
Colloquial Name: Boreal Grassland & Shrubland
Hierarchy Level: Formation
Placement in Hierarchy: 2.B. Temperate & Boreal Grassland & Shrubland (S18)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Boreal Grassland & Shrubland is dominated by mesomorphic perennial grasses, forbs and shrubs, and is found in the northern mid-latitude (boreal) regions of North America and Eurasia, between 55 and 70 degrees N, with extended cold winters and short mild summers.

Type Concept: Boreal Grassland & Shrubland is dominated by mesomorphic perennial grasses, forbs and shrubs, and is found in the northern mid-latitude (boreal) regions of North America and Eurasia. It is associated with cold semi-arid to moist climates, with extended cold winters and short mild summers, and geographically occurs mixed with boreal forests and wetlands. The climate generally favors establishment of forest vegetation; thus, the absence of forest vegetation is a result of local conditions related to water regime, soil parameters or disturbance regimes. The present assemblages of plants and animals date to after the Pleistocene, following glaciation, when modern climates were established. Wildfires and grazing also play a role in some of these grasslands.

Along with the mesomorphic perennial grasses, shrubs, and forbs, mosses and lichens can also play an important role. Boreal tree growth forms are not major components of the vegetation, except as a scattered layer (typically less than 10 percent). In disturbance situations, Boreal Grassland & Shrubland can grade to Boreal Forest & Woodland and may not be clearly separated from it floristically.

Classification Comments: Clarification of the growth forms, distribution and extent, and ecological processes that control boreal shrublands and grasslands is needed. Examples of vegetation from western boreal include: (1) *Betula nana* and/or *Salix glauca* shrublands and *Festuca altaica* grasslands in cold air-influenced valleys and high-elevation areas below the alpine; (2) *Elymus trachycaulus* grassland or *Amelanchier alnifolia / Leymus innovatus / Arctostaphylos uva-ursi* scrub on warm aspects, often on coarse-textured materials; and (3) Post-fire disturbance vegetation that can be dominated by willows and may exclude tree regeneration.

Similar NVC Types:

2.B.2. Temperate Grassland& Shrubland (F012): This type is currently separated based on geography and climate.

Diagnostic Characteristics: Mesomorphic perennial grasses and shrubs are the most common growth forms in this formation, with a variable amount of perennial forbs. Trees are scattered to minimally present (typically less than 10 percent cover) in the northern mid-latitude regions of North America and Eurasia, extending from cool temperate regions into the boreal region between 55 and 70 degrees N latitude.

Vegetation

Physiognomy and Structure: Boreal Grassland & Shrubland is dominated by mesomorphic perennial grasses, forbs and shrubs. Mosses and lichens can also play an important role. Boreal tree growth forms are not major components of the vegetation, except as a scattered layer (typically less than 10 percent). In disturbance situations, Boreal Grassland & Shrubland can grade to Boreal Forest & Woodland and may not be clearly separated from it floristically.

Environment

Environmental Description: *Climate:* This type is associated with cold semi-arid to moist climates, with extended cold winters and short mild summers, and geographically occurs mixed with boreal forests and wetlands. The climate generally favors establishment of forest vegetation; thus, the absence of forest vegetation is a result of local conditions related to water regime, soil parameters, or disturbance regimes. There are lengthy periods of freezing temperatures with the coldest month isotherm of 3 degrees C, and the growing season generally averaging less than 100 days, occasionally interrupted by nights of below-freezing temperatures. Snow may be present for extended periods (7 to 10 months) and soils are frozen in winter. Annual precipitation is 3,850 cm (1,520 inches). The northern and southern boundary of these boreal grasslands may be similar to that of boreal forest, but the reasons for the presence of grassland and shrubland rather than forest typically reflects water regime, soil characteristics, disturbance regime, and local climate that prevent tree growth.

Distribution

Geographic Range: This formation is found in the northern mid-latitude regions of North America and Eurasia, extending through much of the boreal region between 55 and 70 degrees N latitude.

Citations

Synonymy:

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen, S. Ponomarenko and D. Meidinger

Acknowledgments:

Version Date: 26 Aug 2014

2.B.4. Temperate to Polar Scrub & Herb Coastal Vegetation (F005)

Overview

Database Code: 2.B.4 (F005)

Scientific Name: Temperate to Polar Scrub & Herb Coastal Vegetation Formation

Common Name (Translated Scientific Name): Temperate to Polar Scrub & Herb Coastal Vegetation Formation

Colloquial Name: Temperate to Polar Scrub & Herb Coastal Vegetation

Hierarchy Level: Formation

Placement in Hierarchy: 2.B. Temperate & Boreal Grassland & Shrubland (S18)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Temperate to Polar Scrub & Herb Coastal Vegetation is found in temperate to polar coastal habitats, including beaches, bluffs and dunes, where wind and water are major drivers of the vegetation, across the mid to polar latitudes from 23 to 60 to 70 degrees N and S latitude, dominated by prostrate perennials on the beach and foredune, and graminoids and scrub on backdunes and bluffs.

Classification Comments: This formation is only weakly defined by growth forms. It may be a more appropriate division-level distinction, but it does provide a convenient grouping of very similar divisions across the globe; thus it may be a formation, based on global scale coastal ecological processes and justified by a bottom-up perspective. There are windswept inland dunes that can appear similar to coastal environments. They may have established on more ancient coastal shorelines. Review is needed to determine whether the vegetation fits here or in *2.B.2. Temperate Grassland & Shrubland Formation (F012)*. The tropical coastal vegetation tends to have prostrate or low perennial grasses on the beach and foredune and have woody species (favored by the long growing season) on the backdunes. In drier temperate climates, there may be a shift to xeromorphic cool desert species.

Similar NVC Types:

- *2.A.3. Tropical Scrub & Herb Coastal Vegetation (F024)*: The strength of the tropical versus temperate distinction may be weak in these coastal habits, but perennial herbs may be more common in tropical beaches.
- *2.B.2. Temperate Grassland & Shrubland (F012)*: There are similarities between coastal and inland dunes in terms of growth forms and wind-driven processes.

Diagnostic Characteristics: The vegetation often has morphological (psammophytic) adaptations to these habitats, including prostrate herbaceous perennial growth forms, with mesomorphic leaves, neither succulent nor sclerophyllous, less commonly with annual herbs, and increasingly with perennial grasses and shrubs on the stabilized backdunes. The backdune may have more typical mesomorphic or xeromorphic scrub and herb vegetation.

Vegetation

Physiognomy and Structure: The vegetation often has morphological (psammophytic) adaptations to the beach, dune and bluff habitats, including prostrate herbaceous annual growth forms, with mesomorphic leaves, neither succulent nor sclerophyllous, less commonly with annual herbs, and increasingly with perennial grasses and shrubs on the stabilized backdunes. The temperate coastal vegetation tends to have prostrate or low perennial grasses on the beach and foredune and woody species (favored by the long growing season) on the backdunes. In drier climates, there may be a shift to xeromorphic cool desert species (Barbour 1992).

Environment

Environmental Description: This formation includes upland habitats found along the coast, including beaches, bluffs and dunes, where wind, water, and salinity are major drivers of the vegetation. Beaches include the strip of sand or gravel that extends from the mean tideline to the top of the foredune (frontal foredune). The dune extends further inland wherever the sandy/gravelly site conditions restrict tree growth (less than 10 percent cover). Unconsolidated bluffs (but not marine rock cliffs) are more stable, relatively vertical habitats (Barbour 1992).

Beach sand is typically enriched with nutrients and organic matter from the sea or lake. The permeability of the sandy substrate permits drainage and leaching, with a tendency towards arid systems. Proximity to the sea or lake induces permanently high air humidity and reduces climatic extremes. Sea-level changes constantly rework the substrate (Seeliger 1992). Winds are a constant influence.

Distribution

Geographic Range: This formation is found in temperate coastal habitats, including beaches, bluffs and dunes, across the mid- to polar latitudes from 23 to 70 degrees N and S latitude.

Citations

Synonymy:

= The Dune Plant Community (Seeliger 1992) [The author uses the vegetation type as a name for a section in a book on Latin American coastal plant communities. Beaches and dunes are included.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

2.C. Shrub & Herb Wetland (S44)

Overview

Database Code: 2.C (S44)

Scientific Name: Shrub & Herb Wetland Subclass

Common Name (Translated Scientific Name): Shrub & Herb Wetland Subclass

Colloquial Name: Shrub & Herb Wetland

Hierarchy Level: Subclass

Placement in Hierarchy: 2. Shrub & Herb Vegetation (C02)

Lower Level Hierarchy Units:

2.C.1. Tropical Bog & Fen (F002)

2.C.2. Temperate to Polar Bog & Fen (F016)

2.C.3. Tropical Freshwater Marsh, Wet Meadow & Shrubland (F030)

2.C.4. Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland (F013)
2.C.5. Salt Marsh (F035)

Concept Summary

Type Concept Sentence: Shrub & Herb Wetland includes open bogs, fens, fresh and saltwater marshes, wet meadows and wet shrublands. The vegetation occurs from tropical to polar regions.

Classification Comments: These wetlands contain vegetation that is hydrophytic, but none-the-less, largely mesomorphic growth forms, not hydromorphic growth forms.

Similar NVC Types:

1.A. Tropical Forest & Woodland (S17): This subclass contains flooded and swamp forests (which can transition to open bogs and marshes) and mangroves (which can be similar to salt marshes). Where tree cover exceeds 10 percent, stands are typically placed in Forest & Woodland subclasses.

5.B.1. Tropical Freshwater Aquatic Vegetation (F056)

5.B.2. Temperate to Polar Freshwater Aquatic Vegetation (F057)

Diagnostic Characteristics: Shrub & Herb Wetland is dominated by grasses and shrubs, with or without scattered trees (which may have up to 10 percent cover), sometimes with a wet moss layer (bogs and fens), halophytic growth forms (salt marsh), or a mix of emergent and hydromorphic growth forms, with seasonally to annually saturated or flooded soils, or standing water.

Vegetation

Physiognomy and Structure: This type is dominated by grasses and shrubs, with or without scattered trees (but tree cover typically less than 10 percent), sometimes with a strong moss (sphagnum or brown moss) component, or with hydromorphic growth forms. A summary of the range of variation for the various wetlands within the subclass is provided in Table 6.

Environment

Environmental Description: Stands are found in a variety of wetland settings, including seasonally to annually saturated or flooded soils, or standing water.

Distribution

Geographic Range: This subclass is found widely throughout the world in lowland and montane wetland habitats, from the tropics to the poles.

Citations

Synonymy:
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen
Acknowledgments:
Version Date: 26 Aug 2014

2.C.1. Tropical Bog & Fen (F002)

Overview

Database Code: 2.C.1 (F002)
Scientific Name: Tropical Bog & Fen Formation
Common Name (Translated Scientific Name): Tropical Bog & Fen Formation
Colloquial Name: Tropical Bog & Fen
Hierarchy Level: Formation
Placement in Hierarchy: 2.C. Shrub & Herb Wetland (S44)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical Bog & Fen is found where peat-accumulating conditions occur in the cold, wet mountain highlands and in various floodplains of the lowlands, where trees are excluded. They are dominated by sedges, heath, and moss peat.

Classification Comments: Tropical peat swamps, where tree cover exceeds 10 percent, are treated under *1.A.4. Tropical Flooded & Swamp Forest Formation (F029)*.

Similar NVC Types:
2.C.3. Tropical Freshwater Marsh, Wet Meadow & Shrubland (F030)

Diagnostic Characteristics: Tropical Bog & Fen is found where peat-accumulating conditions occur in the cold, wet mountain highlands and in various floodplains of the lowlands, where trees are excluded. They are dominated by sedges, heath, and moss peat.

Vegetation

Physiognomy and Structure: "True" tropical bogs and fens, with sedge or moss peat, are relatively rare. Tropical bogs are covered by a mixed vegetation of sedges and grasses, with scattered or clumped growth of dwarfed trees or shrubs. Given the lack of information on tropical bogs and fens worldwide, a summary is provided from Hawaii (Mueller-Dombois and Fosberg 1998).

The vegetation of most of the Hawaiian bogs may be a continuous or discontinuous dwarf-scrub interspersed with a matrix of hummocky sedges, usually with scattered emergent shrubs 1 or 2 m tall, or rarely, a bed of *Sphagnum* and grass with scattered shrubs and large ferns. Peatmoss (*Sphagnum* spp.) occurs in only a few Hawaiian bogs. Thus, peat is from sedges and grasses, with inclusions of woody peat. Most bogs are found as openings in rainforest, often next to cloud forests (Mueller-Dombois and Fosberg 1998).

Environment

Environmental Description: In tropical regions of the world, peat-accumulating conditions occur in the cold, wet highlands of the Andes and in the floodplains of the lowlands, where peatlands have a fluctuating water table, with groundwater and surface water movements being common, and trees are excluded. "True" tropical bogs and fens, however, with sedge or moss peat are relatively rare. Tropical bogs occur in high, rainy regions, on flat to gently sloping, water-soaked ground with nearly impervious clay beneath peat of depths varying from less than 0.1 to greater than 3 m. Given the lack of information on tropical bogs and fens worldwide, a summary is provided from Hawaii (Mueller-Dombois and Fosberg 1998).

Most Hawaiian bogs are on relatively flat ground underlain by more-or-less impervious clay in areas of high rainfall, usually exceeding 250 cm per year. They range in size from less than 1,000 square m to over 5 ha. Organic overlays may vary from less than 10 cm ("protobogs" or "clay bogs") to those with less than 40 cm ("semi-bogs") to those with over 40 cm organic overlays ("true bogs"). The depth of the overlay is a function of age (some bogs originated over 11,000 years ago), temperature (with cooler locations having slower decomposition and greater peat depths) and anaerobic conditions (MuellerDombois and Fosberg 1998).

Two kinds of Hawaiian bogs can be distinguished: ombrogenous (fed by rainwater) and soligenous (fed by both rain- and groundwater). The first type can occur in areas of high rainfall, exceeding 12 m per year, so that the soil need not even be impervious for the bog to form. The second term, "soligenous bog" (or fen), is more appropriate for most Hawaiian bogs (Mueller-Dombois and Fosberg 1998).

Distribution

Geographic Range: Tropical Bog & Fen is found where peat-accumulating conditions occur in the cold, wet mountain highlands and in various floodplains of the lowlands, where trees are excluded. In the United States, the type is found in Hawaii.

Citations

Synonymy:

> Peatlands (Mitsch and Gosselink 2000) [Bogs and fens are treated together, but tropical and temperate bogs are not separated. Forested bogs are included.]

> Peatlands (Roth 2009) [Bogs and fens are treated together, but tropical and temperate bogs are not separated. Forested bogs are included.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen and C. Josse

Acknowledgments:

Version Date: 26 Aug 2014

2.C.2. Temperate to Polar Bog & Fen (F016)

Overview

Database Code: 2.C.2 (F016)

Scientific Name: Temperate to Polar Bog & Fen Formation

Common Name (Translated Scientific Name): Temperate to Polar Bog & Fen Formation

Colloquial Name: Temperate to Polar Bog & Fen

Hierarchy Level: Formation

Placement in Hierarchy: 2.C. Shrub & Herb Wetland (S44)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Temperate to Polar Bog & Fen includes temperate bogs and fens dominated by *Sphagnum* or brown mosses with ericaceous shrubs, graminoids, and low scrub tree growth forms, across the mid-latitudes of the Northern Hemisphere from 23 to 70 degrees N, but is much less common in the southern mid-latitudes.

Classification Comments: Subarctic and arctic (polar) bogs and fens belong in this formation.

Similar NVC Types:

1.B.5. Boreal Flooded & Swamp Forest (F036): This type includes forested bogs with greater than 10 percent cover along with poor swamps.

2.B.2. Temperate Grassland & Shrubland (F012): Upland transitions to wet-mesic or moist grasslands, such as wet-mesic prairies, can be hard to place.

2.C.4. Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland (F013): Fens and marshes can be similar, especially when fen peat mats are inundated (as with "shore fens").

Diagnostic Characteristics: This peatland type is dominated by *Sphagnum* spp. or brown mosses, with ericaceous shrubs, graminoids, and low scrub tree growth forms (<5 m). The driest bogs, especially in permafrost terrain, may be covered in dwarf-shrubs and lichens. Bogs contain raised or level sphagnum peat surfaces that are ombrotrophic or weakly minerotrophic, whereas fens are groundwater-driven, and moderately to strongly minerotrophic.

Vegetation

Physiognomy and Structure: This peatland type is dominated by *Sphagnum* spp. or brown mosses, with ericaceous shrubs, graminoids, and low scrub tree growth forms (<5 m). The driest bogs, especially in permafrost terrain, may be covered in dwarf-shrubs and lichens. The vegetation on fens is closely related to the depth of the water table and the chemistry of the water present. The composition of vegetation may also reflect regional geographic variations. In general, graminoid vegetation and some bryophytes dominate wetter fens where the water table is above the surface. Shrubs are prominent in drier fens where the water table is lower. Trees appear on the driest fen sites where microtopographic features such as moss hummocks provide habitats as much as 20 cm above the water table. Sites in fens with waters extremely low in dissolved minerals are poor fens and have *Sphagnum* mosses and ericaceous shrubs. Poor fens are sometimes placed with bogs as "acid peatlands." Fens with slightly higher concentrations of dissolved minerals are moderately rich fens and are dominated by sedges and brown mosses (such as *Drepanocladus* sp.). The moderate to extremely rich fens are sometimes collectively called "alkaline peatlands" or "rich peatlands" (National Wetlands Working Group 1997).

Environment

Environmental Description: The bog surface, which is raised or level with the surrounding terrain, is virtually unaffected by runoff waters or groundwater from the surrounding mineral soils. Generally the water table is at or slightly below the bog surface. As the bog surface is raised, so is the bog water table relative to the elevation of the water table at the edges of the bog. Precipitation, fog, and snowmelt are the primary water sources and, thus, all bogs are ombrogenous. Given that precipitation does not contain dissolved minerals and is mildly acidic, the surface bog waters are consequently low in dissolved minerals and acidic. Bog water acidity, usually between pH 4.0 and 4.8 (Gorham and Janssens 1992), is enhanced due to the organic acids that form during decomposition of the peat and the acids present within *Sphagnum* leaves (National Wetlands Working Group 1997). The soils are mainly Histosols in the US soil classification, and Fibrisols, Mesisols and Organic Cryosols (permafrost soils) in the Canadian soil classification system (National Wetlands Working Group 1997) [see Brady and Weil (2002) for comparison of Canadian soil orders with U.S. and FAO systems].

Fens are peatlands with a fluctuating water table. The waters in fens are rich in dissolved minerals and, therefore, are minerotrophic. Groundwater and surface water movement is a common characteristic of fens. Surface flow may be directed through channels, pools, and other open waterbodies that can form characteristic surface patterns. The dominant materials are moderately decomposed sedge and brown moss peats of variable thickness.

Distribution

Geographic Range: This formation is found across the mid-latitudes of the Northern Hemisphere from 23 to 70 degrees N, but is much less common in the southern mid-latitudes.

Citations

Synonymy:

> = Bog Wetland Class (National Wetlands Working Group 1997) [The class may include perhaps poor fens,), but is otherwise synonymous with this formation.]

> Fen Wetland Class (National Wetlands Working Group 1997) [The class is synonymous with the fen part of this formation. Trees are typically less than 10 percent cover.]

> Peatlands (Mitsch and Gosselink 2000) [Bogs and fens are treated together, but tropical and temperate bogs are not separated. Forested bogs are included.]

> Peatlands (Roth 2009) [Bogs and fens are treated together, but tropical and temperate bogs are not separated. Forested bogs are included.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen, after National Wetlands Working Group (1997)

Acknowledgments:

Version Date: 26 Aug 2014

2.C.3. Tropical Freshwater Marsh, Wet Meadow & Shrubland (F030)

Overview

Database Code: 2.C.3 (F030)
Scientific Name: Tropical Freshwater Marsh, Wet Meadow & Shrubland Formation
Common Name (Translated Scientific Name): Tropical Freshwater Marsh, Wet Meadow & Shrubland Formation
Colloquial Name: Tropical Freshwater Marsh, Wet Meadow & Shrubland
Hierarchy Level: Formation
Placement in Hierarchy: 2.C. Shrub & Herb Wetland (S44)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical Freshwater Marsh, Wet Meadow & Shrubland includes freshwater wet meadows, shallow and deep emergent marshes, with the upper limits of salinity at 0.5 ppt, above which it is considered saltwater. The vegetation comprises evergreen emergent aquatic macrophytes, chiefly graminoids such as rushes, reeds, grasses and sedges, and shrubs and other herbaceous species such as broad-leaved emergent macrophytes, floating-leaved and submergent species, and nonvascular plants such as brown mosses, liverworts, and macroscopic algae. It is found widely throughout wetland habitats of the tropical latitudes, from the equator to about 23 degrees N and S.

Classification Comments: Further review is needed of the similarities and differences between temperate and tropical freshwater marshes.

Similar NVC Types:

2.C.1. Tropical Bog & Fen (F002): Tropical Freshwater Marsh, Wet Meadow & Shrubland (F030) more typically contains muck soils and lacks the heath and moss layers found in this bog and fen formation (F002).

2.C.4. Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland (F013)

Diagnostic Characteristics: The vegetation comprises evergreen emergent aquatic macrophytes, chiefly graminoids such as rushes, reeds, grasses and sedges, and shrubs and other herbaceous species such as broad-leaved emergent macrophytes, floating-leaved and submergent species, and nonvascular plants such as brown mosses, liverworts, and macroscopic algae, with tree cover less than 10 percent, with the upper limits of salinity at 0.5 ppt, above which it is considered saltwater, and where freezing temperatures are rare to absent.

Vegetation

Physiognomy and Structure: Tropical Freshwater Marsh, Wet Meadow & Shrubland vegetation predominantly comprises evergreen emergent aquatic macrophytes, chiefly graminoids such as rushes, reeds, grasses and sedges, and shrubs and other herbaceous species such as broad-leaved emergent macrophytes, floating-leaved and submergent species, and nonvascular plants such as brown mosses, liverworts, and macroscopic algae. There is a greater proportion of evergreen herbaceous plants in this tropic type, as compared to the temperate type. Vegetation is usually arranged in distinct zones of parallel or concentric patterns in response to gradients of water depth, frequency of drawdown, water chemistry or disturbance. Seasonal drawdowns may expose mudflats that are revegetated by pioneering herb and grass species.

Environment

Environmental Description: These wetlands have shallow water and levels that usually fluctuate daily, seasonally or annually due to tides (freshwater tidal), flooding, evapotranspiration, groundwater recharge, or seepage losses. Salinity is 0.5 ppt, above which it is considered saltwater. Seasonal drawdowns may occur.

The occurrence of large savanna extensions in flat land (Orinoco basin and Beni savannas), as well as of numerous lakes in the Amazon basin, create some unique tropical geomorphological settings that in the seasonal savannas are occupied by permanent marshes dominated by herbs such as *Cyperus giganteus* and *Thalia geniculata*, and seasonally inundated savannas that are dominated by grasses (*Hymenachne amplexicaulis, Panicum mertensii, Paspalum fasciculatum*). The vegetation surrounding the Amazonian lakes varies from flooded forest to dense aquatic vegetation formations, and the freshwater marshes belong to the more stable conditions in this gradient created by the river's dynamics.

Distribution

Geographic Range: This formation is found widely throughout wetland habitats of the tropical latitudes, from the equator to about 23 degrees N and S.

Citations

Synonymy:

> Freshwater Marshes (Mitsch and Gosselink 2000) [Both tropical and temperate marshes are treated together, and inland saline marshes are included here too, and both emergent and aquatic vegetation.]

> Nontidal Freshwater Marshes (Roth 2009) [It is not clear whether non-tidal salt marshes are included here. Both tropical and temperate marshes are treated together.]

> Tidal Freshwater Marshes (Roth 2009) [Both tropical and temperate marshes are treated together.]

> Tidal Freshwater Marshes (Mitsch and Gosselink 2000) [Both tropical and temperate marshes are treated together, and both emergent and aquatic vegetation.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: C. Josse and D. Faber-Langendoen, after National Wetlands Working Group (1997)

Acknowledgments:

Version Date: 26 Aug 2014

2.C.4. Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland (F013)

Overview

Database Code: 2.C.4 (F013)

Scientific Name: Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland Formation

Common Name (Translated Scientific Name): Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland Formation

Colloquial Name: Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland

Hierarchy Level: Formation

Placement in Hierarchy: 2.C. Shrub & Herb Wetland (S44)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland includes wet riparian and swamp shrublands, wet meadows, wet prairies, and shallow and deep emergent marshes. The vegetation is comprised of seasonal green emergent, hydrophytic shrubs and herbs with at least 10 percent cover, on mucky, inundated or saturated soils across the mid-latitudes of the Northern and Southern hemispheres from 23 to 70 degrees.

Type Concept: Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland includes wet riparian and swamp shrublands, wet meadows, wet prairies, and shallow and deep emergent marshes on mucky, inundated or saturated soils across the mid-latitudes of the Northern and Southern hemispheres from 23 to 70 degrees. These wetlands have shallow water, with levels that usually fluctuate daily, seasonally or annually due to tides (freshwater tidal), flooding, evapotranspiration, groundwater recharge, or seepage losses. The vegetation is comprised of seasonal green emergent hydrophytic woody and herbaceous macrophytes with at least 10 percent cover, including graminoids such as rushes, reeds, grasses and sedges, other herbaceous species such as broad-leaved emergent forbs, and short to tall shrubs (primarily broad-leaved deciduous but some broad-leaved evergreen in warm-temperate regions). Associated with these plants are floating-leaved and submergent species, and nonvascular plants such as brown mosses, liverworts, and macroscopic algae. The vegetation is usually arranged in distinct zones of parallel or concentric patterns in response to gradients of water depth, frequency of drawdown, water chemistry or disturbance. Saline or brackish non-tidal marshes are excluded. Seasonal drawdowns may expose mudflats that are vegetated by pioneering herb and grass species. Plant communities of seasonal marshes are dynamic, shifting spatially with water levels and changing in composition over a short time. Communities of semi-permanent marshes usually are more stable, represented by stands of reeds, which may persist for many years in the absence of severe drought.

Classification Comments: Inland salt marshes are currently excluded here and placed with salt marsh. Freshwater tidal marshes are placed here. Further review is needed of the similarities and differences between temperate and tropical freshwater marshes. Subarctic and arctic (polar) marshes belong in this formation.

Similar NVC Types:

1.B.3. Temperate Flooded & Swamp Forest (F026): Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland (F013) contains tall-shrub swamps that share many structural and habitat similarities to hardwood tree swamps (F026), especially during the tree regeneration stage.

2.C.3. Tropical Freshwater Marsh, Wet Meadow & Shrubland (F030): Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland (F013) is more strongly affected by cold climatic conditions, but vegetation criteria that distinguish these two formations need to be described.

2.C.2. Temperate to Polar Bog & Fen (F016): Fens and marshes can be similar, especially when fen peat mats are inundated (as with "shore fens").

2.C.5. Salt Marsh (F035): Inland salt marshes are non-tidal, but saline (or haline) and may resemble some brackish freshwater marshes.

Diagnostic Characteristics: The vegetation is comprised of seasonal green emergent hydrophytic macrophytes, chiefly graminoids such as rushes, reeds, grasses and sedges, other herbaceous species such as broad-leaved emergent forbs, and short to tall, primarily broad-leaved deciduous shrubs (some broad-leaved evergreen shrubs in warm-temperate climates), across the mid-latitudes of the Northern and Southern hemispheres from 23 to 70 degrees.

Vegetation

Physiognomy and Structure: Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland vegetation predominantly comprises summer green emergent hydrophytic macrophytes, with at least 10 percent cover, including graminoids such as rushes, reeds, grasses and sedges, other herbaceous species such as broad-leaved emergent forbs, and short to tall shrubs (primarily broad-leaved deciduous, but some broad-leaved evergreen in warm-temperate regions). Associated with these plants are floating-leaved and submergent species, and nonvascular plants such as brown mosses, liverworts, and macroscopic algae. Vegetation is usually arranged in distinct zones of parallel or concentric patterns in response to gradients of water depth, frequency of drawdown, water chemistry or disturbance (National Wetlands Working Group 1997).

Environment

Environmental Description: A temperate freshwater marsh is a wetland that has shallow water and levels that usually fluctuate daily, seasonally or annually due to tides (freshwater tidal), flooding, evapotranspiration, groundwater recharge, or seepage losses. Marshes may experience water level drawdowns that will result in portions drying up and exposing the sediments. Marshes receive their water from the surrounding catchment as surface runoff, stream inflow, precipitation, storm surges, groundwater discharge, longshore currents and tidal action. Marshes dependent on surface runoff usually retain less permanent water than sites supplied by groundwater.

The water table usually remains at or below the soil surface, but soil water remains within the rooting zone for most of the growing season, except in years of extreme drought. In semi-arid regions, some basin marshes may remain dry for several consecutive years, and consequently may assume some characteristics of terrestrial ecosystems until water levels are restored by above-average precipitation and runoff (National Wetlands Working Group 1997).

A marsh is a minerotrophic and usually eutrophic wetland. Nutrients are derived from the substrate through periodic aeration. High nutrient levels give rise to the characteristic high productivity of vascular plants and high decomposition rates of the plant material at the end of the growing season. Such high rates of decomposition give rise to marshes producing significant quantities of gases such as methane and carbon dioxide. Freshwater marshes are usually circumneutral to highly alkaline owing to the presence of dissolved minerals such as calcium, potassium carbonate, or potassium bicarbonate.

Soils and substrates encountered in marsh wetlands typically range from mineral soils such as Humic and Rego Gleysols to organic soils such as Humisols and Mesisols in the Canadian soil classification system (see Brady and Weil, 2002, for comparison of Canadian soil orders with U.S. and FAO systems). Normally, marsh sediment is a mixture of unconsolidated organic and inorganic material. Clumps, hummocks, or tussocks of live and dead herbaceous vegetation may exist in standing water. Those marshes that are seasonally dry or exposed to high energy currents usually accumulate little organic matter, in contrast to hydrologically more stable and permanently saturated marshes. In the latter case, such as in lakeshore or delta marshes, Humisols develop; this organic material can accumulate but seldom is more than 40 to 50 cm deep. Under persistent conditions of stable water, sedges and aquatic mosses create floating mats of vegetation. This is characteristic of marsh stages transitional to rich fens (National Wetlands Working Group 1997).

Marshes occur in many geomorphological settings which include low-lying areas adjacent to rivers, lakes, the sea, and any other position on the land surface where groundwater may discharge. In northern regions, marshes are common in nutrient-rich sites associated with rivers either in the floodplains or at their mouth on alluvial fans and deltas (National Wetlands Working Group 1997).

Distribution

Geographic Range: This formation is found on mucky, inundated or saturated soils across the mid-latitudes of the Northern and Southern hemispheres from 23 to 70 degrees.

Citations

Synonymy:

< Freshwater Marshes (Mitsch and Gosselink 2000) [Both tropical and temperate marshes are treated together.]

< Nontidal Freshwater Marshes (Roth 2009) [It is not clear whether nontidal salt marshes are included here. Both tropical and temperate marshes are treated together.]

< Tidal Freshwater Marshes (Roth 2009) [Both tropical and temperate marshes are treated together.]

< Tidal Freshwater Marshes (Mitsch and Gosselink 2000) [Both tropical and temperate marshes are treated together.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen, after National Wetlands Working Group (1997)

Acknowledgments:

Version Date: 26 Aug 2014

2.C.5. Salt Marsh (F035)

Overview

Database Code: 2.C.5 (F035)

Scientific Name: Salt Marsh Formation

Common Name (Translated Scientific Name): Salt Marsh Formation

Colloquial Name: Salt Marsh

Hierarchy Level: Formation

Placement in Hierarchy: 2.C. Shrub & Herb Wetland (S44)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Salt Marsh is a wetland that has shallow water and levels that usually fluctuate due primarily to tides along the coast or changes in water depth in depressions. Coastal salt marshes are primarily intertidal; that is, they are found in areas at least occasionally inundated by high tide but not flooded during low tide, including estuaries, lagoons, and the lee side of barrier islands. The vegetation is comprised of emergent shrubs and herbs with at least 10 percent cover, especially saline or halophytic species. They occur at all latitudes around the globe, but are concentrated in the temperate mid-latitudes (23 to 70 degrees N and S).

Classification Comments: Further review is needed of the similarities and differences between temperate and tropical salt marshes, as well as subarctic and arctic (polar) salt marshes, all of which are placed in this formation. From an overall physiognomic and ecological perspective, maintaining a single salt marsh formation is desirable. Although they represent a small fraction of the overall salt marsh area, there are extensive tropical salt marshes, often found in association with mangroves; the mangroves occupy the lower, regularly tidally inundated part of the intertidal zone and salt marsh the upper zone above the mangroves. Australia has more than one million hectares of salt marsh and sparsely vegetated high level tidal flats, with a large proportion of this being tropical. More information on potentially distinct floristics and growth forms of tropical salt marshes is needed.

Similar NVC Types:

1.A.5. Mangrove (F006): Some mangrove formations may be mixed with salt marshes, but by and large they are physiognomically quite distinct.

2.C.4. Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland (F013): *Salt Marsh (F035)* contains inland salt marshes that are non-tidal and saline (or haline) and may resemble some brackish freshwater marshes (F013).

Diagnostic Characteristics: Salt Marsh is a wetland that has shallow water and levels that usually fluctuate due primarily to tides along the coast or changes in water depth in depressions. Coastal tidal salt marshes are found in areas at least occasionally inundated by high tide but not flooded during low tide. The vegetation is comprised of emergent aquatic macrophytes with at least 10 percent cover, especially saline or halophytic species, chiefly graminoids such as rushes, reeds, grasses and sedges, and shrubs and other herbaceous species such as broad-leaved emergent macrophytes. They occur at all latitudes around the globe, but are concentrated in the temperate mid-latitudes (23 to 70 degrees N and S).

Vegetation

Physiognomy and Structure: Salt Marsh vegetation comprises primarily emergent aquatic macrophytes with at least 10 percent cover, especially saline or halophytic species, chiefly graminoids such as rushes, reeds, grasses and sedges, and shrubs and other herbaceous species such as broad-leaved emergent macrophytes. Floating-leaved and submergent species (aquatic vegetation) and macroscopic algae are present at varying levels of abundance.

In tidal salt marshes, the vegetation is usually arranged in distinct zones of parallel patterns in response to gradients of tidal flooding frequency and duration, water chemistry or disturbance. They are sometimes described simply as “high marsh” (limits of high tide) and “low marsh” (intertidal marsh). These salt marshes have gradients that include barren salt flats at the tidal edge, rushes, and then halophytic herbs and grasses at the outer edge. Daily drawdowns may expose mudflats that contain a sparse mix of pioneering herb and grass species.

Saline or brackish non-tidal marshes also have gradients but with fewer zones that include barren salt flats in the center of the marsh, rushes, and then halophytic herbs and grasses at the outer edge. Seasonal drawdowns may expose mudflats that are revegetated by pioneering herb and grass species.

Although the bulk of salt marshes are temperate to polar, there are tropical salt marshes, often found in association with mangroves; the mangroves occupy the lower, regularly tidally inundated part of the intertidal zone and salt marsh the upper zone above the mangroves. Australia has more than one million hectares of salt marsh and sparsely vegetated high level tidal flat, with the greater proportion of this being tropical. Tropical salt marshes are species-poor, and species richness increases with more temperate conditions; for example in Australia, the richest salt marsh floras are found in Tasmania and Victoria.

Environment

Environmental Description: A salt marsh is a wetland that has shallow water and levels that usually fluctuate due primarily to tides or drawdowns in seasonal saline basins. Coastal salt marshes are primarily intertidal; that is, they are found in areas at least occasionally inundated by high tide but not flooded during low tide, including estuaries, lagoons, and the lee side of barrier islands. Salt marshes form wherever the accumulation of sediments is equal to or exceeds the rate of land subsidence and where there is adequate protection from high energy waves and storms. Salt marshes are located in estuaries or lower stream reaches, and behind baymouth bars or other sheltered sites. Sediments can either be formed on marine-dominated coastlines from reworked marine sediments or formed in deltaic areas where the main source of mineral sediment is riverine.

Salt marsh chemistry is dominated by salinity. Salinity levels vary depending on a complex of factors, including frequency of inundation, rainfall, soil texture, freshwater influence, fossil salt deposits, and other factors. The lower limits of salinity are defined as at least 0.5 ppt, below which it is considered freshwater, though the oligohaline category (0.5 – 5 ppt) can be considered transitional freshwater (see Cowardin and others, 1979, for salinity scale). The concentration of most elements needed for plant growth also varies depending on these factors. A number of studies have shown that salt marshes are especially nitrogen limited. The water in non-tidal saline marshes is high in dissolved salts because water losses through evaporation concentrate sulphates and chlorides of sodium and magnesium. In highly saline non-tidal marshes, vegetation development is severely hampered because salt concentrations are so high as to become toxic to plants (National Wetlands Working Group 1997).

Distribution

Geographic Range: Salt marshes occur at all latitudes around the globe, but are concentrated in the temperate mid-latitudes (23 to 70 degrees N and S).

Citations

Synonymy:
= Salt Marshes (Woodward 2008)
> Tidal Salt Marshes (Mitsch and Gosselink 2000) [Non-tidal inland salt marshes are treated by them under their Freshwater Marsh type.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen, after National Wetlands Working Group (1997)

Acknowledgments:

Version Date: 26 Aug 2014

---

3. Desert & Semi-Desert (C03)

Overview

Database Code: 3 (C03)

Scientific Name: Xeromorphic Woodland, Scrub & Herb Vegetation Class

Common Name (Translated Scientific Name): Xeromorphic Woodland, Scrub & Herb Vegetation Class

Colloquial Name: Desert & Semi-Desert

Hierarchy Level: Class

Lower Level Hierarchy Units:

3.A. Warm Desert & Semi-Desert Woodland, Scrub & Grassland (S06)

3.B. Cool SemiDesert Scrub & Grassland (S11)

Concept Summary

Type Concept Sentence: Cool and warm semi-deserts dominated by xeromorphic growth forms, including *succulent* (e.g., cacti, euphorbias) and *small-leaved shrubs* and *trees*, desert grasses and other xeromorphic growth forms, with an irregular horizontal canopy spacing that is often open to very sparse (1 percent) cover.

Classification Comments: In desert regions, the vegetation may be very sparse (at or below 1 percent). Some judgment is required to ensure how to sample and classify vegetation in stands where there is less than 1 percent vascular plant cover in parts, but not all, of the stand. That is, some deserts may have only patchy non-vegetated areas, whereas others may have extensive non-vegetated areas. More work is needed to define xeromorphic herbaceous growth forms, such as ephemerals, that may appear under rare high-precipitation years.

Semi-desert grasslands may be hard to identify in this class when woody plants are absent or uncommon, because there are no herbaceous growth forms currently recognized that are diagnostic for the xeromorphic class. Desert grasses may be xerophytic but not clearly xeromorphic. However, in many cases they will have strong floristic similarity to open desert shrublands and, if degraded, may be dominated by desert shrubs. More work is needed to determine if such growth forms can be specified (e.g., desert-blooming ephemerals).

Similar NVC Types:

2. Shrub & Herb Vegetation (C02): Desert grasslands typically include xeromorphic shrubs and trees, which place them in the Xeromorphic class. Environmental drivers and stressors can cause desert grasslands to cross thresholds into desert scrub. They may also cause dry mesomorphic grasslands with small-leaved shrubs to appear similar to xeromorphic grasslands (e.g., shortgrass prairie in the North American Great Plains).

4. Polar & High Montane Scrub, Grassland & Barrens (C04): In montane deserts, there may be a transition from cool semi-desert to alpine that may be difficult to distinguish.

6. Open Rock Vegetation (C06): This class is restricted to open rock vegetation where nonvascular vegetation is at least 10 percent and where vascular plants, if present, are mesomorphic.

Diagnostic Characteristics: Xeromorphic tree (*succulent tree, small-leaved tree*) or shrub (*succulent shrub, small-leaved shrub*) growth forms have the majority of the cover compared to mesomorphic and cryomorphic shrub and herb growth forms, and mesomorphic trees have less than 10 percent cover. The vegetation has irregular horizontal canopy spacing, and may be as low as 1 percent cover.

Vegetation

Physiognomy and Structure: *Growth Forms*: Stands are dominated by xeromorphic growth forms (*succulent tree, small-leaved tree, succulent shrub, small-leaved shrub,* some types of *rosette shrub*) and various associated herb growth forms. Drought-deciduous, including facultatively drought-deciduous, trees may be present. Other characteristics include opportunistic leaf-flush (e.g., ocotillo), high incidence of energy allocation to protective structures such as spines, and allocation to heat- or moisture-loss structures. The various herb growth forms currently recognized in

FGDC (2008) are not exclusive to the xeromorphic class, and more work is needed to assess whether additional herbaceous growth form types should be recognized that may be distinctive for this class. For example, Crassulacean Acid Metabolism (CAM) physiology is common in desert plants, especially among succulents.

In addition some desert vegetation has biological crust, comprised of soil particles, cyanobacteria, algae, microfungi, lichens, and bryophytes. The crusts do not develop under a closed canopy of vascular plants. They do occur in all climates following disturbance of that cover. However, the most conspicuous development of crusts occurs in hot, cool, and cold semi-arid and arid areas where plants are widely spaced.

Structure: Stands are very open and have irregular shrub or herb horizontal stem spacing, often with prominent non-vegetated surfaces. Xeromorphic trees are present, occasionally moderately dense (10 to 60 percent). There is less than 10 percent cover of mesomorphic trees, and xeromorphic tree, shrub and/or herb growth forms have the majority of cover compared to mesomorphic or cryomorphic shrubs or herbs. Tree cover varies from sparse to moderately closed (1 percent to 60 percent cover). Nonvascular and dwarf shrub growth forms may vary from 0 to 100 percent. At maturity, xeromorphic trees typically are greater than 2 m, tall shrubs typically greater than 0.3 m, and herbs are of any height, but mostly greater than 0.3 m. A biological crust layer may also be present.

Environment

Environmental Description: *Climate:* In temperate climates, the growing season is typically very dry, and in tropical climates, droughts are persistent, and rain is minimal.

Soil/substrate/hydrology: Soils may be thin, rocky, saline/haline (salt pannes, playas).

Distribution

Geographic Range: This type is found in the Desert divisions in Bailey's (1989) Dry Domain.

Citations

Synonymy:

= Desert Biomes (Quinn 2009)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: Hierarchy Revisions Working Group

Acknowledgments:

Version Date: 17 Jul 2012

3.A. Warm Desert & Semi-Desert Woodland, Scrub & Grassland (S06)

Overview

Database Code: 3.A (S06)

Scientific Name: Warm Desert & Semi-Desert Woodland, Scrub & Grassland Subclass

Common Name (Translated Scientific Name): Warm Desert & Semi-Desert

Woodland, Scrub & Grassland Subclass

Colloquial Name: Warm Desert & Semi-Desert Woodland, Scrub & Grassland

Hierarchy Level: Subclass

Placement in Hierarchy: 3. Desert & Semi-Desert (C03)

Lower Level Hierarchy Units:

3.A.1. Tropical Thorn Woodland (F039)

3.A.2. Warm Desert & Semi-Desert Scrub & Grassland (F015)

Concept Summary

Type Concept Sentence: Warm Desert & Semi-Desert Woodland, Scrub & Grassland occurs in dry warm-temperate, subtropical and tropical climates, uncommon near the equator to increasingly common between 15 and 35 degrees N and S latitude.

Classification Comments: This subclass includes the low desert-like tropical thornwoods, which can form a transition to *1.A.1. Tropical Dry Forest & Woodland Formation (F003)*. In the Neotropics, Brazilian caatinga includes both Tropical Dry Forest & Woodlands and extensive Tropical Thorn Woodland and scrub. This subclass also occurs in the Neotropics in the Guajira (Colombia, Venezuela), Gran Chaco (Bolivia, Argentina, Paraguay), Low Dry Inter-Andean Valleys (Bolivia, Argentina) and Pacific semi-deserts of west-southern Ecuador and northwestern Perú (Tumbes).

Similar NVC Types:

1.A. Tropical Forest & Woodland (S17): Tropical Forest & Woodland (S17) in drier climates may have small-leaved sclerophyllous evergreen trees or deciduous trees that can be similar to trees found in thorn woodland in warm deserts. Thorn woodlands are sometimes included as part of Tropical Forest.

Diagnostic Characteristics: Vegetation is dominated by xeromorphic growth forms, and varies from open to closed woodlands, open shrub-scrub to complexes of succulents, thorn scrub, and microphyllous-leaved subshrubs, often less than 2 m tall, though scattered tall succulents may occur. Ephemeral (therophytic) herbaceous growth forms may also be present.

Vegetation

Physiognomy and Structure: Vegetation is dominated by xeromorphic growth forms, and varies from open to closed woodlands, open shrub-scrub to complexes of succulents, thorn scrub, and microphyllous-leaved subshrubs, often less than 2 m tall, though scattered tall succulents may occur. Ephemeral (therophytic) herbaceous growth forms may also be present within semi-desert woodlands. Desert grasslands often occur in transitional zones, typically containing a sparse layer of xeromorphic shrubs and open ground layer. Included are very open deserts where vegetation is very sparse, and where the ground layer is sandy, stony desert pavements, salt crust. Bare rock, often with nonvascular mats, is placed in open rock vegetation (Whittaker 1975).

Environment

Environmental Description:

Climate: Warm semi-desert woodlands, scrub and grasslands occur in dry warm-temperate, subtropical and tropical climates.

Distribution

Geographic Range: Warm Desert & Semi-Desert Woodland, Scrub & Grassland occurs in dry warm-temperate, subtropical and tropical climates, is uncommon near the equator to increasingly common between 15 and 35 degrees N and S latitude.

Citations

Synonymy:

> Warm Deserts (Quinn 2009) [The author does not include thorn woodlands.]

= Warm semidesert scrub: biome-type 17 (Whittaker 1975) [The author does not include thorn woodlands.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen and G. Navarro

Acknowledgments:

Version Date: 26 Aug 2014

3.A.1. Tropical Thorn Woodland (F039)

Overview

Database Code: 3.A.1 (F039)

Scientific Name: Tropical Thorn Woodland Formation

Common Name (Translated Scientific Name): Tropical Thorn Woodland Formation

Colloquial Name: Tropical Thorn Woodland

Hierarchy Level: Formation

Placement in Hierarchy: 3.A. Warm Desert & SemiDesert Woodland, Scrub & Grassland (S06)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical Thorn Woodland includes warm semi-arid or arid deciduous woodlands and low forests with xeromorphic adaptations found in Tropical, Mediterranean and Temperate xeric and desertic bioclimates around the globe, uncommon near the equator to increasingly common between 15 and 35 degrees N and S latitude.

Classification Comments: Many authors include Tropical Thorn Woodland as part of a broadly defined “Tropical Dry Forest & Woodland” or “seasonally dry tropical forest” (SDTF). For example, Pennington and others (2006) use a wide interpretation of SDTF in the Neotropics, including formations as diverse as tall forest on moister sites to cactus scrub on the driest, but they exclude the Chaco of Argentina, Paraguay, and Bolivia because it receives frost. See also Oliveira-Filho and others (2006) who include caatinga and carrascos within their broad definition of SDTF, but exclude cerrados and chaco. Here, we create a separate formation for Tropical Thorn Woodlands in which we unite the xeromorphic parts of the caatinga, carrascos, cerrados, and chaco, separate from a more narrowly defined *1.A.1. Tropical Dry Forest & Woodland Formation (F003)* that lacks xeromorphic growth forms.

Distribution of this type needs review. It may be most common in tropical climates, but may extend into warm-temperate regions, such as northern Mexico and southwestern United States. By our definition, a certain amount of frost can also occur.

Similar NVC Types:

1.A.1. Tropical Dry Forest & Woodland (F003).

3.A.2. Warm Desert & Semi-Desert Scrub & Grassland (F015).

Diagnostic Characteristics: Tropical Thorn Woodland includes warm semi-arid or arid deciduous woodlands and low forests with several xeromorphic adaptations such as microphyllous and/or resinous leaves, thorns, brachyblasts, pachycaulal treelets and diverse shrubby and arborescent Cactaceae.

Vegetation

Physiognomy and Structure: The canopy is 8 to 15 m tall, open to dense, and dominated by low deciduous trees, arboreal cacti and high shrubs with xeromorphic adaptations. Very characteristic large colonies of thorny terrestrial clumping bromeliads, diverse thorn microphyllous scrubs and xeromorphic herbs and vines are frequently found in the understory.

Environment

Environmental Description: *Climate:* Tropical Thorn Woodland occurs in Tropical, Mediterranean and Temperate xeric and desertic bioclimate categories of the global bioclimatic classification of Rivas-Martínez and Rivas-Saenz (1996, 2009), with dry, semi-arid and arid ombrotypes.

Soil/substrate/hydrology: The soils are well to somewhat well drained, non-floodable and xeric, frequently on old alluvial plains and glacis.

Distribution

Geographic Range: The largest area of this formation in the Neotropics is the Gran Chaco ecoregion in southern Bolivia, northern Argentina, and northwestern Paraguay. Other important areas include the dry Inter-Andean Valley ecoregion of the southern Bolivian Andes and northwestern Argentina and the Caatinga ecoregion in Brazil and the Colombian-Venezuelan Guajira. Minor areas also occur in southwestern Pacific coastal Ecuador and adjacent northwestern Perú (Tumbesian ecoregion). In extratropical areas of South America, this formation occurs in semi-deserts and deserts of central Chile and in central-west Argentina (xeric Patagonia, Argentinian Monte). Elsewhere these woodlands may be expected in Africa and parts of the Indo-Malaysian tropics.

Citations

Synonymy:

= Tropical thorn scrub or thornwood: biome-type 9 (Whittaker 1975)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: G. Navarro and D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

3.A.2. Warm Desert & Semi-Desert Scrub & Grassland (F015)

Overview

Database Code: 3.A.2 (F015)

Scientific Name: Warm Desert & Semi-Desert Scrub & Grassland Formation

Common Name (Translated Scientific Name): Warm Desert & Semi-Desert Scrub & Grassland Formation

Colloquial Name: Warm Desert & Semi-Desert Scrub & Grassland

Hierarchy Level: Formation

Placement in Hierarchy: 3.A. Warm Desert & Semi-Desert Woodland, Scrub & Grassland (S06)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Warm Desert & Semi-Desert Scrub & Grassland occurs in dry warm-temperate, subtropical and tropical climates, is uncommon near the equator to increasingly common between 15 and 35 degrees N and S latitude.

Similar NVC Types:

3.A.1. Tropical Thorn Woodland (F039).

Diagnostic Characteristics: Vegetation is dominated by xeromorphic growth forms, and varies from open shrub-scrub to complexes of succulents, thorn scrub, and microphyllous-leaved subshrubs, often less than 2 m tall, though scattered tall succulents may occur. Ephemeral (therophytic) herbaceous growth forms may also be present.

Vegetation

Physiognomy and Structure: Vegetation is dominated by xeromorphic growth forms, and varies from open shrub-scrub to complexes of succulents, thorn scrub, and microphyllous-leaved subshrubs, often less than 2 m tall, though scattered tall succulents may occur. Ephemeral (therophytic) herbaceous growth forms may also be present. Desert grasslands often occur in transitional zones, typically containing a sparse layer of xeromorphic shrubs and an open ground layer. Included are very open deserts where vegetation is very sparse, and where the ground layer is sandy, stony desert pavements, salt crust (bare rock, often with nonvascular mats is placed in lithomorphic vegetation). Australian semi-deserts, having evolved in long isolation, are most unlike other semi-deserts on other continents; succulents are lacking and spiny tussock grasses (spinifex, *Triodia*) are major plants (Whittaker 1975).

Environment

Environmental Description: *Climate:* Warm Desert & Semi-Desert Scrub & Grassland occurs in dry warm-temperate, subtropical and tropical climates. Mean summer temperatures are 29.5 to 35 degrees C, and mean winter temperatures 7 to 15.5 degrees C. Annual precipitation is 0 to 25 cm as rain only (Quinn 2009). *Soil/substrate/hydrology:* Calcification, salinization, Aridisol, azonal, salt pans, rocky, sandy, with little humus (Quinn 2009).

Distribution

Geographic Range: Warm Desert & Semi-Desert Scrub & Grassland occurs in dry warm-temperate, subtropical and tropical climates, uncommon near the equator to increasingly common between 15 and 35 degrees N and S latitude. In North America, it is found in the Mojave, Sonoran, and Chihuahuan regions, and southward into México; in South America, from Argentina and Chile to Bolivia and Peru, then scattered parts of Venezuela and Colombia; great areas of the semi-desert surround the Sahara in northern Africa and extend through the Arabian Peninsula to Iran and the Thar Deseret of India. More limited areas with distinctive semi-desert occur in parts of the arid areas in East Africa (Somali-Chalbi) and Southwest Africa (Kalahari and Karoo). Australian semi-deserts are a quite distinctive form (Whittaker 1975).

Citations

Synonymy:

= Warm Deserts (Quinn 2009)

= Warm semi-desert scrub: biome-type 17 (Whittaker 1975)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen and G. Navarro

Acknowledgments:

Version Date: 26 Aug 2014

3.B. Cool Semi-Desert Scrub & Grassland (S11)

Overview

Database Code: 3.B (S11)

Scientific Name: Cool Semi-Desert Scrub & Grassland Subclass

Common Name (Translated Scientific Name): Cool Semi-Desert Scrub & Grassland Subclass

Colloquial Name: Cool Semi-Desert Scrub & Grassland

Hierarchy Level: Subclass

Placement in Hierarchy: 3. Desert & Semi-Desert (C03)

Lower Level Hierarchy Units:

3.B.1. Cool Semi-Desert Scrub & Grassland (F033)

Concept Summary

Type Concept Sentence: Cool Semi-Desert Scrub & Grassland occurs in dry, cool-temperate climates, at mid-latitudes (35 to 50 degrees N), typically in the interior of continents, and varies from low shrublands to very open grassland and shrub-steppe, including open rocky or sandy semi-desert vegetation.

Classification Comments: The gradation in growth forms between *2.B Temperate & Boreal Grassland & Shrubland Subclass (S18)* and *3.B Cool Semi-Desert Scrub & Grassland Subclass (S11)* makes delimiting the concept a challenge. For example, in North America, microphyllous sagebrush shrubs may be common in parts of the western Great Plains, comparable to sagebrush types in the Great Basin.

Also montane cool semi-desert, in which the temperatures are more strongly hot/cold, may resemble cryomorphic vegetation. For example, the Salar de Uyuni in southwestern Bolivia is the world's largest salt flat at 10,582 square kilometers (4,086 square miles), near the crest of the Andes, at 3,656 m (11,995 feet) elevation, and contains both xeromorphic and cryomorphic characteristics (C. Josse pers. comm. 2011).

Similar NVC Types:

2.B. Temperate & Boreal Grassland & Shrubland (S18): Cool Semi-Desert Scrub & Grassland (S11) typically has small-leaved, xerophytic shrubs (e.g., sage) and more open bare ground, sometimes with biological crust.

Diagnostic Characteristics: Vegetation is dominated by microphyllous-leaved xeromorphic shrubs. Structure consists of typically low shrubs or graminoids and varies from very open grassland and shrub-steppe to shrubland.

Vegetation

Physiognomy and Structure: The vegetation is dominated by microphyllous-leaved xeromorphic shrubs. Structure consists of typically low shrubs or graminoids and varies from very open grassland and shrub-steppe to shrubland. Vegetation is not as much limited by substrates as by drought and fires (Whittaker 1975). Open rocky or sandy cool semi-desert vegetation is also placed here.

Environment

Environmental Description: *Climate:* Cool Semi-Desert Scrub & Grassland occurs in dry, cool-temperate climates, typically in the interior of continents (Quinn 2009).

Distribution

Geographic Range: This type occupies extensive landscapes of the Great Basin of the western United States, central Asia and Iran, in South America (Patagonia and the Andes) and parts of Australia (Whittaker 1975).

Citations

Synonymy:

= Cold Deserts (Quinn 2009)

= Cool-temperate semi-desert scrub: biome-type 18 (Whittaker 1975)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

3.B.1. Cool Semi-Desert Scrub & Grassland (F033)

Overview

Database Code: 3.B.1 (F033)

Scientific Name: Cool Semi-Desert Scrub & Grassland Formation

Common Name (Translated Scientific Name): Cool Semi-Desert Scrub & Grassland Formation

Colloquial Name: Cool Semi-Desert Scrub & Grassland

Hierarchy Level: Formation

Placement in Hierarchy: 3.B. Cool Semi-Desert Scrub & Grassland (S11)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Cool Semi-Desert Scrub & Grassland occurs in dry, cool-temperate climates, at mid-latitudes (35 to 50 degrees N), typically in the interior of continents.

Classification Comments: The gradation in growth forms between 2.B Temperate & Boreal Grassland & Shrubland Subclass (S18) and 3.B Cool Semi-Desert Scrub & Grassland Subclass (S11) makes delimiting the concept a challenge. For example, in North America, microphyllous sagebrush shrubs may be common in parts of the western Great Plains, comparable to sagebrush types in the Great Basin.

Also montane cool semi-desert, in which the temperatures are more strongly hot/cold, may resemble cryomorphic vegetation. For example, the Salar de Uyuni in southwestern Bolivia is the world's largest salt flat at 10,582 square kilometers (4,086 square miles), near the crest of the Andes, at 3,656 m (11,995 feet) elevation, and contains both xeromorphic and cryomorphic characteristics (C. Josse pers. comm. 2011).

Similar NVC Types:

2.B.2. Temperate Grassland & Shrubland (F012): Cool Semi-Desert Scrub & Grassland (F033) typically has small-leaved, xerophytic shrubs (e.g., sage) and more open bare ground, sometimes with biological crust.

4.A.1. Tropical High Montane Scrub & Grassland (F022): Cool Semi-Desert Scrub & Grassland (F033) at high altitudes in the tropics, may be cool or rather hot/cold deserts that share some characteristics of cryomorphic vegetation of the tropical high montane grasslands (F022) because of the freezing temperatures.

Diagnostic Characteristics: Vegetation is dominated by microphyllous-leaved xeromorphic shrubs. Structure consists of typically low shrubs or graminoids and varies from open grassland and shrub-steppe to shrubland.

Vegetation

Physiognomy and Structure: The vegetation is dominated by microphyllous-leaved xeromorphic shrubs and grasses. Structure consists of typically low shrubs or graminoids and varies from open grassland and shrub-steppe to shrubland. Vegetation not as much limited by substrates as by drought and fires (Whittaker 1975).

Environment

Environmental Description: *Climate:* This type occurs in dry, cool-temperate climates, typically in the interior of continents (Quinn 2009).

Distribution

Geographic Range: This formation occupies extensive landscapes of the Great Basin of the western United States, central Asia and Iran, in South America (Patagonia and the Andes) and parts of Australia (Whittaker 1975).

Citations

Synonymy:

= Cold Deserts (Quinn 2009)

= Cool-temperate semi-desert scrub: biome-type 18 (Whittaker 1975)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

---

4. Polar & High Montane Scrub, Grassland & Barrens (C04)

Overview

Database Code: 4 (C04)

Scientific Name: Cryomorphic Scrub, Herb & Cryptogam Vegetation Class

Common Name (Translated Scientific Name): Cryomorphic Scrub, Herb & Cryptogam Vegetation Class

Colloquial Name: Polar & High Montane Scrub, Grassland & Barrens

Hierarchy Level: Class

Lower Level Hierarchy Units:

4.A. Tropical High Montane Scrub & Grassland (S16)

4.B. Temperate to Polar Alpine & Tundra Vegetation (S12)

Concept Summary

Type Concept Sentence: Tundra, alpine and tropical high montane habitats dominated by cryomorphic growth forms (including *dwarf shrubs*, krummholz, associated *herbs, lichens* and *mosses*), with low height and open to closed canopy.

Classification Comments: Our criteria would place a stand with 1 percent or more cover of cryomorphic shrubs and herbs, and 99 percent cover of nonvascular lichen and moss in this class, if stands lack mesomorphic vegetation (e.g., lichen tundra, typically foliose and fruticose lichens) (Viereck and others 1992). Review is needed on the placement of páramo and puna in South America. Currently only super-páramo and higher elevation puna are placed here, as this class is restricted to the more strongly cryomorphic high montane forms of puna and páramos (e.g., in Venezuela there are stands dominated by cryomorphic growth forms but lack the typical grass cover). This is because lower elevation páramo and moist puna have mesomorphic grasses covering the ground (often exceeding 80 percent cover), whereas cryomorphic shrubs and herbs, although present and conspicuous, may be less than 20 percent cover. These lower elevation stands also lack any cryoturbation. Using these criteria, we would place these lower elevation stands in the mesomorphic "Tropical Montane Grassland & Shrubland" formation. On the other hand, we don't yet have a working set of "cryomorphic herbs" versus "mesomorphic herb" growth forms so it is hard to know how to weigh the presence of these mesomorphic herbs against the cryomorphic shrubs. Consistent placement of the subalpine and alpine zones across tropical, temperate and boreal regions is needed.

Similar NVC Types:

2. Shrub & Herb Vegetation (C02): Distinguishing cryomorphic vegetation from mesomorphic vegetation can be a challenge in both arctic and alpine regions. Here we allow mesomorphic extensions into the cryomorphic climatic zone to be retained in the mesomorphic class (e.g., boreal mesomorphic tall willow shrublands along arctic drainages, or the tropics, lower elevation expressions of high montane páramo and puna in South America).

3. Desert & Semi-Desert (C03): In high montane deserts, the xeromorphic desert growth forms will transition to cryomorphic growth forms. Review is needed to see where issues may arise between temperate alpine and dry deserts or tropical high montane puna and high deserts.

6. Open Rock Vegetation (C06): This class is restricted to cryptogam dominated sites associated with mesomorphic vegetation, as found in tropical, temperate and boreal vegetation regions.

Diagnostic Characteristics: Cryomorphic shrub, krummholz, herb, and nonvascular growth forms (including *dwarf shrubs*, paramoid or associated *herbs, lichens, mosses*) have the majority of cover compared to mesomorphic or xeromorphic shrub and herb growth forms, and mesomorphic trees less than 10 percent cover. The vegetation structure is irregular horizontally, and of low height, often much less than 1 m tall.

Vegetation

Physiognomy and Structure: *Growth Forms*: Stands are dominated by cryomorphic growth forms, such as *dwarf shrub*, caulirrosulate (páramo) and various associated herb growth forms (*forb, graminoid*), along with nonvascular *lichen* and *moss* growth forms. The various herb growth forms are not exclusive to the cryomorphic class, and more work is needed to assess whether additional herbaceous growth form types should be recognized that may be distinctive for this class (e.g., creeping or matted herb growth forms). In addition, lichens in this class may more commonly be foliose or fruticose (e.g., reindeer lichens), at least in Arctic tundra (Billings 2000).

Structure: Stands have open to closed irregular shrub or herb stem spacing; often a single low complex stratum, sometimes with prominent non-vegetated surfaces. There is less than 10 percent mesomorphic tree cover, and typically greater than 10 percent shrub or herb cover (but sparse open cover between 1 percent and 10 percent may occur), and with a majority of that cover being cryomorphic shrub and/or herb growth form, as compared to mesomorphic or xeromorphic shrub and/or herb cover. Nonvascular growth forms may vary from 0 to 100 percent. At maturity, shrubs are typically less than 0.3 m, but occasionally as tall as 1 m, and herbs are typically less than 0.5 m.

Environment

Environmental Description: *Climate:* Growing season is either very short, with snow cover persisting for most of the year, or growth is greatly restricted by freezing to near-freezing temperatures, such as the EDf climate zone of Koeppen (cold continental climate without dry season).

Distribution

Geographic Range: This type occurs in the Bailey (1989) Polar Domain, especially Tundra divisions, but also in the alpine elevations in other domains.

Citations

Synonymy:
= Arctic and Alpine Biomes (Quinn 2008)
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: Hierarchy Revisions Working Group
Acknowledgments:
Version Date: 17 Jul 2012

4.A. Tropical High Montane Scrub & Grassland (S16)

Overview

Database Code: 4.A (S16)
Scientific Name: Tropical High Montane Scrub & Grassland Subclass
Common Name (Translated Scientific Name): Tropical High Montane Scrub & Grassland Subclass
Colloquial Name: Tropical High Montane Scrub & Grassland
Hierarchy Level: Subclass
Placement in Hierarchy: 4. Polar & High Montane Scrub, Grassland & Barrens (C04)
Lower Level Hierarchy Units:
4.A.1. Tropical High Montane Scrub & Grassland (F022)

Concept Summary

Type Concept Sentence: Tropical High Montane Scrub & Grassland is dominated by herbaceous perennials and small-leaved low woody shrubs or small sub-woody species in high tropical mountains, where freezing and cryogenic processes occur. It occurs in all tropical high mountains worldwide, where it occupies the sub-nival elevations.

Classification Comments: The páramo and the dry and moist puna are not included in this subclass, because they have primarily mesomorphic adaptations, and because the soils are not subject to cryogenic processes. These vegetation types are treated with *2.A.2 Tropical Montane Grassland & Shrubland Formation (F017)*. Nonetheless, although the páramo and the dry and moist puna are not subject to cryogenic soil processes, they are subject to varying levels of freezing. Perhaps the term “cryomorphic” places too great a restriction on the concept of “tropical alpine” vegetation.

Also challenging to place consistently in this class is the South American xerophytic vegetation of the Altiplano region of central and-southern Bolivia, northern Argentina, and Chile, because the cryomorphic definition is very similar to xeromorphic; that is to say, they share ecological processes and have similar structures (growth forms) to each other. The vegetation is not Cool Semi-Desert, but is a hot/cold semi-desert, while at the same time is hardly affected by edaphic processes of cryoturbation and geliturbation expected of the cryomorphic class. We find again the diurnal rhythm of ice/thaw of the tropical mountains, but it is marked in these high dry southern areas with very high daily solar temperatures and very low nocturnal temperatures. For example, in the Great Salt Flats of Uyuni (Salar de Uyuni) at 3,800 m of altitude, during the day temperatures can rise to 20 degrees C and at night to –20 degrees C. This is an extreme case related to the immense salt flats, but the lands that surround them repeat almost the same features listed above, although with smaller thermal amplitudes (C. Josse pers. comm. 2011). So high elevation semi-deserts share some characteristics with the tropical high montane vegetation.

Diagnostic Characteristics: Herbaceous perennials and small woody, small-leaved prostrate sub-shrubs, with a predominance of tap roots and creeping or densely caespitose root systems.

Vegetation

Physiognomy and Structure: Tropical High Montane Scrub & Grassland is dominated by herbaceous perennials and woody shrubs or small-leaved low sub-woody species in high tropical mountains, where freezing and cryogenic processes occur. The predominant growth forms are rosulate plants with deep taproots and several plants with densely cespitose root systems and or creeping prostrate habit. The canopy cover varies from very low to open or semi-open. It occurs in all tropical high mountains worldwide, where it occupies the sub-nival altitudinal belt. Species have, in general, adapted to sliding or movement of the substrate due to the diurnal alternation of freezing and melting, which is a typical phenomenon of the high tropical mountains.

Environment

Environmental Description: *Climate:* Diurnal and non-seasonal energy pattern, with seasonal moisture regime consisting of a rainy summer and a dry winter that is a typical pattern of high tropical mountains, in contrast to non-tropical high mountains (temperate, boreal, Mediterranean) where there is a seasonal energy regime and where the rainfall has not matched up with the warmest time of year. In the Andes, this formation is generally above 4,500 m altitude.

Soil/substrate/hydrology: Soils have alterations in structure and texture due to deformation caused by freezing processes (contraction and dilatation) with diurnal periodicity of freezing and thawing. The substrates are mostly fine to medium textured, stony on the surface (loose stony pavement), with a muddy matrix that is saturated with meltwater and freezes daily. In tropical mountains, surface layers that freeze may overlie unfrozen subsurface layers. An important effect of frost heaving is the upward movement of stones in soils and unconsolidated deposits that is more rapid and pervasive in wetter soils with a sparse vegetation cover. The process associated with frost can also cause upward or downward displacement of soil material in mass that can result in slope cryoplanation terraces at several scales. These soils are located in the highest areas of tropical mountains above 4,500 m altitude.

Distribution

Geographic Range: This subclass occurs in tropical high montane regions of South America, eastern Africa, and New Guinea. Further review is needed to determine whether it occurs in Central America, Malaysia, and tropical oceanic islands. In the

Neotropics, this type occupies the highest elevations of the tropical Andes, above 4,500 m altitude, from Venezuela to Argentina, and is well represented in the central Andes of Bolivia and Perú.

Citations

Synonymy:

< Alpine semi-desert: biome-type 19 (Whittaker 1975) [Whittakerdoes not separate out tropical from temperate.]

< Tropical Alpine Biome (Quinn 2008) [Quinn includes both the tropical montane and tropical high montane scrub band grassland in her type.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: G. Navarro and D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

4.A.1. Tropical High Montane Scrub & Grassland (F022)

Overview

Database Code: 4.A.1 (F022)

Scientific Name: Tropical High Montane Scrub & Grassland Formation

Common Name (Translated Scientific Name): Tropical High Montane Scrub & Grassland Formation

Colloquial Name: Tropical High Montane Scrub & Grassland

Hierarchy Level: Formation

Placement in Hierarchy: 4.A. Tropical High Montane Scrub & Grassland (S16)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical High Montane Scrub & Grassland is dominated by herbaceous perennials and small-leaved low woody shrubs or small sub-woody species in high tropical mountains, where freezing and cryogenic processes occur. They occur in all tropical high mountains, where they occupy the sub-nival altitudinal belt, generally above 4,500 m altitude in the Andes.

Classification Comments: The páramo and the dry and moist puna are not in this formation, because they have primarily mesomorphic adaptations, and because the soils are not subject to cryogenic processes. These vegetation types are treated with *2.A.2 Tropical Montane Grassland & Shrubland Formation (F017)*. Nonetheless, although the páramo and the dry and moist puna are not subject to cryogenic soil processes, they are subject to varying levels of freezing. Perhaps the term “cryomorphic” places too great a restriction on the concept of “tropical alpine” vegetation.

Also challenging to place consistently in this class is the South American xerophytic vegetation and the Altiplano of central and southern Bolivia, Argentina, and Chile, because the cryomorphic definition is very similar to xeromorphic; that is to say, they share ecological processes and have similar structures (growth forms) to each other. The vegetation is not Cool Semi-Desert, but is a hot/cold semi-desert, while at the same time is hardly affected by edaphic processes of cryoturbation and geliturbation expected of the cryomorphic class. We find again the diurnal rhythm of ice/thaw of the tropical mountains, but it is marked in these high dry southern areas with very high daily solar temperatures and very low nocturnal temperatures. For example, in the Great Salt Flats of Uyuni (Salar de Uyuni) to 3,800 m of altitude, during the day temperatures can rise to 20 degrees C and at night to –20 degrees C. This is an extreme case related to the immense salt flats, but the lands that surround them repeat almost the same features listed above, although with smaller thermal amplitudes (C. Josse pers. comm. 2011). So high-elevation semi-deserts share some characteristics with the tropical high montane vegetation.

Similar NVC Types:

2.A.1. Tropical Lowland Grassland, Savanna & Shrubland (F019).

2.A.2. Tropical Montane Grassland & Shrubland (F017): This formation contains high montane vegetation that is at or near treeline in the tropics, but is not subject to regular freezing or affected by cryogenic soil processes. In the Neotropics we place páramo and puna in this formation because they predominantly do not have cryogenic soils or experience frost.

3.B.1. Cool Semi-Desert Scrub & Grassland (F033): At high altitudes in the tropics, these cool or rather hot/cold deserts share some characteristics of cryomorphic vegetation because of the freezing temperatures.

4.B.1. Temperate & Boreal Alpine Vegetation (F037): This formation lacks constant freezing temperature and cryomorphic soils.

Diagnostic Characteristics: Herbaceous perennials and small woody, small-leaved prostrate sub-shrubs, with a predominance of taproots and creeping or densely caespitose root systems.

Vegetation

Physiognomy and Structure: Tropical High Montane Scrub & Grassland is dominated by herbaceous perennials and woody shrubs or small-leaved low sub-woody species in high tropical mountains, where freezing and cryogenic processes occur. The predominant growth forms are rosulate plants with deep taproots and several plants with densely cespitose root systems and or creeping prostrate habit. The canopy cover varies from very low to open or semi-open. It occurs in all tropical high mountains worldwide, where it occupies the sub-nival altitudinal belt. Species have, in general, adapted to sliding or movement of the substrate due to the diurnal alternation of freezing and melting, which is a typical phenomenon of the high tropical mountains.

Environment

Environmental Description: *Climate:* Diurnal and nonseasonal energy pattern, with seasonal moisture regime consisting of a rainy summer and a dry winter that is a typical pattern of high tropical mountains, in contrast to non-tropical high mountains (temperate, boreal, Mediterranean) where there is a seasonal energy regime and where the rainfall has not matched up with the warmest time of year. In the Andes, this formation is generally above 4,500 m altitude.

Soil/substrate/hydrology: Soils have alterations in structure and texture due to deformation caused by freezing processes (contraction and dilatation) with diurnal periodicity of freezing and thawing. The substrates are mostly fine to medium textured, stony on the surface (loose stony pavement), with a muddy matrix that is saturated with meltwater and freezes daily. In tropical mountains, surface layers that freeze may overlie unfrozen subsurface layers. An important effect of frost heaving is the upward movement of stones in soils and unconsolidated deposits that is more rapid and pervasive in wetter soils with a sparse vegetation cover. The process associated with frost can also cause upward or downward displacement of soil material in mass that can result in slope cryoplanation terraces at several scales. These soils are located in the highest areas of tropical mountains above 4,500 m altitude.

Distribution

Geographic Range: Tropical High Montane Scrub & Grassland is dominated by herbaceous perennials and small-leaved low woody shrubs or small sub-woody species in high tropical mountains, where freezing and cryogenic processes occur. It occurs in all tropical high mountains worldwide, where it occupies the sub-nival altitudinal belt.

Citations

Synonymy:

< Alpine semi-desert: biome-type 19 (Whittaker 1975) [The author does not separate out tropical from temperate.]

< Tropical Alpine Biome (Quinn 2008) [Quinn includes both the tropical montane and tropical high montane scrub band grassland in her type.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: G. Navarro, C. Josse and D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

4.B. Temperate to Polar Alpine & Tundra Vegetation (S12)

Overview

Database Code: 4.B (S12)

Scientific Name: Temperate to Polar Alpine & Tundra Vegetation Subclass

Common Name (Translated Scientific Name): Temperate to Polar Alpine & Tundra Vegetation Subclass

Colloquial Name: Temperate to Polar Alpine & Tundra Vegetation

Hierarchy Level: Subclass

Placement in Hierarchy: 4. Polar & High Montane Scrub, Grassland & Barrens (C04)

Lower Level Hierarchy Units:

4.B.1. Temperate & Boreal Alpine Vegetation (F037)

4.B.2. Polar Tundra & Barrens (F031)

Concept Summary

Type Concept Sentence: Alpine dwarf shrublands, krummholz, forb meadows, grasslands, and cryptogam barrens occurring above treeline in temperate and boreal regions around the globe, predominantly in North America and Eurasia, with more isolated occurrences in the Southern Hemisphere. Polar tundra is dominated by dwarf shrubs, cushion shrubs, sedges and grasses, mosses and lichens, and is found in the high latitudes north of 60 degrees N in the Arctic region and south of 50 degrees S in the Antarctic region, in permafrost soils that range from dry to seasonally saturated.

Classification Comments: This type excludes very sparse alpine semi-desert vegetation, where the alpine regions grade into high-elevation deserts. Soils show cryogenic features. Alpine tundra, scree, and talus, along with fellfields and barrens, are placed here because they contain cryomorphic vegetation similar to other vegetation in this class. Snowbank vegetation, which can be seasonally saturated, with wetland-like conditions, is tentatively included here.

Placement of alpine vegetation in arctic and subarctic regions is under review. In those regions, the vegetation is beyond the latitudinal limits of trees. If alpine vegetation exists in those regions, then the subclass should include Arctic or Subarctic in the name. Alpine tundra of most Eurasian and North American mountains is similar to that of the Arctic tundra but with a richer flora (Quinn 2008).

The High Arctic is often bare not because it is "rock" but because of the climate (cold and wind) and cryomorphic processes, hence it fits here. In true polar deserts, even cryptogams are sparse, and total cover is 0 to 3 percent (Quinn 2008).

We include "wet tundra" (tundra on saturated, somewhat peaty soils) with dry to mesic tundra. Arctic wet meadows and marshes are treated with temperate and boreal wet meadows and marshes under *2.C.4 Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland Formation (F013)*.

Diagnostic Characteristics: Alpine dwarf shrublands, forb meadows and grasslands occurring above treeline in temperate and boreal regions. Vegetation is dominated by graminoids, low creeping or matted dwarf shrubs, and perennial forbs, often in cushion or rosette form, as well as cryptogams. Polar tundra growth forms are varied, often with complex patterns of dominance by dwarf shrubs, sedges and grasses, mosses and lichens. In many tundra areas, the deep layers of the soil are permanently frozen, and only the surface layer is thawed and becomes biologically active during the summer.

Vegetation

Physiognomy and Structure: Alpine vegetation includes creeping and matted dwarf shrubs, and occasional trees along with alpine grasses and forbs, including cushion forms of dwarf shrubs and forbs. The ground layer varies from densely vegetated to open, rocky, rubbly or frost-sorted habitats (Whittaker 1975; Quinn 2008). Polar tundra exists on the treeless arctic plains; the vegetation growth forms are varied and often with complex patterns of dominance by dwarf shrubs, sedges and grasses, mosses and lichens (Whittaker 1975). The Low Arctic region typically contains continuous vegetation cover (80 to 100 percent), except in rocky places, and contains the typical mix of dwarf shrubs, sedges and grasses, mosses and lichens. Tundra also occurs in the High Arctic, and plants are primarily lichens and mosses with scattered herbs.

It includes polar desert or barrens on rock substrates, where even cryptogams are sparse, and total cover is 1 to 3 percent (Quinn 2008). Alpine tundra of most Eurasian and North American mountains is similar to that of the Arctic but with a richer flora (Quinn 2008).

Environment

Environmental Description: Alpine vegetation occurs above the treeline. Treeline varies depending on latitude and the "mountain mass" (i.e., large mountain masses retain more heat and tend to have higher treeline elevations, whereas smaller and more isolated mountain masses tend to have lower treeline elevations). In addition to elevation, exposure to wind is a key factor in the type of vegetation; in snowy regions, it impacts on the depth and duration of snow cover and, hence, protection of the vegetation, length of growing season, and soil moisture conditions.

Climate: For alpine vegetation, the "tundra" climate of high altitudes does not necessarily correspond to that of high latitudes (i.e., Arctic tundra). Although both regions have low mean annual temperature and short growing seasons, and experience a seasonal change in sun angle (high in the summer, low in the winter), the light regimes are quite different. Alpine regions never experience 24 hours of day or night; day length varies with latitude. And although permafrost occurs on high mountains, it does not produce the kinds of landforms found in the Arctic because few flat sites are available. Conversely, avalanches and rockslides are common in alpine regions, but do not occur in the Arctic (Quinn 2008). Some alpine regions can have very deep snow (several meters), whereas the Arctic generally has low snow cover.

Temperatures in the Arctic and Antarctic vary with the season, which has periods of 24-hour light (summer) and dark (winter). The number of days with those extremes varies with latitude, ranging from 1 day at the Arctic and Antarctic circles (66½ degrees N and S latitude) to 6 months at the poles. Temperatures vary both with latitude and degree of continentality. Mean temperatures of the warmest summer months vary considerably but generally average between 4.5 and 13 degrees C. In the winter, they average from 20 to 30 degrees C. Annual precipitation, which often falls as snow, is typically less than 25 cm, but some localities may have as much as 50 cm.

Soil/substrate/hydrology: Most alpine soils are regularly disturbed by freezing, erosion and downslope slides, and contain a mix of rocks and fine particles (Quinn 2008). Three major types of soils occur in the alpine regions. (1) Poorly developed rocky or stony soils (or Entisols) are sometimes called Lithosols when formed on bare rock of slopes and ridges and Regosols when formed on unconsolidated rock-like talus, scree, or rubble (soil orders from Soil Survey Staff (1999)) (see Brady and Weil 2002 for comparison of U.S. soil orders with Canadian and FAO systems). (2) Alpine turf and meadow soils (or Inceptisols) are up to 75 cm deep and exhibit distinct horizons; and (3) bog soils (Histosols) are found in depressions or where seepage saturates the ground to a depth of 1 m or more (Quinn 2008).

In many polar tundra areas, the deep layers of the soil are permanently frozen (permafrost), and only the surface layer is thawed and becomes biologically active during the summer (Whittaker 1975). Soils may be dry to seasonally saturated.

Permafrost is ground that is permanently frozen, and is widespread in the Arctic, covering large parts of Canada and Russia. It is discontinuous in the Boreal Forest & Woodland region to the south. It can extend down more than 600 m, depending on mean annual temperature, type of soil and rock, proximity to the ocean and topography. In the summer, only the soil surface may thaw, up to 20 to 60 cm. On slopes, the thawed soil may begin to move, a process called solifluction (Quinn 2008). Permafrost also creates specific landscape features collectively called patterned ground, forming circles, polygons, nets, hummocks, steps or stripes (Quinn 2008).

Distribution

Geographic Range: Temperate to Polar Alpine & Tundra Vegetation occurs above treeline in temperate and boreal regions around the globe, predominantly in North America and Eurasia, with more isolated occurrences in the Southern Hemisphere. Polar tundra is dominated by complex patterns of dominance by dwarf-shrubs, sedges and grasses, mosses and lichens, and is found in the high latitudes north of 60 degrees N in the Arctic region and south of 50 degrees S in the Antarctic region, where climatic conditions exclude tree and tall-shrub growth forms.

Citations

Synonymy:
>< Alpine grassland: biome-type 15 (Whittaker 1975)
>< Alpine shrubland: biome-type 14 (Whittaker 1975)
< Arctic and Antarctic Tundra (Quinn 2008) [The author includes both lithomorphic or open rock and cryomorphic vegetation in the Polar High Arctic semi-desert description as well as wet tundras.]
= Low Arctic Tundra (Bliss 2000) [Bliss includes both dry and wet tundra in his description.]
= Mid-latitude Alpine Tundra (Quinn 2008) [Approximately equivalent. Quinn includes alpine scree and talus in her concept.]
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen
Acknowledgments: Chris Lea
Version Date: 26 Aug 2014

4.B.1. Temperate & Boreal Alpine Vegetation (F037)

Overview

Database Code: 4.B.1 (F037)
Scientific Name: Temperate & Boreal Alpine Vegetation Formation
Common Name (Translated Scientific Name): Temperate & Boreal Alpine Vegetation Formation
Colloquial Name: Temperate & Boreal Alpine Vegetation
Hierarchy Level: Formation
Placement in Hierarchy: 4.B. Temperate to Polar Alpine & Tundra Vegetation (S12)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Alpine dwarf shrublands, forb meadows and grasslands occurring above the continuous forest line in temperate and boreal regions around the globe, predominantly in North America and Eurasia, with more isolated occurrences in the Southern Hemisphere.

Classification Comments: Excludes very sparse alpine semi-desert vegetation, where the alpine regions grade into high elevation deserts. Soils show cryogenic features. Krummholz is placed here. Scree and talus are also placed here. Fellfields, which are placed here, have a mix of nonvascular and vascular plants that may overlap with 6.D.2.

Placement of alpine vegetation in arctic and subarctic regions is under review. In those regions, the vegetation is beyond the latitudinal limits of trees. If alpine vegetation exists in those regions, then the subclass should include Arctic or Subarctic in the name. Alpine tundra of most Eurasian and North American mountains is similar to that of the Arctic but with richer flora (Quinn 2008).The growth form distinctions between alpine vegetation and polar tundra need further review.

Alpine tundra of most Eurasian and North American mountains is similar to that of the Arctic but with richer flora (Quinn 2008).

Similar NVC Types:

4.A.1. Tropical High Montane Scrub & Grassland (F022).

4.B.2. Polar Tundra & Barrens (F031): Occurs latitudinally beyond the treeline, though may extend southward into mountains of the subarctic (subpolar) woodland regions.

Diagnostic Characteristics: Alpine dwarf shrublands, forb meadows and grasslands occurring above the continuous forest line in temperate and boreal regions. Vegetation is dominated by graminoids, low creeping or matted dwarf shrubs, and perennial forbs, often in cushion or rosette form. Krummholz and alpine vegetation on scree or talus are also placed here.

Vegetation

Physiognomy and Structure: Creeping and matted dwarf shrubs and occasional trees may occur, along with alpine grasses and forbs, including cushion forms of dwarf shrubs and forbs. Krummholz growth forms may also occur. The ground layer varies from densely vegetated to open, rocky, rubbly or frost sorted habitats (Whittaker 1975; Billings 2000; Quinn 2008). An extended list of alpine growth forms is provided by Billings (2000, Table 14.3).

Environment

Environmental Description: Treeline varies depending on latitude and the "mountain mass" (i.e., large mountain masses retain more heat and tend to have higher treeline elevations, whereas smaller and more isolated mountain masses tend to have lower treeline elevations). In addition to elevation, exposure to wind is a key factor in the type of vegetation; in snowy regions, it impacts the depth and duration of snow cover and, hence, protection of the vegetation, length of growing season, and soil moisture conditions.

Climate: The "tundra" climate of high altitudes does not necessarily correspond to that of high latitudes (i.e., Arctic tundra). Although both regions have low mean annual temperature and short growing seasons, and experience a seasonal change in sun angle (high in the summer, low in the winter), the light regimes are quite different. Alpine regions never experience 24 hours of day or night; day length varies with latitude. And although permafrost occurs on high mountains, it does not produce the kinds of landforms found in the Arctic because few flat sites are available. Conversely, avalanches and rockslides are common in alpine regions, but do not occur in the Arctic (Billings 2000; Quinn 2008). Some alpine regions can have very deep snow (several meters), whereas the Arctic generally has low snow cover.

Soil/substrate/hydrology: Most alpine soils are regularly disturbed by freezing, erosion and downslope slides, and contain a mix of rocks and fine particles (Quinn 2008). Three major types of soils occur in the alpine regions. (1) Poorly developed rocky or stony soils (or Entisols) are sometimes called Lithosols when formed on bare rock of slopes and ridges and Regosols when formed on unconsolidated rock-like talus, scree, or rubble (soil orders from Soil Survey Staff 1999) (see Brady and Weil 2002, for comparison of U.S. soil orders with Canadian and FAO systems). (2) Alpine turf and meadow soils (or Inceptisols) are up to 75 cm deep and exhibit distinct horizons; and (3) bog soils (Histosols) are found in depressions or where seepage saturates the ground to a depth of 1 m or more (Billings 2000; Quinn 2008).

Distribution

Geographic Range: Temperate & Boreal Alpine Vegetation occurs above treeline in temperate and boreal regions around the globe, predominantly in North America and Eurasia, with more isolated occurrences in the Southern Hemisphere.

Citations

Synonymy:

>< Alpine grassland: biome-type 15 (Whittaker 1975)

>< Alpine shrubland: biome-type 14 (Whittaker 1975)

= Mid-latitude Alpine Tundra (Quinn 2008) [Approximately equivalent. Quinn includes alpine scree and talus in her concept.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments: Chris Lea

Version Date: 26 Aug 2014

4.B.2. Polar Tundra & Barrens (F031)

Overview

Database Code: 4.B.2 (F031)

Scientific Name: Polar Tundra & Barrens Formation

Common Name (Translated Scientific Name): Polar Tundra & Barrens Formation

Colloquial Name: Polar Tundra & Barrens

Hierarchy Level: Formation

Placement in Hierarchy: 4.B. Temperate to Polar Alpine & Tundra Vegetation (S12)
Lower Level Hierarchy Units:
See examples in Appendix J

Concept Summary

Type Concept Sentence: Upland or dry polar tundra is dominated by dwarf-shrubs, sedges and grasses, mosses and lichens, and is found in the high latitudes north of 60 degrees N in the Arctic region and south of 50 degrees S in the Antarctic region, in permafrost soils that range from dry to seasonally saturated.

Classification Comments: Plants are primarily lichens and mosses with scattered herbs (Quinn 2008). We include "wet tundra" (tundra on saturated, somewhat peaty soils) with dry to mesic tundra. Arctic wet meadows and marshes are treated with temperate and boreal wet meadows and marshes under *2.C.4 Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland Formation (F013)*. The concept of this formation includes the vegetation types of barrens, graminoid tundras, prostrate-shrub tundras and erect-shrub tundras of the Arctic (CAVM 2003).

Similar NVC Types:

4.B.1. Temperate & Boreal Alpine Vegetation (F037): Polar vegetation may extend southward into the subarctic mountain regions.

Diagnostic Characteristics: The vegetation growth forms are varied and often with complex patterns of dominance by dwarf-shrubs, low sedges and grasses, mosses and lichens, and creeping or matted herbs. Soil conditions are dry to seasonally saturated, with deep layers of the soil permanently frozen, with only the surface layer thawing in summer and becoming biologically active.

Vegetation

Physiognomy and Structure: The vegetation growth forms are varied and often form complex patterns of dominance by dwarf-shrubs, sedges and grasses, mosses and lichens. The Low Arctic region typically contains continuous vegetation cover (80 to 100 percent), except in rocky places, and contains the typical mix of dwarf-shrubs, sedges and grasses, mosses and lichens. Plants in the High Arctic tundra are primarily lichens and mosses with scattered herbs. The High Arctic has fine soil material, and can be wet and strongly influenced by cryoturbation, with more sparse vegetation. Wetter tundra includes low sedge- and moss-dominated types. It is called "graminoid-moss tundra" by Bliss (2000), who describes it as containing species of *Carex* and *Eriophorum*, along with an abundance of bryophytes, but few lichens.

Environment

Environmental Description: *Climate*: Temperatures in the Arctic and Antarctic vary with the season, which has periods of 24-hour light (summer) and dark (winter). The number of days with those extremes varies with latitude, ranging from 1 day at the Arctic and Antarctic circles (66½ degrees N and S latitude) to 6 months at the poles. Temperatures vary both with latitude and degree of continentality. Mean temperatures of the warmest summer months vary considerably but generally average between 4.5 and 13 degrees C. In the winter, they average from –20 to –30 degrees C. Precipitation, which often falls as snow, is typically less than 25 cm, but some localities may have as much as 50 cm.

Soil/substrate/hydrology: In many tundra areas, the deep layers of the soil are permanently frozen (permafrost), and only the surface layer is thawed and becomes biologically active during the summer (Whittaker 1975). Soils may be dry to seasonally saturated. Permafrost is ground that is permanently frozen, and is widespread in the Arctic, covering large parts of Canada and Russia. It is discontinuous in the Boreal Forest & Woodland region to the south. It can extend down more than 600 m, depending on mean annual temperature, type of soil and rock, proximity to the ocean, and topography. In the summer, only the soil surface may thaw, up to 20 to 60 cm. On slopes, the thawed soil may begin to move, a process called solifluction (Quinn 2008). Permafrost also creates specific landscape features collectively called patterned ground, forming circles, polygons, nets, hummocks, steps or stripes (Quinn 2008).

Distribution

Geographic Range: Upland or dry polar tundra is found in the high latitudes north of 60 degrees N in the Arctic region and south of 50 degrees S in the Antarctic region.

Citations

Synonymy:

< Arctic and Antarctic Tundra (Quinn 2008) [Polar (High Arctic) deserts are included in the authors concept.]

< Low Arctic Tundra (Bliss 2000) [Bliss includes dry and wet tundra in his overall concept, but the tall shrub tundra, low shrub tundra, dwarf shrub heath tundra, and cottongrass-dwarf-shrub heath tundra are all dry tundra and fit here.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen and S. Ponomarenko

Acknowledgments:

Version Date: 26 Aug 2014

---

5. Aquatic Vegetation (C05)

Overview

Database Code: 5 (C05)

Scientific Name: Hydromorphic Vegetation Class

Common Name (Translated Scientific Name): Hydromorphic Vegetation Class

Colloquial Name: Aquatic Vegetation

Hierarchy Level: Class

Lower Level Hierarchy Units:

5.A. Saltwater Aquatic Vegetation (S09)

5.B. Freshwater Aquatic Vegetation (S13)

Concept Summary

Type Concept Sentence: Open freshwater and saltwater wetlands dominated by aquatic vegetation, either rooted with leaves rising up to or near the surface, or floating freely on the water surface. Stands typically have surface water, generally up to 2 m in depth, along ocean, lake, pond, and river margins in non-tidal, tidal and intertidal habitats.

Classification Comments: Open-water submerged and floating *aquatic herb* and *alga* wetland vegetation is included here if found in shallow aquatic habitats, usually less than 2 m in depth (e.g., along lakeshores and rivershores) and less than 8 ha in size (i.e., ponds), where active wave-forming or bedrock shoreline features are lacking (following the U.S. wetland classification criteria of Cowardin and others 1979). Other deeper or larger aquatic habitats, such as lakes, rivers, estuaries and oceans, are included in the non-vegetated aquatic class, where the vegetation layer is no longer a controlling layer in the system. Submerged tidal aquatic vegetation has been mapped where cover is less than 10 percent (Orth and others 2010).

Similar NVC Types: Non-vegetated category: lakes and rivers may overlap with this class, but typically are >2 m deep and larger than 8 ha, and lakeshores are shaped by wave-forming processes.

7. Agricultural & Developed Vegetation (CCL01): These cultural wetlands may have a vegetation structure that is regularly managed (e.g., rice paddies), the water levels may be regularly manipulated, or the shores of the wetland may be highly modified by concrete, berms, etc.

Diagnostic Characteristics: Hydromorphic growth forms dominate, including rooting and floating *aquatic herbs* and *alga*. Emergent growth forms have less than 10 percent cover, and hydromorphic vegetation is at least 1 percent cover. Vegetation structure has irregular horizontal canopy spacing, and shoreline edges are shaped by natural processes.

Vegetation

Physiognomy and Structure: *Growth Forms*: Stands have hydromorphic growth forms, including rooted and floating *aquatic herbs* and *alga*, with various other growth forms.

Structure: Stands typically have surface water, up to 2 m in depth, and have *aquatic herbs* either rooted with leaves rising up to or near the surface or floating freely on the water surface, or *alga*. The vegetation cover varies from very open to closed, with irregular horizontal canopy spacing. Emergent growth forms have less than 10 percent cover, and hydromorphic vegetation is at least 1 percent cover. The height of the vegetation is a function of the water depth along the ocean, lake, river, or in the pond, but practically, only vegetation within 2 m of the water surface is included in this type.

Environment

Environmental Description: *Climate:* Found in any climate where water regimes are sufficient to support rooted or floating vegetation.

Soil/substrate/hydrology: This type includes shallow aquatic habitats, typically less than 2 m in depth (e.g., along ocean, lake and river shores) and less than 8 ha in size (i.e., ponds), where active wave-forming or bedrock shoreline features are lacking (Cowardin 1985). Other deeper or larger aquatic habitats, such as lakes, rivers, estuaries and oceans, are included in the non-vegetated Aquatic class, where the vegetation layer is no longer a controlling layer in the system.

Distribution

Geographic Range: This type is found around the globe wherever open freshwater lakes, rivers and ponds are found.

Citations

Synonymy:

< Coastal Mudflats and Brackish Waters (Rodwell and others 2002)

< Freshwater Aquatic Vegetation (Rodwell and others 2002)

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: Hierarchy Revisions Working Group

Acknowledgments:

Version Date: 26 Aug 2014

5.A. Saltwater Aquatic Vegetation (S09)

Overview

Database Code: 5.A (S09)

Scientific Name: Saltwater Aquatic Vegetation Subclass

Common Name (Translated Scientific Name): Saltwater Aquatic Vegetation Subclass

Colloquial Name: Saltwater Aquatic Vegetation

Hierarchy Level: Subclass

Placement in Hierarchy: 5. Aquatic Vegetation (C05)

Lower Level Hierarchy Units:

5.A.1. Floating & Suspended Macroalgae Saltwater Vegetation (F052)

5.A.2. Benthic Macroalgae Saltwater Vegetation (F053)

5.A.3. Benthic Vascular Saltwater Vegetation (F054)

5.A.4. Benthic Lichen Saltwater Vegetation (F055)

Concept Summary

Type Concept Sentence: Saltwater Aquatic Vegetation occurs in shallow to deep saline habitats where emergent vegetation is less than 10 percent cover, and submerged or floating-aquatic plants have greater than 1 percent cover, occurring around the globe from the equator to the polar regions.

Similar NVC Types:

5.B. Freshwater Aquatic Vegetation (S13).

Diagnostic Characteristics: Saltwater Aquatic Vegetation occurs in shallow to deep water habitats where emergent vegetation is less than10 percent cover, and submerged or floating-aquatic plants have greater than 1 percent cover, with the lower limits of salinity set at 0.5 ppt, below which it is considered freshwater. Water levels are seasonally stable, permanently flooded, or intermittently exposed during droughts, low flows, or intertidal periods. This vegetation occurs around the globe from the equator to polar regions in saltwater habitats.

Vegetation

Physiognomy and Structure: Submerged or floating aquatic plants and/or macroalgae usually dominate the vegetation, with less than 10 percent of the surface water area occluded by standing emergent or woody plants. Macroalga may be common. Open surface water at a range of depths is present for all or most of the year.

Environment

Environmental Description: Saltwater Aquatic Vegetation occurs in deeper waters of wetlands or in shallow open-water habitats that are transitional along the coast between the intertidal salt marshes or other intertidal areas, and permanent, deep-water oceans. Water levels may be influenced by intertidal periods. More rarely, they occur as floating vegetation in shallow zones of deep oceans or in inland saline habitats with permanent water. The lower limits of salinity for this formation are set at 0.5 ppt, below which aquatic vegetation is considered freshwater.

Distribution

Geographic Range: Saltwater Aquatic Vegetation occurs in both shallow to moderately deep saltwater benthic habitats and in floating habitats around the globe from the equator to the polar regions.

Citations

Synonymy:

>< Shallow Water Wetland Class (National Wetlands Working Group 1997) [The authors include both saltwater aquatic and freshwater aquatic vegetation in their concept and restrict the type to wetland aquatic vegetation, whereas the concept used here could extend to deeper water habitats.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen, C. Lea, K. Goodin

Acknowledgments:

Version Date: 26 Aug 2014

5.A.1. Floating & Suspended Macroalgae Saltwater Vegetation (F052)

Overview

Database Code: 5.A.1 (F052)

Scientific Name: Floating & Suspended Macroalgae Saltwater Vegetation Formation

Common Name (Translated Scientific Name): Floating & Suspended Macroalgae Saltwater Vegetation Formation

Colloquial Name: Floating & Suspended Macroalgae Saltwater Vegetation

Hierarchy Level: Formation

Placement in Hierarchy: 5.A. Saltwater Aquatic Vegetation (S09)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Floating & Suspended Macroalgae Saltwater Vegetation includes areas dominated by macroalgae that are floating on the surface or are suspended freely in the water column, i.e., macroalgae that are not rooted or attached to the bottom. Examples include *Gracilaria* Rafts, Kelp Rafts, Rockweed Rafts, *Sargassum* Rafts, and *Ulva* Rafts.

Classification Comments: There are no known marine, floating, or suspended vascular plant species. Vascular vegetation that floats on the surface, but is rooted in the substrate is included in *5.A.3 Benthic Vascular Saltwater Vegetation Formation (F054)*.

Diagnostic Characteristics: Includes areas dominated by macroalgae that are floating on the surface or are suspended freely in the water column, i.e., macroalgae that are not rooted or attached to the bottom.

Vegetation

Physiognomy and Structure: The vegetation includes areas dominated by macroalgae that are floating on the surface or are suspended freely in the water column, i.e., macroalgae that are not rooted or attached to the bottom. Examples include *Gracilaria* Rafts, Kelp Rafts, Rockweed Rafts, *Sargassum* Rafts, and *Ulva* Rafts.

Environment

Environmental Description: The macroalgae are floating on the surface or are suspended freely in the water column.

Distribution

Geographic Range: This type is found throughout the world's oceans.

Citations

Synonymy:

= Biotic Subclass: Floating/Suspended Macroalgae (FGDC 2012)

Primary Concept Source: Federal Geographic Data Committee (2012)

Author of Description: K. Goodin and D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

5.A.2. Benthic Macroalgae Saltwater Vegetation (F053)

Overview

Database Code: 5.A.2 (F053)

Scientific Name: Benthic Macroalgae Saltwater Vegetation Formation

Common Name (Translated Scientific Name): Benthic Macroalgae Saltwater Vegetation Formation

Colloquial Name: Benthic Macroalgae Saltwater Vegetation

Hierarchy Level: Formation

Placement in Hierarchy: 5.A. Saltwater Aquatic Vegetation (S09)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: The vegetation includes subtidal or intertidal bottoms and other areas dominated by attached macroalgae, including kelp, intertidal fucoids, and calcareous algae, which are usually submersed within or extend to the surface of the water column, though they may be exposed during low tides.

Type Concept: Benthic Macroalgae Saltwater Vegetation includes subtidal or intertidal bottoms and any other areas characterized by a dominant cover of attached macroalgae, which are usually submersed within or extend to the surface of the water column. They may be exposed during low tides. The aquatic beds dominated by macroalgae include kelp, intertidal fucoids, and calcareous algae. Macroalgal communities can exist at all depths within the photic zone, on diverse substrates, and across a range of energy and water chemistry regimes. Many macroalgal types and communities have low temporal persistence and can bloom and die back within short periods. This aspect of macroalgae can be reflected with a temporal persistence modifier.

Classification Comments: Free-floating macroalgae are included under *5.A.1 Floating & Suspended Macroalgae Saltwater Vegetation Formation (F052)*. Macroalgal communities (typically coralline/crustose algae) that build substrate in a reef setting are categorized separately as Reef Biota and not included here.

Similar NVC Types:

5.A.3. Benthic Vascular Saltwater Vegetation (F054).

5.A.4. Benthic Lichen Saltwater Vegetation (F055).

Vegetation

Physiognomy and Structure: The vegetation includes subtidal or intertidal bottoms and any other areas characterized by a dominant cover of attached macroalgae, which are usually submersed within or extend to the surface of the water column. They may be exposed during low tides. The aquatic beds dominated by macroalgae include kelp, intertidal fucoids, and calcareous algae. Many macroalgal types and communities have low temporal persistence and can bloom and die back within short periods. This aspect of macroalgae can be reflected with a temporal persistence modifier.

While many researchers organize macroalgae based on their pigmentation, the Coastal and Marine Ecological Classification Standard (CMECS) (FGDC 2012) takes a growth morphology approach to defining benthic algal biotic groups. This decision was driven by the fact that macroalgal assemblages often include a variety of co-existing algal species, making delineations of individual species difficult. This approach also captures the influence that the algal growth structure has in shaping the local environment, by providing shelter, shade, and detrital material to an area, which is important to associated fauna. Thus CMECS distinguishes sheet group, filamentous group, coarsely branched group, thick leathery group, jointed calcareous group, and crustose group

Environment

Environmental Description: This type can exist at all depths within the photic zone, on diverse substrates, and across a range of energy and water chemistry regimes.

Distribution

Geographic Range: This type is found throughout the world's oceans.

Citations

Synonymy:

= Biotic Subclass: Benthic Macroalgae (FGDC 2012)

Primary Concept Source: Federal Geographic Data Committee (2012)

Author of Description: K. Goodin and D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

5.A.3. Benthic Vascular Saltwater Vegetation (F054)

Overview

Database Code: 5.A.3 (F054)

Scientific Name: Benthic Vascular Saltwater Vegetation Formation

Common Name (Translated Scientific Name): Benthic Vascular Saltwater Vegetation Formation

Colloquial Name: Benthic Vascular Saltwater Vegetation

Hierarchy Level: Formation

Placement in Hierarchy: 5.A. Saltwater Aquatic Vegetation (S09)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: The vegetation includes subtidal or intertidal bottoms of rooted vascular vegetation beds commonly dominated by any number of seagrass or eelgrass species, including species of *Cymodocea, Halodule, Thalassia, Halophila, Vallisneria, Ruppia, Phyllospadix*, and *Zostera*, and which are usually submersed in the water column or floating on the surface, or exposed during low tides.

Classification Comments: Non-rooted floating vascular plants are not known to occur in marine environments, and free floating macroalgae are included under *5.A.1 Floating & Suspended Macroalgae Saltwater Vegetation Formation (F052)*.

Similar NVC Types:

5.A.2. Benthic Macroalgae Saltwater Vegetation (F053).

5.A.4. Benthic Lichen Saltwater Vegetation (F055).

5.B.1. Tropical Freshwater Aquatic Vegetation (F056).

5.B.2. Temperate to Polar Freshwater Aquatic Vegetation (F057).

Diagnostic Characteristics:

Vegetation

Physiognomy and Structure: The vegetation includes subtidal or intertidal bottoms and any other areas characterized by a dominant cover of rooted vascular plants that are usually submersed in the water column or floating on the surface. They may be exposed during low tides. The vascular vegetation beds are commonly dominated by any number of seagrass or eelgrass species, including *Cymodocea, Halodule, Thalassia, Halophila, Vallisneria, Ruppia, Phyllospadix*, and *Zostera*..

Environment

Environmental Description: Seagrass beds may occur in true marine salinities, and they may extend into the lower salinity zones of estuaries. Seagrass beds are complex structural habitats that provide refuge and foraging opportunities for abundant and diverse faunal communities in shallow waters. Seagrass beds require a specific set of ecological conditions for success, and they are generally perceived as areas of high environmental quality.

Distribution

Geographic Range: This type is found throughout the world's oceans.

Citations

Synonymy:

= Biotic Subclass: Aquatic Vascular Vegetation (FGDC 2012)

Primary Concept Source: Federal Geographic Data Committee (2012)

Author of Description: K. Goodin and D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

5.A.4. Benthic Lichen Saltwater Vegetation (F055)

Overview

Database Code: 5.A.4 (F055)

Scientific Name: Benthic Lichen Saltwater Vegetation Formation

Common Name (Translated Scientific Name): Benthic Lichen Saltwater Vegetation Formation

Colloquial Name: Benthic Lichen Saltwater Vegetation

Hierarchy Level: Formation

Placement in Hierarchy: 5.A. Saltwater Aquatic Vegetation (S09)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Saltwater tidal areas dominated by submerged or emergent lichens on the surface of the substrate, occurring in two major zones: the intertidal (or Littoral) Lichen Zone, and the Supratidal (or Supralittoral) Lichen Zone.

Classification Comments: Fletcher (1973) describes Marine Lichen types. Lichen zones are described by Fletcher (1973), Gilbert and Giavarini (1997), and Hawksworth (2000). Although some mosses have been reported in tidal salt marshes, they have not been reported as dominant (Garbary and others 2008). Thus, at this time, benthic communities dominated by mosses are only recognized in freshwater tidal situations.

Similar NVC Types:

5.A.2. Benthic Macroalgae Saltwater Vegetation (F053).

5.A.3. Benthic Vascular Saltwater Vegetation (F054).

Vegetation

Physiognomy and Structure: Benthic saltwater tidal areas dominated by submerged or emergent lichens may form patches or visible patterns on the surface of the substrate. Lichens are generally recognized as a symbiotic association with a fungus and an alga (or cyanobacterium) living together and forming patches or a visible pattern on the surface of the substrate.

Environment

Environmental Description: Benthic saltwater lichens occur in relatively recognizable zones based on, among other factors, the extent to which they are submerged or flooded. The two major zones are the Intertidal (or Littoral) Lichen Zone, dominated by patches of lichens that are regularly submerged by marine tides, and the Supratidal (or Supralittoral) Lichen Zone, which are rarely submerged, but are regularly wetted by splash and sea spray, often in rocky habitats.

Distribution

Geographic Range: This type distribution is not well known.

Citations

Synonymy:
= Biotic Subclass: Marine Lichens (FGDC 2012)
Primary Concept Source: Federal Geographic Data Committee (2012)
Author of Description: K. Goodin and D. Faber-Langendoen
Acknowledgments:
Version Date: 26 Aug 2014

5.B. Freshwater Aquatic Vegetation (S13)

Overview

Database Code: 5.B (S13)
Scientific Name: Freshwater Aquatic Vegetation Subclass
Common Name (Translated Scientific Name): Freshwater Aquatic Vegetation Subclass
Colloquial Name: Freshwater Aquatic Vegetation
Hierarchy Level: Subclass
Placement in Hierarchy: 5. Aquatic Vegetation (C05)
Lower Level Hierarchy Units:
5.B.1. Tropical Freshwater Aquatic Vegetation (F056)
5.B.2. Temperate to Polar Freshwater Aquatic Vegetation (F057)

Concept Summary

Type Concept Sentence: Freshwater Aquatic Vegetation occurs in shallow to deep freshwater habitats where emergent vegetation is less than10 percent cover, and submerged or floating-aquatic plants have greater than 1 percent cover, occurring around the globe from the equator to the polar regions.

Classification Comments: The concept of this subclass extends to deeper water habitats (i.e., deeper than 2 m in lakes) and to riverine bottoms, but in practice, freshwater aquatic classifications may supersede this one from a user standpoint [see Formation Class]. That is, it may be desirable to first assign a lake or river type to the aquatic system, and secondarily note the NVC vegetation type present. Vegetation found in many urban and agricultural ponds may be very similar to natural freshwater aquatic vegetation, because agricultural and urban ponds typically manipulate the physical setting, not the vegetation itself. There are distinct cultural aquatic vegetation types, but these should be limited to situations in which the vegetation itself is manipulated for horticultural (e.g., aquatic gardens) or agricultural (e.g., water chestnuts grown in impoundments, rice paddies) that are parallel with terrestrial cultural vegetation. However, many agricultural ponds may actively prevent vegetation from forming. For practical applications of classification and mapping of freshwater aquatic vegetation, the agricultural and urban ponds may be initially placed within the *7. Agricultural & Developed Vegetation Class (CCL01)*, and, where evidence is gathered to show they have a natural composition, they may be reclassified.

Similar NVC Types:

5.A. Saltwater Aquatic Vegetation (S09).

7.C. Herbaceous & Woody Developed Vegetation (CSC03).

7.D. Agricultural & Developed Aquatic Vegetation (CSC04).

Diagnostic Characteristics: Freshwater Aquatic Vegetation occurs in shallow to deep water habitats where emergent vegetation is less than10 percent cover, and submerged or floating aquatic plants have greater than 1 percent cover, with the upper limits of salinity set at 0.5 ppt, above which it is considered saltwater. Water levels are seasonally stable, permanently flooded, or intermittently exposed during droughts, low flows or intertidal periods. Freshwater Aquatic Vegetation occurs around the globe from the equator to the polar regions in freshwater habitats.

Vegetation

Physiognomy and Structure: Submerged or floating aquatic plants usually dominate the vegetation, with less than 10 percent of the surface water area covered by standing emergent or woody plants. Open surface water up to 2 m or more deep is present for all or most of the year (National Wetlands Working Group 1997).

Environment

Environmental Description: Freshwater Aquatic Vegetation is subject to aquatic processes typical of upper limnetic or infralittoral lake zones, such as nutrient and gas exchange, oxidation and decomposition. Ionic composition of waters varies widely. The upper limits of salinity for Freshwater Aquatic Vegetation are set at 0.5 ppt, above which the vegetation is considered *5.A Saltwater Aquatic Vegetation Subclass (S09)*. Dissolved minerals, acid base balances, and nutrient levels are influenced by the hydrology, underlying geological materials, nutrient fluxes, and plant communities. Freshwater Aquatic Vegetation is usually situated on substrates of limnic peat, mixed limnic organic mineral material, and marl in stable water regimes. Little sediment accumulation occurs in high energy shallow waters such as tidal regimes, rivers or large lakes. In semi arid regions, shallow waters dry up intermittently, often leaving evaporite alkaline salt deposits. Except in highly saline or acidic waters, these deposits provide a substrate for rooted submerged and floating macrophytes, algae and aquatic mosses (National Wetlands Working Group 1997).

Freshwater Aquatic Vegetation is found in shallow water that usually has standing or flowing water less than 2 m deep in mid-summer. Water levels are seasonally stable, permanently flooded, or intermittently exposed during droughts or low flows. Shallow-water vegetation may also occupy bays and margins of profundal zones of lakes (National Wetlands Working Group 1997).

Freshwater Aquatic Vegetation occurs in ponds, pools, shallow lakes, oxbows, sloughs, natural and artificial impoundments, or channels. Boundaries are determined by water-eroded shorelines, beaches or landward margins of mudflats, recent limnic deposits, floating mats, emergents or hydrophytic trees or shrubs. Bordering mats of rooted emergent vegetation, including inundated trees, may occupy up to 10 percent of the shallow-water area. Shallow waters are found in all hydrogeomorphic settings, but are usually associated with lacustrine, fluvial, stream, river, and permafrost systems (National Wetlands Working Group 1997).

Distribution

Geographic Range: Freshwater Aquatic Vegetation occurs in shallow to deep freshwater habitats around the globe from the equator to the polar regions.

Citations

Synonymy:

>< Freshwater Marshes (Mitsch and Gosselink 2000) [Both tropical and temperate marshes are treated together, and inland saline marshes are included here too, as are emergent and aquatic vegetation.]

>< Shallow Water Wetland Class (National Wetlands Working Group 1997) [The authors include both saltwater aquatic and freshwater aquatic vegetation in their concept and restrict the type to wetland aquatic vegetation, whereas the concept used here could extend to deeper water habitats.]

>< Tidal Freshwater Marshes (Mitsch and Gosselink 2000) [Both tropical and temperate marshes are treated together, as are emergent and aquatic vegetation.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen, after National Wetlands Working Group (1997)

Acknowledgments:

Version Date: 26 Aug 2014

5.B.1. Tropical Freshwater Aquatic Vegetation (F056)

Overview

Database Code: 5.B.1 (F056)

Scientific Name: Tropical Freshwater Aquatic Vegetation Formation

Common Name (Translated Scientific Name): Tropical Freshwater Aquatic Vegetation Formation

Colloquial Name: Tropical Freshwater Aquatic Vegetation

Hierarchy Level: Formation

Placement in Hierarchy: 5.B. Freshwater Aquatic Vegetation (S13)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical Freshwater Aquatic Vegetation occurs in shallow to deep freshwater habitats where emergent vegetation is less than10 percent cover, and submerged or floating-aquatic plants have greater than 1 percent cover, occurring around the globe within the tropical regions (roughly, between 30 degrees N and 30 degrees S in latitude).

Classification Comments: The concept of this formation extends to deeper water habitats (i.e., deeper than 2 m in lakes) and to riverine bottoms, but in practice, freshwater aquatic classifications may supersede this one from a user standpoint [see Formation Class and Subclass Classification Comments].

Similar NVC Types:

5.A.3. Benthic Vascular Saltwater Vegetation (F054).

5.B.2. Temperate to Polar Freshwater Aquatic Vegetation (F057).

7.D.1. Agricultural Aquatic Vegetation (CFO12): Although in some cases there may be difficulty distinguishing natural ponds (F056) from agricultural ponds (CFO12), in the large majority of cases, they are distinct in ecological setting, edges, and in composition.

7.D.2. Developed Aquatic Vegetation (CFO13): Although in some cases there may be difficulty distinguishing natural (F056) from urban ponds (CFO13), in the large majority of cases, they are distinct in ecological setting, edges, and in composition.

Diagnostic Characteristics: Tropical Freshwater Aquatic Vegetation occurs in shallow to deep water habitats where emergent vegetation is less than10 percent cover, and submerged or floating-aquatic plants have more than1 percent cover, with the upper limits of salinity set at 0.5 ppt, above which it is considered saltwater. Water levels are seasonally stable, permanently flooded, or intermittently exposed during droughts, low flows or intertidal periods. Tropical Freshwater Aquatic Vegetation occurs around the globe within the tropical regions (roughly, between 30 degrees North and 30 degrees South in latitude). Vegetation is more typically present throughout the year, or fluctuates in response to factors other than temperature.

Vegetation

Physiognomy and Structure: Submerged or floating aquatic plants usually dominate the vegetation, with less than 10 percent of the surface water area covered by standing emergent or woody plants. Above-sediment or floating biomass remains relatively constant in abundance throughout the year, or fluctuates in response to factors other than temperature change (e.g., water levels or suspended sediment). Open surface water up to 2 m or more deep is present for all or most of the year (National Wetlands Working Group 1997).

Environment

Environmental Description: Tropical Freshwater Aquatic Vegetation is subject to aquatic processes typical of upper limnetic or infralittoral lake zones, such as nutrient and gaseous exchange, oxidation and decomposition. Ionic composition of waters varies widely. The upper limits of salinity for Tropical Freshwater Aquatic Vegetation are set at 0.5 ppt. Dissolved minerals, acid-base balances, and nutrient levels are influenced by hydrology, underlying geological materials, nutrient fluxes and plant communities. Tropical Freshwater Aquatic Vegetation usually is situated on substrates of limnic organic or mineral material, or marl in stable-water regimes. Little sediment accumulation occurs in high-energy shallow waters such as tidal regimes, rivers or large lakes. In semi-arid regions, shallow waters dry up intermittently, often leaving evaporite alkaline salt deposits. Except in highly saline or acidic waters, these deposits provide a substrate for rooted submerged and floating macrophytes, algae and aquatic mosses (National Wetlands Working Group 1997).

Tropical Freshwater Aquatic Vegetation is found in shallow water that usually has standing or flowing water less than 2 m deep in mid-summer. Water levels are seasonally stable, permanently flooded, or intermittently exposed during droughts or low flows. Shallow-water vegetation may also occupy bays and margins of profundal zones of lakes (National Wetlands Working Group 1997).

Tropical Freshwater Aquatic Vegetation occurs in ponds, pools, shallow lakes, oxbows, sloughs, natural and artificial impoundments, canals, or stream and river channels, including freshwater portions of estuaries. Boundaries are determined by water-eroded shorelines, beaches or landward margins of mudflats, recent limnic deposits, floating mats, emergents or hydrophytic trees or shrubs. Bordering mats of rooted emergent vegetation, including inundated trees, may occupy up to 10 percent of the shallow water area. Shallow waters are found in all hydrogeomorphic settings, but are usually associated with lacustrine, fluvial, stream, river and permafrost systems (National Wetlands Working Group 1997).

Distribution

Geographic Range: Tropical Freshwater Aquatic Vegetation occurs in shallow to deep freshwater habitats around the globe within the tropical regions (roughly, between 30 degrees N and 30 degrees S latitude).

Citations

Synonymy:

>< Freshwater Marshes (Mitsch and Gosselink 2000) [Both tropical and temperate marshes are treated together, and inland saline marshes are included here too, as are emergent and aquatic vegetation.]

>< Shallow Water Wetland Class (National Wetlands Working Group 1997) [The authors include both saltwater aquatic and freshwater aquatic vegetation in their concept and restrict the type to wetland aquatic vegetation, whereas the concept used here could extend to deeper water habitats.]

>< Tidal Freshwater Marshes (Mitsch and Gosselink 2000) [Both tropical and temperate marshes are treated together, as are emergent and aquatic vegetation.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen, after National Wetlands Working Group (1997), modified C. Lea

Acknowledgments:

Version Date: 26 Aug 2014

5.B.2. Temperate to Polar Freshwater Aquatic Vegetation (F057)

Overview

Database Code: 5.B.2 (F057)

Scientific Name: Temperate to Polar Freshwater Aquatic Vegetation Formation

Common Name (Translated Scientific Name): Temperate to Polar Freshwater Aquatic Vegetation Formation

Colloquial Name: Temperate to Polar Freshwater Aquatic Vegetation

Hierarchy Level: Formation

Placement in Hierarchy: 5.B. Freshwater Aquatic Vegetation (S13)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Temperate to Polar Freshwater Aquatic Vegetation occurs in shallow to deep freshwater habitats (e.g., lakes, ponds, canals, streams, rivers, and freshwater portions of estuaries) where emergent vegetation is less than10 percent cover, and submerged or floating-aquatic plants have greater than 1 percent cover, occurring around the globe in both hemispheres, from the tropics north and south to the polar regions.

Classification Comments: The concept of this formation extends to deeper water habitats (i.e., deeper than 2 m in lakes) and to riverine bottoms, but in practice, freshwater aquatic classifications may supersede this one from a user standpoint [see Formation Class and Subclass Classification Comments].

Similar NVC Types:

- *5.A.3. Benthic Vascular Saltwater Vegetation (F054)*.
- *5.B.1. Tropical Freshwater Aquatic Vegetation (F056)*.
- *7.D.1. Agricultural Aquatic Vegetation (CFO12)*: Although in some cases there may be difficulty distinguishing natural (F057) from agricultural ponds (CFO12), in the large majority of cases, they are distinct in ecological setting, edges, and in composition.
- *7.D.2. Developed Aquatic Vegetation (CFO13)*: Although in some cases there may be difficulty distinguishing natural (F057) from urban ponds (CFO13), in the large majority of cases, they are distinct in ecological setting, edges, and in composition.

Diagnostic Characteristics: Temperate to Polar Freshwater Aquatic Vegetation occurs in shallow to deep water habitats (e.g., lakes, ponds, canals, streams, rivers, and freshwater portions of estuaries) where emergent vegetation is less than10 percent cover, and submerged or floating-aquatic plants have greater than 1 percent cover, with the upper limits of salinity set at 0.5 ppt, above which it is considered saltwater. Water levels are seasonally stable, permanently flooded, or intermittently exposed during droughts, low flows or intertidal periods. Temperate to Polar Freshwater Aquatic Vegetation occurs around the globe in both hemispheres, from the tropics north and south to the polar regions. Vegetation may only be seasonally present, and is absent during colder months.

Vegetation

Physiognomy and Structure: Submerged or floating aquatic plants usually dominate the vegetation, with less than 10 percent of the surface water area covered by standing emergent or woody plants. In cold seasons, rooted vegetation (submerged and floating-leaved) usually dies back to sediment, and floating plants may largely disappear. Biomass may persist longer or throughout the year in warmer parts of the range. Open surface water up to 2 m or more deep is present for all or most of the year (National Wetlands Working Group 1997).

Environment

Environmental Description: Temperate to Polar Freshwater Aquatic Vegetation is subject to aquatic processes typical of upper limnetic or infra-littoral lake zones, such as nutrient and gas exchange, oxidation and decomposition. Ionic composition of waters varies widely. The upper limits of salinity for Temperate to Polar Freshwater Aquatic Vegetation are set at 0.5 ppt. Dissolved minerals, acid-base balances, and nutrient levels are influenced by the hydrology, underlying geological materials, nutrient fluxes, and plant communities. Temperate to Polar Freshwater Aquatic Vegetation is usually situated on substrates of limnic organic or mineral material, or on marl in stable-water regimes. Little sediment accumulation occurs in high-energy shallow waters such as tidal regimes, rivers, or large lakes. In semi-arid regions, shallow waters dry up intermittently, often leaving evaporite alkaline salt deposits. Except in highly saline or acidic waters, these deposits provide a substrate for rooted submerged and floating macrophytes, algae, and aquatic mosses (National Wetlands Working Group 1997).

Temperate to Polar Freshwater Aquatic Vegetation is found in shallow water that usually has standing or flowing water less than 2 m deep in mid-summer. Water levels are seasonally stable, permanently flooded, or intermittently exposed during droughts or low flows. Shallow water vegetation may also occupy bays and margins of profundal zones of lakes (National Wetlands Working Group 1997).

Temperate to Polar Freshwater Aquatic Vegetation occurs in ponds, pools, shallow lakes, oxbows, sloughs, natural and artificial impoundments, canals, or stream and river channels, including freshwater portions of estuaries. Boundaries are determined by water-eroded shorelines, beaches or landward margins of mudflats, recent limnic deposits, floating mats, emergents or hydrophytic trees or shrubs. Bordering mats of rooted emergent vegetation, including inundated trees, may occupy up to 10 percent of the shallow water area. Shallow waters are found in all hydrogeomorphic settings, but are usually associated with lacustrine, fluvial, stream, river, and permafrost systems (National Wetlands Working Group 1997).

Distribution

Geographic Range: Temperate to Polar Freshwater Aquatic Vegetation occurs in shallow to deep freshwater habitats around the globe in both hemispheres, from the tropics north and south to the polar regions.

Citations

Synonymy:

>< Freshwater Marshes (Mitsch and Gosselink 2000) [Both tropical and temperate marshes are treated together, and inland saline marshes are included here too, as are emergent and aquatic vegetation.]

>< Shallow Water Wetland Class (National Wetlands Working Group 1997) [The authors include both saltwater aquatic and freshwater aquatic vegetation in their concept and restrict the type to wetland aquatic vegetation, whereas the concept used here could extend to deeper water habitats.]
>< Tidal Freshwater Marshes (Mitsch and Gosselink 2000) [Both tropical and temperate marshes are treated together, as are emergent and aquatic vegetation.]
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen, after National Wetlands Working Group (1997), modified C. Lea
Acknowledgments:
Version Date: 26 Aug 2014

---

6. Open Rock Vegetation (C06)

Overview

Database Code: 6 (C06)
Scientific Name: Cryptogam - Open Mesomorphic Vegetation Class
Common Name (Translated Scientific Name): Cryptogam - Open Mesomorphic Vegetation Class
Colloquial Name: Open Rock Vegetation
Hierarchy Level: Class
Lower Level Hierarchy Units:
6.A. Tropical Open Rock Vegetation (S02)
6.B. Temperate & Boreal Open Rock Vegetation (S04)

Concept Summary

Type Concept Sentence: Tropical, temperate, and boreal habitats are characterized or dominated by plant growth forms, such as *lichen, bryophyte, alga*, or *fern*, that have structural adaptations for living on stable rock surfaces or on unstable rocky substrates, such as cliffs, talus, scree, pavement, cobble, lava or boulderfields, and with associated mesomorphic grass, shrub and tree growth forms.

Classification Comments: This class is defined by primarily nonvascular, often crustose lichen, ferns or very sparse other vascular vegetation that is controlled by the rocky substrate. The substrate can be classed as either stable (large boulders, outcrops, monoliths, etc.) or unstable (colluvium such as scree, talus or dense, alluvial cobble). Stable substrates prevent vascular plant roots from penetrating. Species adapted to such substrates have no roots and occupy the surface of the substrates, such as nonvasculars (lichens, mosses, liverworts), or are largely prevented from growing on the substrate, except in localized fissures or cracks. Whenever the vegetation is able to establish sufficient cover on the rocky surface (typically greater than 10 percent cover), the growth forms of the vegetation determine the class. Vascular spore-bearing plants (ferns and others) are included in this class. Spikemoss (*Selaginella*) regularly adheres to cliff and outcrops, as do many species of ferns such as *Polypodium*, *Cheilanthes*, *Pellaea*, etc.

Lithology may be consolidated or unconsolidated, but the conditions of the substrate preclude development of soil and either strongly impede the penetration of roots or require specialized adaptations of roots to support the plant species. Lithomorphic or open rock vegetation may be similar to desert or polar types where climate *per se* limits the overall plant growth, and substrate limitations are secondary.

Open sand dunes are excluded from this class in general as open sand dunes are an extreme condition of other classes (i.e., mesomorphic, xeromorphic), where the constant movement of sand (ablation, deposition, etc.) is at too extreme a pace for even the typical adaptations of psammophytic plants, such as creeping stolons, rhizomes, etc., to keep up.

Larson and others (2000) characterize cliffs as having a "high, steep, or overhanging face of rock," whereas rock outcrop is a "portion of bedrock protruding through the soil." Lava flows and colluvial deposits would lay over the soil. They include both consolidated and unconsolidated cliffs in their definition, including sand, gravel or loess, as well as rock cliffs. Here we restrict it to rock (or at least very rocklike) materials. Apart from stating that a cliff need only be "high enough that falling off will kill you," they suggest that even 3 m of height is sufficient to create suitable cliff habitat.

Defining this class to include sparse vascular vegetation stands that are limited in their cover because of substrate is an issue. For example, scree vegetation could be considered very similar to psammophytic (dune and other sandy) vegetation and be treated as an extreme form of mesomorphic vegetation [mostly or all in *2. Shrub & Herb Vegetation Class (C02)*]. Scree is usually dominated by sparse vascular plants, has considerable soil development for vascular plant establishment, but has unstable substrate on which nonvascular vegetation cannot become well established (C. Lea pers. comm. 2012). However, whereas dunes can have vegetation that greatly exceeds 10 percent cover, this is less common on scree; by-and-large, the vascular vegetation remains sparse, and nonvascular vegetation is typical. Talus is generally stable enough that it has significant nonvascular vegetation, whereas scree may be unstable and less commonly contains a strong nonvascular component; further review of this distinction is needed. Thus talus fits in this Open Rock Vegetation Class based on the nonvascular vegetation criteria, and scree fits in this class because of the sparse vascular vegetation, perhaps in combination with nonvascular vegetation.

Further review may suggest that this class can be improved by distinguishing (probably at the subclass level), the less "rocklike" vegetation (including vegetation on scree, badlands, pavement) from the true solid open rock vegetation (C. Lea pers. comm. 2012). Scree and other loose rocky substrates (volcanic cinders) typically have enough soil development to support a dominant layer of disturbance-adapted, facultative mesomorphic shrubs and/or herbs (e.g., in the United States, *Ribes* spp., *Prunus virginiana*, and other forest, woodland, or shrubland shrubs in the central Rockies), and true lithomorphs (saxicolous lichens) are quite sparse, if present at all. Although the surface may be "rocky," the driving ecological factor is the availability of soil in quantity under the relatively shallow rock armoring and the absence of large, stable substrates for true lithomorphs (saxicolous lichens) to establish. Cobbles along rivers and streams may also not typically support lithomorphic growth forms, and may best be treated as sometimes sparse flooded types within mesomorphic formations. Badlands (hard clays) and desert pavements also tend to support facultative vascular species, as opposed to lithomorphs or lithophiles, and could be considered for the xeromorphic class. Given this narrower definition of open rock vegetation, a requirement for less than10 percent vascular cover and nonvascular cover greater than vascular cover may be more appropriate, to separate them from sparse or occasionally sparse types (scree, volcanic cinders) in which vascular layers are clearly dominant and nonvascular is insignificant (C. Lea pers. comm. 2012).

Similar NVC Types:

2. Shrub & Herb Vegetation (C02): In moist climates, cliff, talus, scree, and rock outcrops can contain inclusions of mesomorphic vegetation, but the lithomorphic or rock substrate limits their cover. Where mesomorphic cover is greater than 10 percent of total vascular vegetation (excluding ferns and allies), the vegetation is placed in this class.

3. Desert & Semi-Desert (C03): Dry habitats with sparse vegetation on rocky surfaces. When xeromorphic plants have greater than 10 percent cover on rocky substrates, or, if less than 10 percent, are the dominant growth present, stands are classified as xeromorphic vegetation.

4. Polar & High Montane Scrub, Grassland & Barrens (C04): In either extreme alpine habitats or in polar deserts, the vegetation will be limited to growing on rocks and become so sparse as to qualify as lithomorphic or open rock vegetation. But where the vegetation typically has less than 10 percent cover of total vascular vegetation (excluding ferns and allies), and is dominated by cryomorphic growth forms, it belongs in this class. This class also includes stands in polar regions where the vascular vegetation has extensive moss or fruticose or foliose lichen (but not crustose lichen) and is on mineral soil (i.e., lichen tundra vegetation).

Diagnostic Characteristics: Lithomorphic or open rock growth forms dominate, including *lichen* (especially foliose and crustose *lichens*)*, bryophyte, alga*, *ferns* (non-woody, including clubmosses, etc.), and crevice-dwelling (rupicolous) vascular plants. Vascular vegetation is less than 10 percent cover, and is comprised of mesomorphic vegetation. Vegetation structure may be patchy across the rocky surfaces.

Vegetation

Physiognomy and Structure: *Growth Forms*: Stands have varying levels of nonvascular growth forms (including *bryophyte*, *lichen, alga*), and vascular *ferns*, and vascular flowering vegetation is typically sparse to absent. Foliose and crustose (saxicolous) lichens may be particularly diagnostic. Vascular plants may have a variety of adaptations that allow them to thrive in these rocky habitats (sometimes referred to as rupicolous species).

Structure: The structure is very open to closed, with irregular spacing of nonvascular and fern vegetation, which can vary from absent (but vascular plants are at least sparsely present up to 10 percent) to continuous. Vascular plant cover is patchy, confined to crevices in the substrate, and is comprised of mesomorphic vegetation. Height of the nonvascular or fern species is typically less than 0.3 m; other growth forms are highly variable in height, as they may include creeping or matted to tall erect herbs, shrubs, and trees.

Environment

Environmental Description: *Climate:* Found on bare rock and in rock crevices of cliffs, scree, talus, lava, pavement, other rock outcrops, and cobble-gravel habitat, with soils typically absent. Most often in non-desert or non-polar climates where substrate features limit establishment of mesomorphic vegetation. Habitat with flat bedrock, but with thin soil layers, typically excluded.

Soil/substrate/hydrology: Organic soil component usually lacking, substrate either consolidated rock, or cobble, gravel, or stone with or without regular movement.

Distribution

Geographic Range: Azonal areas found in regions from tropical to polar zones.

Citations

Synonymy:

= Cliff, Bluffs and Rock Outcrops (Wardle 1991) [Wardle's concept is applied to New Zealand.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: Hierarchy Revisions Working Group

Acknowledgments:

Version Date: 26 Aug 2014

6.A. Tropical Open Rock Vegetation (S02)

Overview

Database Code: 6.A (S02)

Scientific Name: Tropical Open Rock Vegetation Subclass

Common Name (Translated Scientific Name): Tropical Open Rock Vegetation Subclass

Colloquial Name: Tropical Open Rock Vegetation

Hierarchy Level: Subclass

Placement in Hierarchy: 6. Open Rock Vegetation (C06)

Lower Level Hierarchy Units:

6.A.1. Tropical Cliff, Scree & Other Rock Vegetation (F011)

Concept Summary

Type Concept Sentence: Tropical rock habitats (such as cliffs, talus, scree, pavement, cobbles, lava, or boulderfields) at low elevations from approximately 23 degrees N to 23 degrees S latitude (typically frost free) from the equator characterized by nonvascular plant growth forms that have structural adaptations for living on stable rock surfaces or in unstable rocky substrates. A sparse cover of various mesomorphic vascular growth forms, including woody plants, may be present.

Classification Comments: There is little information that has been comprehensively evaluated across the globe, making it difficult to describe the type concept. We suggest that cliff and slope sites with hardpacked sedimentary rocks and clays be included in this class. More work is needed to clarify the distinctions between Open Rock Vegetation and other sparsely vegetated habitats where rocky substrates are dominant and lichen vegetation is absent. For example, many rocky river and lake shoreline types may be placed in *2.A.3. Tropical Scrub & Herb Coastal Vegetation Formation (F024)* where vegetation is patchy but may exceed 10 percent.

Currently all vascular plant cover is treated together. But cover of *ferns* (non-woody, including clubmosses, etc.), *bromeliads*, and crevice-dwelling (rupicolous) vascular plants may need to be considered separately from other vascular cover when deciding on cover thresholds for this class.

Further review may suggest that this subclass can be improved by distinguishing the less "rocklike" vegetation (including vegetation on scree, badlands, and pavement) from the true lithomorphic (solid rock) vegetation (C. Lea pers. comm. 2012).

Similar NVC Types:

6.B. Temperate & Boreal Open Rock Vegetation (S04): Warm-temperate cliffs contain subtropical-like cliff features.

Diagnostic Characteristics: Rocky or rocklike substrates dominated by lithomorphic or open rock growth forms, including *lichen* (especially foliose and crustose *lichens*), *bryophyte*, and *alga*, with cover greater than 1 percent; vascular vegetation (including clubmosses, etc.), *bromeliads*, and crevice-dwelling (rupicolous) vascular plants is typically less than 10 percent cover. Vascular cover may include either evergreen broad-leaved or drought-deciduous trees and shrubs or evergreen herbs. Vegetation structure may be patchy across the rocky surfaces.

Vegetation

Physiognomy and Structure: Stands typically contain a covering of crustose lichens and/or sparse covering of vascular plants. Vascular and nonvascular plant cover, especially *bryophytes, lichens, algae*, or *ferns*, is greater than 1 percent; vascular plant cover, including bromeliad growth forms, is largely determined by the rock fissures and is typically less than 10 percent, with irregular horizontal spacing. Vascular woody growth forms of either evergreen broad-leaved or drought-deciduous woody plants, including lianas, may be present.

Environment

Environmental Description: Stable rock surfaces (e.g., outcrops) prevent vascular plant roots from penetrating, and their presence is largely determined by the rock fissures. On unstable rocky surfaces (e.g., talus), the presence of vascular plants is largely determined by a degree of permanence. Tropical climates, where daily temperate changes are greater than the seasonal changes, are various and often less determinative than presence of open rock surfaces. Substrates are typically dry to moist, but occasionally wet, and typically lack soil development of any kind.

Distribution

Geographic Range: Tropical Open Rock Vegetation is found in localized areas throughout the tropical latitudes, where frost is essentially absent, approximately from 23 degrees N to S around the equator.

Citations

Synonymy:

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen and J. Sawyer

Acknowledgments:

Version Date: 26 Aug 2014

6.A.1. Tropical Cliff, Scree & Other Rock Vegetation (F011)

Overview

Database Code: 6.A.1 (F011)

Scientific Name: Tropical Cliff, Scree & Other Rock Vegetation Formation

Common Name (Translated Scientific Name): Tropical Cliff, Scree & Other Rock Vegetation Formation

Colloquial Name: Tropical Cliff, Scree & Other Rock Vegetation

Hierarchy Level: Formation

Placement in Hierarchy: 6.A. Tropical Open Rock Vegetation (S02)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Tropical rock habitats (such as cliffs, talus, scree, pavement, cobbles, lava, or boulderfields) at low elevations from approximately 23 degrees N to 23 degrees S latitude (typically frost free) from the equator characterized by nonvascular plant growth forms that have structural adaptations for living on stable rock surfaces or in unstable rocky substrates. A sparse cover of various mesomorphic vascular growth forms, including woody plants, may be present.

Classification Comments: There is little information that has been comprehensively evaluated across the globe, making it difficult to describe the type concept. We suggest that cliff and slope sites with hardpacked sedimentary rocks and clays be included in this class. More work is needed to clarify the distinctions between Open Rock Vegetation and other sparsely vegetated habitats where rocky substrates are dominant and lichen vegetation is absent. For example, many rocky river and lake shoreline types may be placed in *2.A.3. Tropical Scrub & Herb Coastal Vegetation Formation (F024)* where vegetation is patchy but may exceed 10 percent.

Currently all vascular plant cover is treated together. But cover of *ferns* (non-woody, including clubmosses, etc.), *bromeliads*, and crevice-dwelling (rupicolous) vascular plants may need to be considered separately from other vascular cover when deciding on cover thresholds for this class.

Similar NVC Types:

6.B.1. Temperate & Boreal Cliff, Scree & Other Rock Vegetation (F034): Warm-temperate cliffs contain subtropical-like cliff features.

Diagnostic Characteristics: Rocky or rocklike substrates dominated by cryptogam growth forms, including *lichen* (especially foliose and crustose *lichens*), *bryophyte*, and *alga*, with cover greater than 1 percent; vascular vegetation (including clubmosses, etc.), *bromeliads*, and crevice-dwelling (rupicolous) vascular plants is typically less than 10 percent cover. Vascular cover may include either evergreen broad-leaved or drought-deciduous trees and shrubs or evergreen herbs. Vegetation structure may be patchy across the rocky surfaces.

Vegetation

Physiognomy and Structure: Stands typically contain a covering of crustose lichens and/or sparse covering of vascular plants. Vascular and nonvascular plant cover, especially *bryophytes, lichens, algae*, or *ferns*, is greater than 1 percent; vascular plant cover, including bromeliad growth forms, largely determined by the rock fissures is typically less than 10 percent, with irregular horizontal spacing. Vascular woody growth forms of either evergreen broad-leaved or drought-deciduous woody plants, including lianas, may be present.

Environment

Environmental Description: Stable rock surfaces (e.g., outcrops) prevent vascular plant roots from penetrating, and their presence is largely determined by the rock fissures. On unstable rocky surfaces (e.g., talus), the presence of vascular plants is largely determined by a degree of permanence. Tropical climates, where daily temperate changes are greater than the seasonal changes, are various and often less determinative than presence of open rock surfaces. Substrates are typically dry to moist, but occasionally wet and typically lack soil development of any kind.

Distribution

Geographic Range: Tropical Cliff, Scree & Other Rock Vegetation is found in localized areas throughout the tropical latitudes from 23 degrees N to S around the equator.

Citations

Synonymy:
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen and J. Sawyer
Acknowledgments:
Version Date: 26 Aug 2014

6.B. Temperate & Boreal Open Rock Vegetation (S04)

Overview

Database Code: 6.B (S04)
Scientific Name: Temperate & Boreal Open Rock Vegetation Subclass
Common Name (Translated Scientific Name): Temperate & Boreal Open Rock Vegetation Subclass
Colloquial Name: Temperate & Boreal Open Rock Vegetation
Hierarchy Level: Subclass
Placement in Hierarchy: 6. Open Rock Vegetation (C06)
Lower Level Hierarchy Units:
6.B.1. Temperate & Boreal Cliff, Scree & Other Rock Vegetation (F034)

Concept Summary

Type Concept Sentence: Rocky habitats (such as cliffs, talus, scree, pavement, cobbles, recent lava flows, or large rock outcrops) characterized by temperate, including Mediterranean, and boreal cryptogam and lithophilic growth forms, including saxicolous *lichens, bryophytes, algae*, and/or *ferns* and other pteridophytes. Tree growth forms typically have less than 10 percent cover, are very sparse; woody growth forms, when present, include cold-deciduous broad-leaved and needle-leaved trees and shrubs.

Classification Comments: There is little information that has been comprehensively evaluated across the globe, making it difficult to describe the type concept. We tentatively include cliff and slope sites with hardpacked sedimentary rocks and clays (badlands) within this class. More work is needed to clarify the distinctions between rock vegetation and other sparsely vegetated habitats where rocky substrates are dominant and lichen vegetation is absent, such as scree or volcanic cinders. For example, many rocky river and lake shoreline types may be placed in *2.B.4 Temperate to Polar Scrub & Herb Coastal Vegetation Formation (F005)* where vegetation is patchy but may exceed 10 percent.

Further review may suggest that this subclass can be improved by distinguishing the less "rocklike" vegetation (including vegetation on scree, badlands, pavement) from the true open consolidated rock vegetation (C. Lea pers. comm. 2012). Scree and other loose rocky substrates (volcanic cinders), where the median particle size is greater than 10 cm in diameter, typically have enough soil development to support a dominant layer of disturbance-adapted, facultative mesomorphic shrubs and/or herbs (e.g., in the United States, *Ribes* spp., *Prunus virginiana*, and other forest, woodland, or shrubland shrubs in the central Rockies), and true lithomorphs (saxicolous lichens) are quite sparse, if present at all. Although the surface may be "rocky," the driving ecological factor is the availability of soil in quantity under the relatively shallow rock armoring and the absence of large, stable substrates for lithomorphs (saxicolous lichens) to establish. Cobbles along rivers and streams may also not typically support lithomorphic or open rock growth forms, and may best be treated as sometimes sparse flooded types within mesomorphic formations. Badlands (hard clays) and desert pavements also tend to support facultative vascular species, as opposed to cryptogams, and could be considered for the xeromorphic class. Given this narrower definition of lithomorphic or open rock vegetation, a requirement for less than 10 percent vascular cover and nonvascular cover greater than vascular cover would be more appropriate for distinguishing the "true" lithomorphic types, and separate out sparse or occasionally sparse types (scree, volcanic cinders) in which vascular layers are clearly dominant and lithomorphic nonvascular is insignificant (C. Lea pers. comm. 2012).

Similar NVC Types:

2.B. Temperate & Boreal Grassland & Shrubland (S18): Many rocky river and lake shoreline types are placed in *2.B.4 Temperate to Polar Scrub & Herb Coastal Vegetation Formation (F005)* where vegetation may be patchy but can exceed 10 percent.

6.A. Tropical Open Rock Vegetation (S02): Subtropical cliffs may resemble warm-temperate cliffs.

Diagnostic Characteristics: Rocky or rocklike substrates dominated by cryptogam species, including *lichens* (especially foliose and crustose *lichens*), *bryophytes, algae*, and rupicolous mesomorphic vascular plants, often with a strong component of *ferns* and other pteridophytes. Vascular vegetation is typically less than 10 percent cover, and may include either evergreen needle-leaved or cold-deciduous broad-leaved trees or shrubs. Vegetation structure may be patchy across the rocky surfaces.

Vegetation

Physiognomy and Structure: Stands typically contain a covering of saxicolous foliose and/or crustose lichens growing directly on rock surfaces and/or sparse covering of vascular plants growing in soil pockets. Vascular and nonvascular plant cover is greater than 1 percent; vascular plant cover is typically less than 10 percent, with irregular horizontal spacing, and is typically exceeded by nonvascular cover, especially lichens, bryophytes, and/or algae. A sparse cover of vascular mesomorphic growth forms, including evergreen needle-leaved or cold-deciduous broad-leaved woody plants, may be present. Herbs are often seasonally green.

Environment

Environmental Description: This vegetation occurs on large relatively stable rocky habitats, such as cliffs, talus, recent lava flows, or rock outcrops, at low to moderate elevations. On stable rock surfaces (e.g., outcrops), vascular plant roots are prevented from penetrating most of the substrate, and their presence is largely determined by the rock fissures, where minimal soil development and more moisture occurs. On less stable rocky surfaces (e.g., talus), the presence of vascular plants is largely determined by a degree of permanence and depth to soil under the boulders. Low-elevation temperate and boreal climates are various, often less determinative than presence of open rock surfaces. Substrates are typically very dry to moist, but occasionally wet and typically lack soil development of any kind. The climate is cool and warm temperate, Mediterranean, and to boreal, and even subarctic, where frosts occur regularly (except in part of the Mediterranean region), snow is not permanent, and there are strong daily and seasonal temperature changes. The median particle size is greater than 10 cm in diameter.

Distribution

Geographic Range: Temperate & Boreal Open Rock Vegetation is found in localized areas throughout the mid-latitudes from 23 to 70 degrees N or S around the globe.

Citations

Synonymy:

= Cliff, bluffs and rock outcrops (Wardle 1991) [Wardle's concept is applied to New Zealand.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen 2012)

Author of Description: D. Faber-Langendoen and J. Sawyer

Acknowledgments:

Version Date: 26 Aug 2014

6.B.1. Temperate & Boreal Cliff, Scree & Other Rock Vegetation (F034)

Overview

Database Code: 6.B.1 (F034)

Scientific Name: Temperate & Boreal Cliff, Scree & Other Rock Vegetation Formation

Common Name (Translated Scientific Name): Temperate & Boreal Cliff, Scree & Other Rock Vegetation Formation

Colloquial Name: Temperate & Boreal Cliff, Scree & Other Rock Vegetation

Hierarchy Level: Formation

Placement in Hierarchy: 6.B. Temperate & Boreal Open Rock Vegetation (S04)

Lower Level Hierarchy Units:

See examples in Appendix J

Concept Summary

Type Concept Sentence: Vegetation in temperate and boreal habitats found in rocky or rocklike habitats (such as cliffs, talus, scree, pavement, cobbles, lava, boulderfields, or badlands) at low elevations at mid latitudes around the globe characterized by nonvascular plant growth forms that have structural adaptations for living on stable rock surfaces or in unstable rocky substrates. A sparse cover of vascular mesomorphic growth forms, including needle-leaved and cold deciduous broad-leaved woody plants, may be present.

Classification Comments: Mediterranean rock vegetation is included here with temperate rock vegetation. We suggest that cliff and slope sites with hardpacked sedimentary rocks and clays (badlands) be included in this class. More work is needed to clarify the distinctions between rock vegetation and other sparsely vegetated habitats where rocky substrates are dominant and lichen vegetation is absent. For example, many rocky river and lake shoreline types may be placed in *2.B.4 Temperate to Polar Scrub & Herb Coastal Vegetation Formation (F005)* where vegetation is patchy but may exceed 10 percent.

The term scree is used broadly to include talus. Talus may be the preferred term for lower elevation habitats, where a variety of geological factors are at work, whereas scree may be the preferred term for high elevation or polar habitats where frost action is the driving factor in producing the rocky habitat. Colloquially, in the western United States, and as used here, scree generally refers to smaller particle, looser, rock debris, and is often mixed with soil, whereas talus generally refers to larger, more stable particles, with little surface soil. Scree may be somewhat more abundant in high montane settings (perhaps because of more pronounced freeze-thaw cycles and weathering of rock), but both can be found at all elevations and latitudes.

Currently, vascular plant cover includes *ferns* (non-woody, including clubmosses, etc.) and crevice-dwelling (rupicolous) vascular plants. Consideration could be given to excluding these from the vascular species cover estimates.

More work is needed to separate rock vegetation from very sparsely vegetated habitats dominated by rocky substrates where lichen vegetation is absent. Placement of rocky river and lake shoreline types needs review. **Similar NVC Types:**

6.A.1. Tropical Cliff, Scree & Other Rock Vegetation (F011): Warm temperate cliffs within the temperate & boreal cliff formation (F034) contain subtropical-like cliff features similar to tropical cliffs (F011).

Diagnostic Characteristics: Rocky or rocklike substrates dominated by cryptogam growth forms, including *lichen* (especially foliose and crustose *lichens*), *bryophyte*, and *alga,* and lithophilic or rupicolous vascular plants, often with a strong component of *ferns* and other pteridophytes. Vascular vegetation is typically <10 percent cover, and may include mesomorphic vegetation, such as evergreen needle-leaved or cold-deciduous broad-leaved trees or shrubs. Vegetation structure may be patchy.

Vegetation

Physiognomy and Structure: Stands typically contain a covering of saxicolous foliose and/or crustose lichens growing directly on rock surfaces, and/or sparse covering of vascular plants growing in soil pockets. Vascular and nonvascular plant cover is greater than 1 percent; vascular plant cover is typically less than 10 percent, with irregular horizontal spacing, and is typically exceeded by nonvascular cover, especially lichens, bryophytes, and/or algae. The vascular woody growth forms are a mix of evergreen needle-leaved or cold-deciduous broad-leaved trees and shrubs.

Environment

Environmental Description: Stable rock surfaces (e.g., outcrops) prevent vascular plant roots from penetrating most of the substrate, and their presence is largely determined by the rock fissures, where minimal soil development and more moisture occurs. On less stable rocky surfaces (e.g., talus), the presence of vascular plants is largely determined by a degree of permanence, and depth to soil under the boulders. The low-elevation climates are temperate or boreal (excluding Mediterranean ones), where there are strong daily temperate changes and even greater seasonal variations. These climates, though, are often less determinative than presence of open rock surfaces. Substrates are typically very dry to moist, but occasionally wet, and typically lack soil development of any kind.

Distribution

Geographic Range: Temperate & Boreal Cliff, Scree & Other Rock Vegetation is found in localized low elevations throughout the temperate and boreal region (including the Mediterranean region) of the mid-latitudes from 23 or 70 degrees N or S.

Citations

Synonymy:

< Cliff, bluffs and rock outcrops (Wardle 1991) [Wardle's concept is applied through New Zealand, including both alpine and temperate regions.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen and J. Sawyer

Acknowledgments:

Version Date: 26 Aug 2014

7. Agricultural & Developed Vegetation (CCL01)

Overview

Database Code: 7 (CCL01)
Scientific Name: Anthromorphic Vegetation Class
Common Name (Translated Scientific Name): Anthromorphic Vegetation Class
Colloquial Name: Agricultural & Developed Vegetation
Hierarchy Level: Cultural Class
Lower Level Hierarchy Units:
7.A. Woody Agricultural Vegetation (CSC01)
7.B. Herbaceous Agricultural Vegetation (CSC02)
7.C. Herbaceous & Woody Developed Vegetation (CSC03)
7.D. Agricultural & Developed Aquatic Vegetation (CSC04)

Concept Summary

Type Concept Sentence: Vegetation of agricultural lands, including row crops, intensive pastures, orchards, vineyards, plowed or harvested fallow fields, rice paddies, and farm ponds, and vegetation of developed lands, including urban, suburban and rural cities and villages, typically lawns, parks, horticultural gardens, golf courses, and urban ponds.

Classification Comments: Although this is a somewhat "bulky" class in terms of structural variation (including tree, shrub and herbaceous stands), they largely intergrade based on human manipulation, and the subclasses jointly cross ecological gradients. Thus, ecologically, it appears most helpful to group them initially into a single class. It is important to conceptually separate this class of planted and cultivated vegetation (such as intensive short-rotation pine plantations) from natural/semi-natural vegetation (such as successional and natural pine communities, or restoration pine plantings or long-rotation pine plantations where the understory is largely controlled by natural processes) because of the distinctive growth forms, species, ecology, biogeographic patterns (or lack thereof) and degree of human manipulation; this is best done by explicitly accounting for this distinctive vegetation in this class.

If mesomorphic tree growth forms are greater than 10 percent in canopy and at least of minor importance in the regeneration layer, stands may better fit *1. Forest & Woodland Class (C01)*, whereas, if the forests may have an irregular tree canopy but a highly regular or mowed understory, such as in urban parks and lawns, they better fit with developed vegetation.

Agricultural orchards have a very regularly spaced tree canopy (often pruned or trained), with a plowed, mowed, or hayed ground layer.

Urban and agricultural ponds typically have a highly managed growth form composition, regulated water levels, and hardened, human-created shorelines.

Separation of agricultural and developed vegetation based on anthropogenic processes from vegetation formed under natural processes is parallel to that proposed in soil taxonomy, where the need for separation of soils altered by humans over centuries has been proposed (Bryant and Galbraith 2003). Several national soil systems, such as that for China (Zitong and others 2003), and international systems, such as the FAO (1988, in Di Gregorio 2005), already recognize a new soil order, Anthrosols, and Bryant and Galbraith (2003) suggest that the U.S. system should do the same.

Similar NVC Types:

1. *Forest & Woodland (C01)*: Where mesomorphic tree growth forms are greater than 10 percent in canopy, and are irregular in structure in the understory (i.e., natural processes occur for tree saplings, seedlings, herbs and shrubs), stands may better fit here (e.g., tree plantations where the ground layer is not managed or eliminated).
2. *Shrub & Herb Vegetation (C02)*: Where mesomorphic shrub and herb growth forms are irregular in structure (i.e., natural processes occur for tree seedlings, herbs and shrubs), stands may better fit here (e.g., pastures where non-intensive grazing of livestock on native or introduced grasslands).
5. *Aquatic Vegetation (C05)*: Farm and urban ponds that are not regularly managed may contain a native set of growth forms and species that place them in this class.

Diagnostic Characteristics: Agricultural vegetation often has a very regularly horizontally spaced tree, shrub or herb canopy, with the ground layer subject to annual plowing, planting, pruning, haying, sometimes coupled with flooding (e.g., rice paddies). Developed vegetation may have a regular or irregularly spaced canopy layer, but always has a highly regular ground layer, typically caused by annual, often frequent, mowing or clipping, or essentially absent and replaced by pavement.

Vegetation

Physiognomy and Structure: *Growth Forms*: Agricultural stands are dominated by tree, shrub, and herb growth forms, sometimes with distinctive cultural forms (vineyards, orchard trees, rice paddies). No growth forms *per se* have been described that are specific to agricultural vegetation. Developed stands are dominated by a wide variety of growth forms, but herb and shrub growth forms are often most characteristic, used to create lawns and gardens, with annuals, bulbs, or perennial rooted plants. FGDC (2008) does not provide guidance on cultural growth forms.

Structure: Agricultural vegetation structure is very open to closed, typically with very regular horizontal spacing and regularly manipulated heights; with some or all of the plant parts being harvested, often on an annual or more frequent basis. A tree sapling or seedling layer is typically absent under the canopy (e.g., vineyards, orchards). Vegetation typically has greater than 10 percent cover, but completely bare or flooded surfaces are possible for short durations (e.g., plowed fields, rice paddies). Developed vegetation is typically closed, with regular or irregular horizontal spacing and height, often closely mown on a regular basis (resulting in uniform, short heights (<0.1 m), or the vegetation pattern is irregular, but highly regulated (e.g., flower gardens). Vegetation cover typically is greater than 10 percent, but completely bare surfaces are possible for short durations.

Environment

Environmental Description: *Climate:* Found in all climatic domains, most common in non-arid climates.

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:

< Agricultural Land (Anderson and others 1976)

>< Cultivated Aquatic or Regularly Flooded Areas (Di Gregorio 2005) [This type is restricted to only wetland vegetation, but includes both agricultural and developed vegetation.]

>< Cultivated and Managed Terrestrial Areas (Di Gregorio 2005) [This type is restricted to only upland vegetation, but includes both agricultural and developed vegetation.]

>< Urban or Builtup Land (17. Other Urban or Build Up Land) (Anderson and others 1976) [Anderson includes both non-vegetated and vegetated urban lands in this class, but subclass 17 covers the more extensive developed vegetation types.]

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen, G. Fults, and T. Keeler-Wolf

Acknowledgments:

Version Date: 26 Aug 2014

7.A. Woody Agricultural Vegetation (CSC01)

Overview

Database Code: 7.A (CSC01)

Scientific Name: Woody Agricultural Vegetation Subclass

Common Name (Translated Scientific Name): Woody Agricultural Vegetation Subclass

Colloquial Name: Woody Agricultural Vegetation

Hierarchy Level: Cultural Subclass

Placement in Hierarchy: 7. Agricultural & Developed Vegetation (CCL01)

Lower Level Hierarchy Units:

7.A.1. Woody Horticultural Crop (CFO01)

7.A.2. Forest Plantation & Agroforestry (CFO02)

7.A.3. Woody Wetland Horticultural Crop (CFO03)

Concept Summary

Type Concept Sentence: Agricultural crops dominated by shrub and tree vegetation, including orchards, vineyards, woody berry crops, intensive (often short-rotation) forest plantations, various agroforestry woody crops, and woody wetland crops, such as cranberries.

Similar NVC Types:

1.A. Tropical Forest & Woodland (S17): Long-rotation plantations or woody restoration plantings with an irregular structure and a largely spontaneous ground layer may initially be similar in their early stages of development, especially if planted in rows and the understory is strongly manipulated.

1.B. Temperate & Boreal Forest & Woodland (S15): Long-rotation plantations or woody restoration plantings with an irregular structure and a largely spontaneous ground layer may initially be similar in their early stages of development, especially if planted in rows and the understory is strongly manipulated.

7.B. Herbaceous Agricultural Vegetation (CSC02).

7.C. Herbaceous & Woody Developed Vegetation (CSC03).

7.D. Agricultural & Developed Aquatic Vegetation (CSC04): Some urban ponds with woody vegetation may be similar to 7.A.

Vegetation

Physiognomy and Structure: Agricultural crops dominated by shrub and tree vegetation, including orchards, vineyards, woody berry crops, intensive (often short-rotation) forest plantations, various agroforestry woody crops, and woody wetland crops, such as cranberries.

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

7.A.1. Woody Horticultural Crop (CFO01)

Overview

Database Code: 7.A.1 (CFO01)

Scientific Name: Woody Horticultural Crop Formation

Common Name (Translated Scientific Name): Woody Horticultural Crop Formation

Colloquial Name: Woody Horticultural Crop

Hierarchy Level: Cultural Formation

Placement in Hierarchy: 7.A. Woody Agricultural Vegetation (CSC01)

Concept Summary

Type Concept Sentence: Agricultural crops dominated by shrub and tree vegetation, including orchards, vineyards, and woody berry crops.

Similar NVC Types:

7.A.2. Forest Plantation & Agroforestry (CFO02).

Diagnostic Characteristics: Typically found as row crops, often in monocultures.

Vegetation

Physiognomy and Structure: Agricultural crops dominated by shrub and tree vegetation, including orchards, vineyards, and woody berry crops.

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

7.A.2. Forest Plantation & Agroforestry (CFO02)

Overview

Database Code: 7.A.2 (CFO02)

Scientific Name: Forest Plantation & Agroforestry Formation

Common Name (Translated Scientific Name): Forest Plantation & Agroforestry Formation

Colloquial Name: Forest Plantation & Agroforestry

Hierarchy Level: Cultural Formation

Placement in Hierarchy: 7.A. Woody Agricultural Vegetation (CSC01)

Concept Summary

Type Concept Sentence: Agricultural crops dominated by intensive (often short-rotation) forest plantations and various agroforestry woody crops.

Classification Comments: Long-rotation plantations or woody restoration plantings with an irregular structure and a largely spontaneous ground layer are placed in *1.A Tropical Forest & Woodland Subclass (S17)* or *1.B. Temperate & Boreal Forest & Woodland Subclass (S15)* as the vegetation structure and composition may be largely native or naturalized. But in their early stages of development, especially if planted in rows and the understory is strongly manipulated, they may better fit within this class.

Similar NVC Types:

1.A.1. Tropical Dry Forest & Woodland (F003): Long-rotation plantations or woody restoration plantings with an irregular structure and a largely spontaneous ground layer may initially be similar in their early stages of development, especially if planted in rows and the understory is strongly manipulated.

1.B.2. Cool Temperate Forest & Woodland (F008): Long-rotation plantations or woody restoration plantings with an irregular structure and a largely spontaneous ground layer may initially be similar in their early stages of development, especially if planted in rows and the understory is strongly manipulated.

1.B.4. Boreal Forest & Woodland (F001): Long-rotation plantations or woody restoration plantings with an irregular structure and a largely spontaneous ground layer may initially be similar in their early stages of development, especially if planted in rows and the understory is strongly manipulated.

7.A.1. Woody Horticultural Crop (CFO01).

Vegetation

Physiognomy and Structure: Agricultural crops dominated by intensive (often short-rotation) forest plantations and various agroforestry woody crops.

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen
Acknowledgments:
Version Date: 26 Aug 2014

7.A.3. Woody Wetland Horticultural Crop (CFO03)

Overview

Database Code: 7.A.3 (CFO03)
Scientific Name: Woody Wetland Horticultural Crop Formation
Common Name (Translated Scientific Name): Woody Wetland Horticultural Crop Formation
Colloquial Name: Woody Wetland Horticultural Crop
Hierarchy Level: Cultural Formation
Placement in Hierarchy: 7.A. Woody Agricultural Vegetation (CCL01)

Concept Summary

Type Concept Sentence: Agricultural crops dominated by woody wetland crops, such as cranberries.

Classification Comments: There may be planted wetland tree crops that may also be placed here, though if they are intensive tree plantations, they may preferably be placed in *7.A.2 Intensive Forestry Plantation & Agroforestry Crop Formation (F043)*.

Vegetation

Physiognomy and Structure: Agricultural crops dominated by woody wetland crops, such as cranberries.

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen
Acknowledgments:
Version Date: 26 Aug 2014

7.B. Herbaceous Agricultural Vegetation (CSC02)

Overview

Database Code: 7.B (CSC02)

Scientific Name: Herbaceous Agricultural Vegetation Subclass

Common Name (Translated Scientific Name): Herbaceous Agricultural Vegetation Subclass

Colloquial Name: Herbaceous Agricultural Vegetation

Hierarchy Level: Cultural Subclass

Placement in Hierarchy: 7. Agricultural & Developed Vegetation (CCL01)

Lower Level Hierarchy Units:

7.B.1. Row & Close Grain Crop (CFO04)

7.B.2. Pasture & Hay Field Crop (CFO05)

7.B.3. Herbaceous Horticultural Crop (CFO06)

7.B.4. Fallow Field & Weed Vegetation (CFO07)

7.B.5. Herbaceous Wetland Crop (CFO08)

Concept Summary

Type Concept Sentence: Agricultural vegetation, including row crops, planted grain crops, pastures, hayfields, horticultural crops (such as commercial flower operations), fallow fields and early successional weed fields, and wetland rice and taro crop fields.

Similar NVC Types:

7.A. Woody Agricultural Vegetation (CCL01).

7.C. Herbaceous & Woody Developed Vegetation (CSC03): Residential vegetable gardens overlap with 7.B.

Vegetation

Physiognomy and Structure: Agricultural vegetation, including row crops, planted grain crops, pastures, hayfields, horticultural crops (such as commercial flower operations), fallow fields and early successional weed fields, and wetland rice and taro crop fields.

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

7.B.1. Row & Close Grain Crop (CFO04)

Overview

Database Code: 7.B.1 (CFO04)

Scientific Name: Row & Close Grain Crop Formation

Common Name (Translated Scientific Name): Row & Close Grain Crop Formation

Colloquial Name: Row & Close Grain Crop

Hierarchy Level: Cultural Formation

Placement in Hierarchy: 7.B. Herbaceous Agricultural Vegetation (CSC02)

Concept Summary

Type Concept Sentence: Agricultural vegetation, including row crops, such as corn, soybeans, cotton, tobacco, sunflowers, a wide variety of vegetables, and some planted grain crops (annual rye, wheat).

Classification Comments: Some planted grain crops, such as annual rye or wheat are more akin to row crops than to hay or pasture and so they are placed here, rather than in *7.B.2 Pasture & Hay Field Crop Formation (CFO05)*.

Vegetation

Physiognomy and Structure: Agricultural vegetation, including row crops, such as corn, soybeans, cotton, tobacco, sunflowers, a wide variety of vegetables, and some planted grain crops (annual rye, wheat).

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

7.B.2. Pasture &Hay Field Crop (CFO05)

Overview

Database Code: 7.B.2 (CFO05)

Scientific Name: Pasture & Hay Field Crop Formation

Common Name (Translated Scientific Name): Pasture & Hay Field Crop Formation

Colloquial Name: Pasture & Hay Field

Hierarchy Level: Cultural Formation

Placement in Hierarchy: 7.B. Herbaceous Agricultural Vegetation (CSC02)

Concept Summary

Type Concept Sentence: Agricultural vegetation, including pastures and hayfields, often regularly mowed, fertilized, intensively grazed, and/or manipulated to maintain a particular desirable structure and composition.

Classification Comments: Agricultural pastures and hayfields differ from native or naturalized grasslands in the degree to which both structure and composition are manipulated through regular mowing, fertilization, intensive grazing, and other practices. These modifications to structure and composition provide distinctive vegetation characteristics as compared to native or natural grasslands. If agricultural practices are discontinued, native and exotic species from the surrounding landscape may establish and the field will become more "semi-natural." Where this occurs, the vegetation is reclassified as a native or naturalized "old-field" [see *2.A Tropical Grassland, Savanna & Shrubland Subclass (S01)* or *2.B Temperate & Boreal Grassland & Shrubland Subclass (S18*].

Some planted grain crops, such as annual rye or wheat, are more akin to row crops than to hay or pasture and so they are placed in *7.B.1 Row & Close Grain Crop Formation (CFO04)*.

Similar NVC Types:

2.A.1. Tropical Lowland Grassland, Savanna & Shrubland (F019): Pastures may overlap in composition with native grasslands, particularly in grassland regions. In regions where a pastoral tradition has existed from hundreds to thousands of years, recognition of native versus agricultural grasslands may be challenging.

2.B.2. Temperate Grassland & Shrubland (F012): Pastures may overlap in composition with native grasslands, particularly in grassland regions. In regions where a pastoral tradition has existed from hundreds to thousands of years, recognition of native versus agricultural grasslands may be challenging.

Vegetation

Physiognomy and Structure: Agricultural vegetation, including pastures and hayfields, often regularly mowed, fertilized, intensively grazed, and/or manipulated to maintain a particular desirable structure and composition.

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

7.B.3. Herbaceous Horticultural Crop (CFO06)

Overview

Database Code: 7.B.3 (CFO06)

Scientific Name: Herbaceous Horticultural Crop Formation

Common Name (Translated Scientific Name): Herbaceous Horticultural Crop Formation

Colloquial Name: Herbaceous Horticultural Crop
Hierarchy Level: Cultural Formation
Placement in Hierarchy: 7.B. Herbaceous Agricultural Vegetation (CSC02)

Concept Summary

Type Concept Sentence: Agricultural vegetation, including horticultural crops (such as commercial flower operations).

Vegetation

Physiognomy and Structure: Agricultural vegetation, including horticultural crops (such as commercial flower operations).

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen
Acknowledgments:
Version Date: 26 Aug 2014

7.B.4. Fallow Field & Weed Vegetation (CFO07)

Overview

Database Code: 7.B.4 (CFO07)
Scientific Name: Fallow Field & Weed Vegetation Formation
Common Name (Translated Scientific Name): Fallow Field & Weed Vegetation Formation
Colloquial Name: Fallow Field & Weed Vegetation
Hierarchy Level: Cultural Formation
Placement in Hierarchy: 7.B. Herbaceous Agricultural Vegetation (CSC02)

Concept Summary

Type Concept Sentence: Agricultural vegetation, fallow fields and early successional weed fields.

Vegetation

Physiognomy and Structure: Agricultural vegetation, fallow fields and early successional weed fields.

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

7.B.5. Herbaceous Wetland Crop (CFO08)

Overview

Database Code: 7.B.5 (CFO08)

Scientific Name: Herbaceous Wetland Crop Formation

Common Name (Translated Scientific Name): Herbaceous Wetland Crop Formation

Colloquial Name: Herbaceous Wetland Crop

Hierarchy Level: Cultural Formation

Placement in Hierarchy: 7.B. Herbaceous Agricultural Vegetation (CSC02)

Concept Summary

Type Concept Sentence: Agricultural wetland vegetation, such as wetland rice and taro crop fields.

Vegetation

Physiognomy and Structure: Agricultural wetland vegetation, such as wetland rice and taro crop fields.

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

7.C. Herbaceous & Woody Developed Vegetation (CSC03)

Overview

Database Code: 7.C (CSC03)

Scientific Name: Herbaceous & Woody Developed Vegetation Subclass

Common Name (Translated Scientific Name): Herbaceous & Woody Developed Vegetation Subclass

Colloquial Name: Herbaceous & Woody Developed Vegetation

Hierarchy Level: Cultural Subclass

Placement in Hierarchy: 7. Agricultural & Developed Vegetation (CCL01)

Lower Level Hierarchy Units:

7.C.1. Lawn & Recreational Vegetation (CFO09)
7.C.2. Horticultural Garden Vegetation (F041)
7.C.3. Open Developed Vegetation (CFO10)
7.C.4. Developed Wetland Vegetation (CFO11)

Concept Summary

Type Concept Sentence: Vegetation includes closely cropped vegetation such as lawns, gardens, sports fields, and golf courses, as well as vegetation growing in urban materials, such as pavement, from dry lands to emergent wetlands. Tree canopy varies from 0 to 100 percent (e.g., open to shaded lawns and gardens).

Similar NVC Types:

5.B. Freshwater Aquatic Vegetation (S13).

7.A. Woody Agricultural Vegetation (CCL01).

7.B. Herbaceous Agricultural Vegetation (CSC02): Herbaceous & Woody Developed Vegetation (CSC03) contains residential vegetable gardens that overlap with Herbaceous Agricultural Vegetation (CSC02).

Vegetation

Physiognomy and Structure: Vegetation includes closely cropped vegetation such as lawns, gardens, sports fields, and golf courses, as well as vegetation growing in urban materials, such as pavement, from dry lands to emergent wetlands. Tree canopy varies from 0 to 100 percent (e.g., open to shaded lawns and gardens).

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen
Acknowledgments:
Version Date: 26 Aug 2014

7.C.1. Lawn, Garden & Recreational Vegetation (CFO09)

Overview

Database Code: 7.C.1 (CFO09)
Scientific Name: Lawn & Recreational Vegetation Formation
Common Name (Translated Scientific Name): Lawn & Recreational Vegetation Formation
Colloquial Name: Lawn & Recreational Vegetation
Hierarchy Level: Cultural Formation
Placement in Hierarchy: 7.C. Herbaceous & Woody Developed Vegetation (CSC03)

Concept Summary

Type Concept Sentence: Vegetation includes closely cropped vegetation such as lawns, gardens, sports fields, and golf courses, as well as gardens. Tree canopy varies from 0 to 100 percent (e.g., open to shaded lawns and gardens).

Vegetation

Physiognomy and Structure: Vegetation includes closely cropped vegetation such as lawns, gardens, sports fields, and golf courses, as well as gardens. Tree canopy varies from 0 to 100 percent (e.g., open to shaded lawns and gardens).

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

7.C.2. Other Developed Vegetation (CFO10)

Overview

Database Code: 7.C.2 (CFO10)

Scientific Name: Other Developed Vegetation Formation

Common Name (Translated Scientific Name): Other Developed Vegetation Formation

Colloquial Name: Other Developed Vegetation

Hierarchy Level: Cultural Formation

Concept Summary

Type Concept Sentence: Other Developed vegetation includes vegetation growing in urban materials, such as pavement. Tree canopy varies from 0 to 100 percent (e.g., open to shaded weed vegetation in pavement cracks).

Vegetation

Physiognomy and Structure: Other Developed vegetation includes vegetation growing in urban materials, such as pavement. Tree canopy varies from 0 to 100 percent (e.g., open to shaded weed vegetation in pavement cracks).

Distribution

Geographic Range: Widely distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen
Acknowledgments:
Version Date: 26 Aug 2014

7.C.3. Developed Wetland Vegetation (CFO11)

Overview

Database Code: 7.C.3 (CFO11)
Scientific Name: Developed Wetland Vegetation Formation
Common Name (Translated Scientific Name): Developed Wetland Vegetation Formation
Colloquial Name: Developed Wetland Vegetation
Hierarchy Level: Cultural Formation
Placement in Hierarchy: 7.C. Herbaceous & Woody Developed Vegetation (CSC03)

Concept Summary

Type Concept Sentence: Very uncommon vegetation that includes urban, suburban and rural planted and managed emergent and woody wetlands, such as small urban ponds with emergent vegetation. Tree canopy can vary from 0 to 100 percent (e.g., open to shaded planted wetlands).

Classification Comments: Type is very uncommon and concept needs review. Emergent and woody wetlands are typically natural to semi-natural.

Vegetation

Physiognomy and Structure: Vegetation includes urban, suburban and rural planted and managed emergent and woody wetlands, such as small urban ponds with emergent vegetation. Tree canopy can vary from 0 to 100 percent (e.g., open to shaded planted wetlands).

Distribution

Geographic Range: Localized across the globe, except in very dry or very cold regions.

Citations

Synonymy:
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen
Acknowledgments:
Version Date: 26 Aug 2014

7.D. Agricultural & Developed Aquatic Vegetation (CSC04)

Overview

Database Code: 7.D (CSC04)
Scientific Name: Agricultural & Developed Aquatic Vegetation Subclass
Common Name (Translated Scientific Name): Agricultural & Developed Aquatic

Vegetation Subclass

Colloquial Name: Agricultural & Developed Aquatic Vegetation

Hierarchy Level: Cultural Subclass

Placement in Hierarchy: 7. Agricultural & Developed Vegetation (CCL01)

Lower Level Hierarchy Units:

7.D.1. Agricultural Aquatic Vegetation (CFO12)

7.D.2. Developed Aquatic Vegetation (CFO13)

Concept Summary

Type Concept Sentence: Floating and submerged vegetation found in managed agricultural and developed sites, such as farm ponds, urban ponds, and other open water sites in urban, suburban, and rural settings.

Classification Comments: Agricultural and developed aquatic vegetation that is not regularly managed may contain a native or naturalized set of growth forms and species that places it in 5.B Freshwater Aquatic Vegetation Subclass (S13).

Similar NVC Types:

5.B. Freshwater Aquatic Vegetation (S13).

7.A. Woody Agricultural Vegetation (CCL01): Agricultural & Developed Aquatic Vegetation (CFO12) contains urban ponds with woody vegetation that may be similar to Woody Agricultural Vegetation (CCL01).

Vegetation

Physiognomy and Structure: Floating and submerged vegetation found in managed agricultural and developed sites, such as farm ponds, urban ponds, and other open water sites in urban, suburban, and rural settings.

Environment

Environmental Description: Typical habitats include farm ponds, urban ponds, and other open water sites in urban, suburban, and rural settings.

Distribution

Geographic Range: Patchily distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

7.D.1. Agricultural Aquatic Vegetation (CFO12)

Overview

Database Code: 7.D.1 (CFO12)

Scientific Name: Agricultural Aquatic Vegetation Formation

Common Name (Translated Scientific Name): Agricultural Aquatic Vegetation Formation

Colloquial Name: Agricultural Aquatic Vegetation
Hierarchy Level: Cultural Formation
Placement in Hierarchy: 7.D. Agricultural & Developed Aquatic Vegetation (CSC04)

Concept Summary

Type Concept Sentence: Floating and submerged vegetation found in managed agricultural sites, such as farm ponds.

Classification Comments: Agricultural aquatic vegetation that is not regularly managed may contain a native or naturalized set of growth forms and species that places it in *5.B Freshwater Aquatic Vegetation Subclass (S13)*.

Similar NVC Types:

5.B.1. Tropical Freshwater Aquatic Vegetation (F056): Although in some cases there may be difficulty distinguishing natural from agricultural ponds, in the large majority of cases, they are distinct in ecological setting, edges, and in composition.

5.B.2. Temperate to Polar Freshwater Aquatic Vegetation (F057): Although in some cases there may be difficulty distinguishing natural from agricultural ponds, in the large majority of cases, they are distinct in ecological setting, edges, and in composition.

7.D.2. Developed Aquatic Vegetation (CFO13).

Diagnostic Characteristics: Agricultural aquatic vegetation typically has a highly managed growth form composition, regulated water levels, and hardened, human-created shorelines.

Vegetation

Physiognomy and Structure: Floating and submerged vegetation found in managed agricultural sites, such as farm ponds.

Environment

Environmental Description: Commonly found in agricultural aquatic sites, such as farm ponds.

Distribution

Geographic Range: Patchily distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:
Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012Faber-Langendoen and others 2012)
Author of Description: D. Faber-Langendoen
Acknowledgments:
Version Date: 26 Aug 2014

7.D.2. Developed Aquatic Vegetation (CFO13)

Overview

Database Code: 7.D.2 (CFO13)

Scientific Name: Developed Aquatic Vegetation Formation

Common Name (Translated Scientific Name): Developed Aquatic Vegetation Formation

Colloquial Name: Developed Aquatic Vegetation

Hierarchy Level: Cultural Formation

Placement in Hierarchy: 7.D. Agricultural & Developed Aquatic Vegetation (CSC04)

Concept Summary

Type Concept Sentence: Floating and submerged vegetation found in managed developed sites, such as urban ponds.

Classification Comments: Developed aquatic vegetation sites that are not regularly managed may contain a native or naturalized set of growth forms and species in which case the vegetation is placed in *5.B Freshwater Aquatic Vegetation Subclass (S13)*.

Similar NVC Types:

5.B.1. Tropical Freshwater Aquatic Vegetation (F056): Although in some cases there may be difficulty distinguishing natural from urban ponds, in the large majority of cases, they are distinct in ecological setting, edges, and in composition.

5.B.2. Temperate to Polar Freshwater Aquatic Vegetation (F057): Although in some cases there may be difficulty distinguishing natural from urban ponds, in the large majority of cases, they are distinct in ecological setting, edges, and in composition.

7.D.1. Agricultural Aquatic Vegetation (CFO12).

Vegetation

Physiognomy and Structure: Floating and submerged vegetation found in managed developed sites.

Environment

Environmental Description: The vegetation can be found in urban ponds, and other open water sites in urban, suburban and rural settings.

Distribution

Geographic Range: Patchily distributed across the globe, except in very dry or very cold regions.

Citations

Synonymy:

Primary Concept Source: Hierarchy Revisions Working Group, Federal Geographic Data Committee (Faber-Langendoen and others 2012)

Author of Description: D. Faber-Langendoen

Acknowledgments:

Version Date: 26 Aug 2014

References

Anderson, J. R., E. E. Hardy, J. T. Roach, and R. E. Witmer. 1976. A land use and land cover classification system for use with remote sensor data. Professional Paper No. 964. U.S. Department of the Interior, Geological Survey, Washington, DC. 26 pp.

Bailey, R. G. 1989. Explanatory supplement to ecoregions map of the continents. Environmental Conservation 16: 307–309.

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

Barbour, M. G. 1992. Life at the leading edge: The beach plant syndrome. Pages 291-307 in: U. Seeliger, eds. Coastal plant communities of Latin America. Academic Press, Inc., New York.

Barbour, M. G., T. Keeler-Wolf, and A. A. Schoenherr, editors. 2007. Terrestrial vegetation of California. Third edition. University of California Press, Berkeley.

Beard, J. S. 1973. The physiognomic approach. Pages 355–386 in: R. H. Whittaker, ed. Handbook of vegetation science. Part V. Ordination and classification of communities. W. Junk, The Hague, Netherlands.

Belnap, J., and O. L. Lange, editors. 2003. Biological soil crusts: Structure, function, and management. Second edition. Springer-Verlag, Berlin.

Billings, W. D. 2000. Alpine vegetation of North America. Pages 537–572 in: M. G. Barbour and W. D. Billings, eds. North American terrestrial vegetation. Second edition. Cambridge University Press, New York. 434 pp.

Bliss, L. C. 2000. Arctic tundra and polar desert biome. Pages 1-40 in: M. G. Barbour and W. D. Billings, editors. North American terrestrial vegetation. Second edition. Cambridge University Press, New York.

Blondel, J., J. Aronson, J-Y. Bodiou, and G. Boeuf. 2010. The Mediterranean Region: Biological diversity in space and time. Second edition. Oxford University Press, Inc., New York.

Bohn, U., R. Neuhäusl, G. Gollub, C. Hettwer, Z. Neuhäuslová, H. Schlüter, H. Weber. 2000/2003. Karte der natürlichen Vegetation Europas / Map of the Natural Vegetation of Europe. Maßstab / Scale 1 : 2 500 000. Münster (Landwirtschaftsverlag).

Bond, W. J., F. I. Woodward, and G. F. Midgley. 2005. The global distribution of ecosystems in a world without fire. New Phytologist 165: 525–538.

Box, E. O. 1981. Macroclimate and plant forms: An introduction to predictive modeling in phytogeography. Dr. W. Junk, The Hague. 258 p.

Box, E.O. and K. Fujiwara. 2005. Vegetation types and their broad-scale distribution. Pages 106–128 in: E. van der Maarel. Vegetation ecology. Blackwell Publishing. Malden, MA

Box, E.O. and K. Fujiwara. 2013. Vegetation types and their broad-scale distribution. Pages 455–485 in: E. van der Maarel and J Franklin, eds. Vegetation ecology. Second edition. Wiley-Blackwell. New York.

Brady, N. C., and R. R. Weil. 2002. The nature and properties of soils. Thirteenth edition. Prentice Hall, Upper Saddle River, NJ.

Brandt, J. P. 2009. The extent of the North American boreal zone. Environmental Review 17: 101–161.

Braun, E. L. 1950. Deciduous forests of eastern North America. Hafner Press, New York. 596 pp.

Brewer, C.; B. Schwind, R. Warbington, W. Clerke, P. Krosse, L. Suring, and M. Schanta. 2005. Section 3: Existing vegetation mapping protocol. In: Brohman; R. Bryant, L. eds. Existing vegetation classification and mapping technical guide. Gen. Tech. Rep. WO-67. U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff, Washington, DC.

Brohman; R., L. Bryant, eds. 2005. Existing vegetation classification and mapping technical guide. Gen. Tech. Rep. WO-67. Washington, DC: U.S. Department of Agriculture Forest Service, Ecosystem Management Coordination Staff.

Brown, D. E., F. Reichenbacher, and S. E. Franson. 1998. A classification of North American biotic communities. The University of Utah Press, Salt Lake City. 141 pp.

Bryant, R. B., and J. M. Galbraith. 2003. Incorporating anthropogenic processes in soil classification. Pages 57–66 in: H. Eswaran, T. Rice, R. Ahrens, and B. A. Steward. Soil classification: A global desk reference. CRC Press, New York.

Chytrý, M. and Tichý, L. 2003. Diagnostic, constant and dominant species of vegetation classes and alliances of the Czech Republic: a statistical revision. Folia Facultatis Scientierum Naturalium Universitalis Masarykianae Brunensis. Biologia 108: 1–231.

Collins, M. 1990. The last rain forests: A world conservation atlas. Oxford University Press, New York.

Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. Ecological systems of the United States: A working classification of U.S. terrestrial systems. NatureServe, Arlington, VA. 61 pp. + Appendices.

Comer, P., and K. Schulz. 2007. Standardized ecological classification for meso-scale mapping in southwest United States. Rangeland Ecology and Management 60: 324–335.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS79/31. U.S. Department of the Interior, Fish & Wildlife Service, Office of Biological Services, Washington, DC. 103 pp.

Cramer, W. 1997. Using plant functional types in a global vegetation model. Pages 271–288 in: T.M. Smith, H.H. Shugart, and F.I. Woodward. Plant functional types: their relevance to ecosystem properties and global change. Cambridge University Press, New York, NY.

Curtis, J. T. 1959. The vegetation of Wisconsin: An ordination of plant communities. Reprinted in 1987. University of Wisconsin Press, Madison. 657 pp.

Dallman, P. R. 1998. Plant life in the world's Mediterranean climates. California Native Plant Society, University of California Press, Berkeley, CA.

Daubenmire, R.F. 1968. Plant communities: a textbook of plant synecology. Harper and Row, New York. 300 pp.

Davies, C.E., D. Moss, and M.O. Hill. 2004. EUNIS Habitat Classification Revised 2004. Report to the European Topic Centre on Nature Protection and Biodiversity. European Environment Agency.

Den Hartog, C. 2003. Phytosociological classification of seagrass communities. Phytocoenologia 33: 203-229.

Devillers,P., J. Devillers-Terschuren, and J.-P. Ledant. 1991. CORINE biotopes manual. Vol. 2. Habitats of the European community. Office for Official Publications of the European Communities, Luxembourg.

Devillers,P., Devillers-Terschuren, J. 1996. A classification of Palaearctic habitats. Council of Europe, Strasbourg: Nature and Environment, No. 78.

Di Gregorio, A. 2005. Land cover classification system (LCCS), version 2: Classification concepts and user manual. FAO Environment and Natural Resources Service Series, No.8. Food and Agriculture Organization, Rome.

Dixon, A.P., D. Faber-Langendoen, C. Josse, C.J. Loucks, J. Morrison. 2014. Distribution mapping of world grassland types. Journal of Biogeography 41(11): 2002-2019.

Driscoll, R. S., D. L. Merkel, D. L. Radloff, D. E. Snyder, and J. S. Hagihara. 1984. An ecological land classification framework for the United States. Miscellaneous Publication No. 1439. U.S. Department of Agriculture, Forest Service, Washington, DC. 56 pp.

Ellenberg, H. 1988. Vegetation ecology of Central Europe. Fourth edition, English Translation. Cambridge University Press, Great Britain.

Elliott-Fisk, D. L. 2000. The taiga and boreal forest. Pages 41–73 in: M. G. Barbour and W. D. Billings, editors. North American terrestrial vegetation. Second edition. Cambridge University Press, New York.

Faber-Langendoen, D. and C. Josse. 2010. World Grasslands and Biodiversity Patterns. NatureServe, Arlington, VA. 20 pp. + Appendices.

Faber-Langendoen, D., T. Keeler-Wolf, D. Meidinger, C. Josse, A. Weakley, D. Tart, G. Navarro, B. Hoagland, S. Ponomarenko, J.-P. Saucier, G. Fults, E. Helmer. 2012. Classification and description of world formation types. Part I (Introduction) and Part II (Description of formation types). Hierarchy Revisions Working Group, Federal Geographic Data Committee, FGDC Secretariat, U.S. Geological Survey, Reston, VA, and NatureServe, Arlington, VA.

Faber-Langendoen D., T. Keeler-Wolf, D. Meidinger, D. Tart, B. Hoagland, C. Josse, G. Navarro, S. Ponomarenko, J.-P. Saucier, A. Weakley, P. Comer. 2014. EcoVeg: A new approach to vegetation description and classification. Ecological Monographs. 84(4): 533-561.

Faber-Langendoen, D., D.L. Tart, and R.H. Crawford. 2009. Contours of the revised U.S. National Vegetation Classification standard. Bulletin of the Ecological Society of America 90: 87–93.

Faber-Langendoen, D., D. Tart, A. Gray, B. Hoagland, Otto Huber, C. Josse, S. Karl, T. Keeler-Wolf, D. Meidinger, S. Ponomarenko, J-P. Saucier, Alejandro Velázquez-Montes, A. Weakley. 2007. Guidelines for an integrated physiognomic-floristic approach to vegetation classification. Unpublished document on file at: Hierarchy Revisions Working Group, Federal Geographic Data Committee, Vegetation Subcommittee, Washington, DC.

FAO [Food and Agriculture Organization]. 1988. FAOUNESCO soil map of the World. Revised Legend. FAO/UNESCO/ISRIC World Soil Resources Reports. No. 60. Reprinted in 1990. Food and Agriculture Organization of the United Nations, Rome.

FAO [Food and Agriculture Organization]. 2001. Global Forest Resources Assessment 2000: Main Report. FAO Forestry Paper 140. Food and Agriculture Organization of the United Nations, Rome. 482 pp.

FGDC [Federal Geographic Data Committee]. 1997. National vegetation classification standard. FGDC-STD-005. Vegetation Subcommittee, Federal Geographic Data Committee, Reston, VA.

FGDC [Federal Geographic Data Committee]. 2008. National vegetation classification standard (Version 2.0). FGDC-STD-005-2008. Vegetation Subcommittee, Federal Geographic Data Committee, Reston, VA. 126 pp.

FGDC [Federal Geographic Data Committee]. 2012. Coastal and marine ecological classification standard (Version 4.0). FGDC-STD-018-2012. Federal Geographic Data Committee, FGDC Secretariat, U.S. Geological Survey. Reston, VA. 246 pp. plus appendices.

Fletcher, A. 1973. The ecology of marine (supra littoral) lichens on some rocky shores of Anglesey. Lichenologist 5: 401–422.

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

Garbary, A., A. Miller, R. Scrosati, K. Kim, and W. Schofield. 2008. Distribution and salinity tolerance of intertidal mosses from Nova Scotian salt marshes. The Bryologist 111(2): 282–291.

Gentry, A. H. 1995. Diversity and floristic composition of neotropical dry forests. Pages 146–194 in: S. H. Bullock, H. A. Mooney, and E. Medina, eds. Seasonally dry tropical forests. Cambridge University Press, Cambridge.

Gilbert, O. L., and V. J. Giavarini. 1997. The lichen vegetation of acid watercourses in England. Lichenologist 29: 347–367.

Gillison, A.N. 2013. Plant functional types and traits at the community, ecosystem and world level. Pages 347–386 in: E. van der Maarel, and J. Franklin, eds. Vegetation ecology. Second edition. Wiley-Blackwell, New York.

Gilmore, R. G., Jr., and S. C. Snedaker. 1993. Mangrove forests. Pages 165198 in: W. H. Martin, S. G. Boyce, and A. C. Echternacht, eds. Biodiversity of the southeastern United States: Lowland terrestrial communities. John Wiley and Sons, New York. 502 pp.

Gitay, H. and I.R. Nobel. 1997. What are functional types and how should we seek them. Pages 3–19 in: T.M. Smith, H.H. Shugart, and F.I. Woodward. Plant functional types: their relevance to ecosystem properties and global change. Cambridge University Press, New York, NY.

Gong, Z., G. Zhang, and Z Chen. 2003. Development of soil classification in China. Pages 101–125 in: H.Eswaran, T. Rice, R. Ahens, B.A. Stewart. Soil classification: a global desk reference. CRC Press, New York.

Grossman, D. H., D. Faber-Langendoen, A. S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. D. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International classification of ecological communities: Terrestrial vegetation of the United States. Volume I. The national vegetation classification system: Development, status, and applications. The Nature Conservancy, Arlington, VA.

Haines, T. L. 1981. California chaparral. Pages 139–174 in: F. di Castri, D. W. Goodall, and R. L. Specht, eds. Mediterranean-type shrublands. Ecosystems of the World. Volume 11. Elsevier Scientific Publishing Co., Amsterdam.

Hawksworth, D. L. 2000. Freshwater and marine lichen-forming fungi. Pages 1–7 in: K. D. Hyde, W. H. Ho, and S. B. Pointing, eds. Aquatic mycology across the millennium. Fungal Diversity 5: 1–7.

Hogarth, P. 2007. The biology of mangroves and seagrasses. Oxford University Press, Inc. New York.

Holdridge, L. R. 1967. Life zone ecology. Tropical Science Center, San Jose, Costa Rica.

Holzman, B. A. 2008. Tropical forest & woodlandbiomes. Greenwood guide to biomes of the world. S. L. Woodward, general editor. Greenwood Press, Westport, CT.

Irmler, U. 1977. Inundation forest types in the vicinity of Manaus. Biogeographica 8: 17–29.

Jardim, A., T. J. Killeen, and A. F. Fuentes. 2003. Guía de Árboles y Arbustos del Bosque Seco Chiquitano, Bolivia. FCBC and Missouri Botanical Garden. Editorial FAN. Santa Cruz de la Sierra, Bolivia. 324 pp.

Jennings, M.D., D. Faber-Langendoen, O.L. Loucks, R.K. Peet, and D. Roberts. 2009. Standards for associations and alliances of the U.S. National Vegetation Classification. Ecological Monographs 79: 173–199.

Josse, C., G. Navarro, P. Comer, R. Evans, D. Faber-Langendoen, M. Fellows, G. Kittel, S. Menard, M.Pyne, M. Reid, K Schulz, K. Snow, and J. Teague. 2003. Ecological systems of Latin America and the Caribbean: A working classification of terrestrial systems*.* NatureServe, Arlington, VA.

Josse, C. 2011. Alcance conceptual, clasificación y factores diagnósticos para la clasificación de ecosistemas adoptados por los países de la Comunidad Andina: Diagnóstico y propuesta metodológica para un mapa regional. Internal Report Submitted to CAN (Comunidad Andina de Naciones). Unpublished report on file at NatureServe, Arlington, VA.

Josse, Carmen. 2011. Personal communication. Senior Ecologist, Latin America. NatureServe, Arlington, VA.

Keeler-Wolf, T. 2011. Personal communication. Senior Vegetation Ecologist, Wildlife and Habitat Data Analysis Branch, California Department of Fish and Game, Sacramento, CA.

Keeley, J. 2001. Fire and invasive species in Mediterranean-climate ecosystems in California. Pages 81–94 in: K. E. M. Galley and T. P. Wilson, eds. Proceedings of the invasive species workshop: The role of fire in the control and spread of invasive species. Miscellaneous Publications 11. Tall Timbers Research Station, Tallahassee, FL.

Keeley, J. E. 1994. Seed-germination patterns in fire-prone Mediterranean-climate regions. Pages 239–273 in: M. T. K. Arroyo, P. H. Zedler, and M. D. Fox, eds. Ecology and biogeography of Mediterranean ecosystems in Chile, California, and Australia. Springer-Verlag, New York, NY.

Killeen, T. J., A. Jardim, F. Mamani, and P. Saravia. 1998. Diversity, composition, and structure of a tropical semideciduous forest in the Chiquitanía región of Santa Cruz, Bolivia. Journal of Tropical Ecology 14: 803–827.

Kolbek, J., M. Valachoviæ, N. Ermakov, and Z. Neuhäuslovä. 2003. Comparison of forest syntaxa and types in northeast Asia. Pages 409–423 in: J. Kolbek, M. Srùtek, and E. O. Box, eds. Forest vegetation of northeast Asia. Geobotany 28. Kluwer Academic Publications, London.

Kubitzki, K. 1989. The ecogeographical differentiation of Amazonian inundation forests. Plant Systematics and Evolution 162: 285–304.

Küchler, A.W. 1969. Natural and cultural vegetation. The Professional Geographer 21: 383–385

Kudryashov, V. 2010. The great Soviet encyclopedia. Third edition (1970-1979). The Gale Group, Inc.

Kuennecke, B. H. 2008. Temperate Forest Biomes. Greenwood Press, Westport, CT.

Ladle, R.J. and R.J. Whittaker, editors. 2011.Conservation biogeography. First edition. Blackwell Publishing Ltd., Hoboken, NJ.

Larson, D. W., U. Matthes, and P. E. Kelly. 2000. Cliff ecology: Patterns and processes in cliff ecosystems. Cambridge University Press, Cambridge, MA.

Lea, Chris. 2012. Personal communication. Ecologist, formerly with National Park Service, USGS / NPS Vegetation Mapping Program, Denver, CO.

Leemans, R. 1997. The use of plant functional type classifications to model global land cover and simulate the interactions between the terrestrial biosphere and the atmosphere. Pages 289–316 in: T.M. Smith, H.H. Shugart, and F.I. Woodward. Plant functional types: Their relevance to ecosystem properties and global change. Cambridge University Press, New York, NY.

Linares-Palomino, R., R. T. Pennington, and S. Bridgewater. 2003. The phytogeography of the seasonally dry tropical forests in Equatorial Pacific South America. Candollea 58: 473–499.

Lincoln, R., G. Boxshall, and P. Clark. 1998. A dictionary of ecology, evolution and systematics. Cambridge University Press, New York. 361 pp.

Lugo, A. E., E. Medina, J. C. Trejo-Torres, and E. Helmer. 2006. Botanical and ecological basis for the resilience of Antillean Dry Forests. Pages 359–381 in: R. T.

Pennington, G. P. Lewis, and J. A. Ratter, eds. Neotropical savannas and seasonally dry forests: Plant diversity, biogeography and conservation. CRC Press, Boca Raton, FL.

MacKenzie, W. H., and J. R. Moran. 2004. Wetlands of British Columbia: A guide to identification. Land Management Handbook No. 52. Research Branch, British Columbia Ministry of Forests and Lands, Victoria, BC. 287 pp.

Malanson, G. P., and J. F. O'Leary. 1995. The coastal sage scrub-chaparral boundary and response to global climatic change. Pages 363–376 in: J. M. Moreno and W. C. Oechel, eds. Global change and Mediterranean-type ecosystems. Springer-Verlag, New York, NY.

McLaughlin, S. P. 2007. Tundra to Tropics: The floristic plant geography of North America. Sida Botanical Miscellany Publication 30: 1–58.

Miles, L., A. Newton, R. DeFries, C. Ravilious, I. May, S. Blyth, V. Kapos, and J. E. Gordon. 2006. A global overview of the conservation status of tropical dry forests. Journal of Biogeography 33: 491–505.

Miller, P. C. 1982. Nutrients and water relations in Mediterranean-type ecosystems. Pages 325–332 in: Proceedings of the symposium on dynamics and management of Mediterranean-type ecosystems. Gen. Tech. Rep. PSW-58. U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.

Minnesota DNR [Minnesota Department of Natural Resources]. 2005. Field guide to the native plant communities of Minnesota: The Prairie Parkland and Tallgrass Aspen Parklands provinces. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. Minnesota Department of Natural Resources, St. Paul.

Mitsch, W. J., and J. G. Gosselink. 2000. Wetlands. Third edition. John Wiley & Sons, Inc., New York. 920 pp.

Mooney, H. A., S. H. Bullock, and E. Medina. 1995. Introduction. Pages 1–8 in: S. H. Bullock, H. A. Mooney, and E. Medina, eds. Seasonally dry tropical forests. Cambridge University Press, Cambridge.

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

Mucina L., J.H.J. Schaminée, and J.S. Rodwell. 2000. Common data standards for recording releves in field survey for vegetation classification. Journal of Vegetation Science 11: 769–772.

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

Mueller-Dombois, D., and F. R. Fosberg. 1998. Vegetation of the tropical Pacific islands. Springer-Verlag, New York. 733 pp.

National Wetlands Working Group. 1997. Wetlands of Canada. C. D. A Rubec, ed. Ecological Land Classification Series No. 24. Environment Canada, Ottawa, and Polyscience Publications, Inc., Montreal. 452 pp.

Navarro, G. 2002. Vegetación y unidades biogeográficas de Bolivia. En: G. Navarro and M. Maldonado, Geografía Ecológica de Bolivia. Vegetación y Ambientes Acuáticos. Fundación Simón I. Patiño. Cochabamba. 745 pp.

Navarro, G. 2004. Mapa de Vegetación del Parque Nacional y Area Natural de Manejo Integrado "KAAIYA" del Gran Chaco. CABI WCS USAID. Editorial FAN. Santa Cruz de la Sierra. 42 pp. + 1 mapa.

Navarro, G. 2011. Clasificación de la Vegetación de Bolivia. Editorial Centro de Ecología Difusión Simón I. Patiño. Santa Cruz de la Sierra, Bolivia. 713 pp.

Navarro, G., and M. Maldonado. 2002. Geografía Ecológica de Bolivia: Vegetación y Ambientes Acuáticos. Editorial Centro de Ecología Simón I. Patiño. Cochabamba, Bolivia. 719 pp.

Navarro, G., J. A. Molina, and L. Perez de Molas. 2006. Classification of the forests of the Northern Paraguayan Chaco. Phytocoenologia 36(4).

Nelson, P. 2005. The terrestrial natural communities of Missouri. Third edition. Missouri Natural Areas Committee, Department of Natural Resources and the Department of Conservation, Jefferson City, MO. 550 pp.

NWLRA (National Land and Water Resources Audit Advisory Council). 2001. Australian native vegetation assessment 2001. National Land and Water Resources Audit. Canberra, Australia.

NWWG (National Wetlands Working Group). 1997. Wetlands of Canada. C. D. A. Rubec, ed. Ecological Land Classification Series No. 24. Environment Canada, Ottawa, and Polyscience Publications, Inc., Montreal. 452 pp.

Oliveira-Filho, A. T., J. A. Jarenkow, and M. G. Nogueira Rodal. 2006. Floristic relationships of seasonally dry forests of eastern South America based on tree species distribution patterns. Pages 159–192 in: R. T. Pennington, G. P. Lewis, and J. A. Ratter, eds. Neotropical savannas and seasonally dry forests: Plant diversity, biogeography and conservation. CRC Press, Boca Raton, FL.

Oliveira-Filho, A. T., and J. A Ratter. 2002. Vegetation physiognomies and woody flora of the Cerrado Biome. In: P.S. Oliveira and R. J. Marquis, editors. The Cerrados of Brazil: Ecology and natural history of a Neotropical savanna. Columbia University Press, New York.

Orth, R. J., D. J. Wilcox, J. R. Whiting, L. S. Nagey, A. L. Owens, and A. K. Keene. 2010. 2009 Distribution of submerged aquatic vegetation in Chesapeake and coastal bays. Special Scientific Report Number 152. Virginia Institute of Marine Sciences, College of William and Mary, Gloucester Point, VA. Online: http://www.vims.edu/bio/sav/sav09.

Peet, R. K. 2006. Ecological classification of longleaf pine woodlands. Pages 51–94 in: S. Jose, E. Jokela and D. Miller, editors. Longleaf pine ecosystems: Ecology, management, and restoration. Springer, NY. .

Peet R.K. 2008. A decade of effort by the ESA Vegetation Panel leads to a new Federal standard. Bulletin of the Ecological Society of America 89(3): 210–211.

Peet, R. K., T. R. Wentworth, and P. S. White. 1998. A flexible, multipurpose method for recording vegetation composition and structure. Castanea 63: 262–274.

Peinado, M., J. L. Aguirre, and M. de la Cruz. 1998. A phytosociological survey of the Boreal Forest & Woodland (Vaccinio-Piceetea) in North America. Plant Ecology 137(2): 151–202.

Peinado, M., F. Alcaraz, J. L. Aguirre, J. Delgadillo, and I. Aguado. 1995. Shrubland formations and associations in Mediterranean-desert transitional zones of northwestern Baja California. Plant Ecology 117: 165–179.

Pennington, R. T., G. P. Lewis, and J. A. Ratter. 2006. An overview of the plant diversity, biogeography and conservation of neotropical savannas and seasonally dry forests. Pages 1–29 in: R. T. Pennington, G. P. Lewis, and J. A. Ratter, eds. Neotropical savannas and seasonally dry forests: Plant diversity, biogeography and conservation. CRC Press, Boca Raton, FL.

Prado, D. E., and P. E. Gibbs. 1993. Patterns of species distribution in the dry seasonal forests of South America. Annals of the Missouri Botanical Garden 80: 902–927.

Prance, G. T. 1979. Notes on the vegetation of Amazonia. III. The terminology of Amazonian forest types subject to inundation. Brittonia 31(1): 26–38.

Quinn, J. A. 2008. Arctic and Alpine Biomes. Greenwood Press. Westport, CT.

Quinn, J. A. 2009. Desert Biomes. Greenwood Press, Westport, CT.

Quinn, R. D. 1994. Mammalian herbivory and resilience in Mediterranean-type ecosystems. Pages 113–128 in: B. Dell, A. J. M. Hopkins, and B. B. Lamont, eds. Resilience in Mediterranean-type ecosystems. Junk, Dordrecht, the Netherlands.

Richards, P. W. 1996. The Tropical rain forest: An ecological study. Second edition. Cambridge University Press, Cambridge, UK. 600 pp.

Rivas-Martinez, S., A. Penas, and T.E. Diaz. 2004. Bioclimatic Map of Europe, Thermoclimatic Belts. Cartographic Service, University of Leon, Spain.

Rivas-Martinez, S., and S. Rivas-Saenz. 1996–2009. Worldwide Bioclimatic Classification System. Phytosociological Research Center, Spain. Online: http://www.globalbioclimatics.org.

Rivas-Martinez, S, S.Rivas-Saenz, G. Navarro, and M Costa. (In press). Bioclimates of South America. Global Geobotany.

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

Rivas-Martínez, S., D. Sánchez-Mata, and M. Costa. 1999b. North American new phytosociological classes. Itinera Geobotanica 13: 349–352.

Rodwell, J. S., J. H. J. Schamineé, L. Mucian, S. Pignatti, J. Dring, and D. Moss. 2002. The diversity of European vegetation. An overview of phytosociological alliances and their relationships to EUNIS habitats. ECLNV. Report ECLNV nr. 2002/054. National Reference Centre for Agriculture, Nature and Fisheries, Wageningen, NL.

Roth, R. A. 2009. Freshwater aquatic biomes. Greenwood Press, Westport, CT.

Rundell, P. W., G. Montenegro, and F. M. Jaksic, eds. 1998. Landscape disturbance and biodiversity in Mediterranean-type ecosystems. Springer-Verlag, New York, NY.

Rzedowski, J. 1978. Vegetación de México. Editorial Limusa, México D. F. 432 pp.

SánchezAzofeifa, G., and C. Portillo-Quintero. 2011. Extent and drivers of change for neotropical seasonally dry tropical forests. Pages 45–57 in: R. Dirzo, H. S. Young, H. A. Mooney, and G. Ceballos, eds. Seasonally dry tropical forests: Ecology and conservation. Island Press, Washington, DC.

Schultz, J. 1995. The ecozones of the world. Springer-Verlag, New York.

Seeliger, U. 1992. Coastal foredunes of southern Brazil: Physiography, habitats and vegetation. Pages 367–381 in: U. Seeliger, ed. Coastal plant communities of Latin America. Academic Press, Inc., New York.

Shimwell, D. W. 1971. The description and classification of vegetation. University of Washington Press, Seattle.

Short, F., T. Carruthers, W. Dennison , and M. Waycott. 2007. Global seagrass distribution and diversity: A bioregional model. Journal of Experimental Marine Biology and Ecology 350: 3–20.

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. Second ed. USDA Natural Resources Conservation Service, Washington, DC.

Spribille, T., and M. Chytrý. 2002. Vegetation surveys in the circumboreal coniferous forests: A review. Folia Geobotanica 37(4): 365–382.

Stoddart, D. R., F. R. Fosberg, and D. L. Spellman. 1982. Cays of the Belize barrier reef and lagoon. Atoll Research Bulletin 256: 156 pp.

Stromberg, M. R., J. D. Corbin, and C. M. D'Antonio, eds. 2007. California grasslands: Ecology and management. University of California Press, Berkeley, CA.

Takhtajan, A. 1986. Floristic regions of the world. University of California Press, Berkeley. 522 pp.

Tart, D., C.K. Williams, C.K. Brewer, J.P. DiBenedetto, and B. Schwind. 2005a. Section 1: Existing vegetation classification and mapping framework. Pp 1-1 – 1-24. in: Brohman, R. and L. Bryant, eds. Existing vegetation classification and mapping technical guide. Gen. Tech. Rep. WO-67. U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff, Washington, DC.

Tart, D.; Williams, C.; DiBenedetto, J.; Crowe, E.; Girard, M.; Gordon, H.; Sleavin, K.; Manning, M.; Haglund, J.; Short, B.; and Wheeler, D. 2005b. Section 2: Existing Vegetation Classification Protocol. Pages 2-1 – 2-34 in: Brohman, R. and L. Bryant, eds. Existing vegetation classification and mapping technical guide. Gen. Tech. Rep. WO-67. U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff, Washington, DC.

Tiner, R.W. 1998. In search of swampland: a wetland sourcebook and field guide. Rutgers University Press, New Brunswick, NJ.

UNESCO [United Nations Educational, Scientific and Cultural Organization]. 1973. International classification and mapping of vegetation. Series 6, Ecology and Conservation. United Nations Educational, Scientific, and Cultural Organization. Paris. 93 pp.

U.S. Army Corp of Engineers. 1987. Army Corps of Engineers Wetland Delineation Manual. Technical Report Y-87-1. U.S. Army Corp of Engineers, Environmental Laboratory, Waterways Experiment Station, Vicksburg, MS.

U.S. Geological Survey (USGS). 2001. NLCD land cover class definitions, USGS EROS Data Center, Sioux Falls, South Dakota. Online: http: //landcover.usgs.gov/natllandcover.php, [last accessed 30 August 2006].

Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. Gen. Tech. Rep. PNW-GTR-286. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 278 pp.

Walter, H. 1985. Vegetation of the Earth and ecological systems of the geo-biosphere. Third edition. Springer-Verlag, New York.

Wardle, P. 1991. Vegetation of New Zealand. Reprinted in 2002. The Blackburn Press, Caldwell, NJ.

Warming, E. 1909. Oecology of plants: an introduction to the study of plant communities. Reprint 1977, Arno Press, A New York Times Company..

Westhoff, V., and E. van der Maarel. 1973. The Braun-Blanquet approach. Pages 617–726 in: R.H. Whittaker, editor. Handbook of vegetation science. Part V. Ordination and classification of communities. W. Junk, The Hague, Netherlands.

Westman, W. E. 1983. Xeric Mediterranean-type shrubland associations of Alta and Baja California and the community/continuum debate. Vegetatio 52: 3–19.

Whitmore, T. C. 1984. Tropical rain forests of the Far East. Second edition. Clarendon Press, Oxford.

Whitmore, T. C. 1998. An introduction to tropical rain forests. Second edition. Oxford University Press, Oxford.

Whittaker, R.H. 1962. Classification of natural communities. Botanical Review 28: 1–239.

Whittaker, R. H. 1975. Communities and ecosystems. Second edition. Macmillan Publishing Co., New York. 387 pp.

Woodward, S. 2008. Grassland Biomes. Greenwood Press, Westport, CT.

Zitong, G., G. Ghang, and Z. Chen. 2003. Development of soil classification in China. Pages 101–126 in: H. Eswaran, T. Rice, R. Ahrens, and B. A. Steward. Soil classification: A global desk reference. CRC Press, New York.

Appendix A. Hierarchy Revisions Working Group 2010–2012

Canada	
Del Meidinger	British Columbia Ministry of Forests, now consultant
Serguei Ponomarenko	NatureServe-Canada
Jean-Pierre Saucier	Ministère des Ressources naturelles, Québec
United States	
Don Faber-Langendoen	NatureServe (chair)
Gene Fults	Natural Resources Conservation Service
Andy Gray	U.S. Forest Service
Eileen Helmer	U.S. Forest Service, Puerto Rico
Bruce Hoagland	University of Oklahoma
Todd Keeler-Wolf	California Department of Fish and Game
David Tart	U.S. Forest Service
Alan Weakley	North Carolina Botanic Garden, University of North Carolina
Latin America	
Carmen Josse	NatureServe, Chile
Gonzalo Navarro	Bolivia & Universidad Complutense de Madrid

Appendix B. Formation level units, Level 1 to Level 3.

Level 1– Formation Class	Level 2 – Formation Subclass	Level 3 – Formation Wetland and aquatic formations marked with *
1. Forest & Woodland [Mesomorphic Tree Vegetation]	**1.A. Tropical Forest & Woodland**	**1.A.1. Tropical Dry Forest & Woodland**
		1.A.2. Tropical Lowland Humid Forest
		1.A.3. Tropical Montane Humid Forest
		1.A.4. Tropical Flooded & Swamp Forest *
		1.A.5. Mangrove*
	1.B. Temperate & Boreal Forest & Woodland	**1.B.1. Warm Temperate Forest & Woodland**
		1.B.2. Cool Temperate Forest & Woodland
		1.B.3. Temperate Flooded & Swamp Forest *
		1.B.4. Boreal Forest & Woodland
		1.B.5. Boreal Flooded & Swamp Forest *
2. Shrub & Herb Vegetation [Mesomorphic Shrub & Herb Vegetation]	**2.A. Tropical Grassland, Savanna & Shrubland**	**2.A.1. Tropical Lowland Grassland, Savanna & Shrubland**
		2.A.2. Tropical Montane Grassland & Shrubland
		2.A.3. Tropical Scrub & Herb Coastal Vegetation
	2.B. Temperate & Boreal Grassland & Shrubland	**2.B.1. Mediterranean Scrub & Grassland**
		2.B.2. Temperate Grassland & Shrubland
		2.B.3. Boreal Grassland & Shrubland
		2.B.4. Temperate to Polar Scrub & Herb Coastal Vegetation
	2.C. Shrub & Herb Wetland	**2.C.1. Tropical Bog & Fen ***
		2.C.2. Temperate to Polar Bog & Fen*
		2.C.3. Tropical Freshwater Marsh, Wet Meadow & Shrubland*
		2.C.4. Temperate to Polar Freshwater Marsh, Wet Meadow & Shrubland*
		2.C.5. Salt Marsh*
3. Desert & Semi-Desert [Xeromorphic Woodland, Scrub & Herb Vegetation]	**3.A. Warm Desert & Semi-Desert Woodland, Scrub & Grassland**	**3.A.1. Tropical Thorn Woodland**
		3.A.2. Warm Desert & Semi-Desert Scrub & Grassland

		3.B. Cool Semi-Desert Scrub & Grassland	**3.B.1. Cool Semi-Desert Scrub & Grassland**
	4. Polar & High Montane Scrub, Grassland & Barrens [Cryomorphic Scrub, Herb & Cryptogam Vegetation]	**4.A. Tropical High Montane Scrub & Grassland**	**4.A.1. Tropical High Montane Scrub & Grassland**
		4.B. Temperate to Polar Alpine & Tundra Vegetation	**4.B.1. Temperate & Boreal Alpine Dwarf-shrub & Grassland**
		-	**4.B.2. Polar Tundra & Barrens**
	5. Aquatic Vegetation [Hydromorphic Vegetation]	**5.A. Saltwater Aquatic Vegetation**	**5.A.1. Floating & Suspended Macroalgae Saltwater Vegetation***
			5.A.2. Benthic Macroalgae Saltwater Vegetation*
			5.A.3. Benthic Vascular Saltwater Vegetation*
			5.A.4. Benthic Lichen Saltwater Vegetation*
		5.B. Freshwater Aquatic Vegetation	**5.B.1. Tropical Freshwater Aquatic Vegetation***
			5.B.2. Temperate to Polar Freshwater Aquatic Vegetation*
	6. Open Rock Vegetation [Cryptogam - Open Mesomorphic Vegetation]	**6.A. Tropical Open Rock Vegetation**	**6.A.1. Tropical Cliff, Scree & Other Rock Vegetation**
		6.B. Temperate & Boreal Open Rock Vegetation	**6.B.1. Temperate & Boreal Cliff, Scree & Other Rock Vegetation**
	7. Agricultural & Developed Vegetation [Anthromorphic Vegetation]	**7.A. Woody Agricultural Vegetation**	**7.A.1. Woody Horticultural Crop**
			7.A.2. Forest Plantation & Agroforestry
			7.A.3. Woody Wetland Horticultural Crop*
		7.B. Herbaceous Agricultural Vegetation	**7.B.1. Row & Close Grain Crop**
			7.B.2. Pasture & Hay Field Crop
			7.B.3. Herbaceous Horticultural Crop
			7.B.4. Fallow Field & Weed Vegetation
			7.B.5. Herbaceous Wetland Crop*
		7.C Herbaceous & Woody Developed Vegetation	**7.C.1. Lawn, Garden & Recreational Vegetation**
			7.C.2. Other Developed Vegetation
			7.C.3. Developed Wetland Vegetation*
		7.D. Agricultural & Developed Aquatic Vegetation	**7.D.1. Agricultural Aquatic Vegetation***
			7.D.2. Urban & Recreational Aquatic Vegetation*

	6 natural classes	*13 natural subclasses*	*37 natural formations*
	1 cultural subclass	*4 cultural subclasses*	*13 cultural formations*
Non-vegetated Classes (non - NVC)	**8. Natural Open Fresh Water**	**Lake**	
		River	
		Subterranean Freshwater	
	9. Natural Open Salt Water	**Estuary and Ocean**	
	10. Cultural Open Water	**Reservoir and Canal (etc.)**	
	11. Perennial Snow/Ice	**Perennial Snowfield**	
		Ice Sheet	
		Glacier	
	12. Natural Surface Bare Area	**Consolidated Bare Area (Rock, etc)**	
		Unconsolidated Bare Area (Sand, Gravel, etc)	
	13. Natural Subterranean	**Cave (etc).**	
	14. Cultural Surface Bare Area	**Developed, Low Intensity**	
		Developed, Medium In-tensity	
		Developed, High Intensity	
	15. Cultural Subterranean	**Mine Shaft (etc.)**	

Appendix C. Glossary of Terms

The following set of terms are selected from the FGDC (2008) standard.

Agricultural vegetation — A vegetation type that exhibits (a) rapid turnover in structure, typically at least on an annual basis, either through comprehensive manipulation of physiognomy and floristics by harvesting and/or planting, or by continual removal of above ground structure (e.g., cutting, haying), or (b) showing strong linear (planted) features. The herbaceous layer may be bare at various times of the year.

Abiotic — Pertaining to the nonliving parts of an ecosystem, such as soil particles, bedrock, air, and water (Helms 1998).

Abundance — The total number of individuals of a taxon or taxa in an area, volume, population, or community; often measured as cover in plants (Lincoln and others 1998).

Basal area — The cross-sectional area of all stems of a species or all stems in a stand measured at breast height (4.5 feet or 1.37 meters above the ground) and expressed per unit of land area (Helms 1998).

Biome — Major type of natural vegetation that occurs wherever a particular mix of climatic and edaphic conditions is encountered; also considered as a major ecosystem type. (Ladle and Whittaker 2011).

Canopy cover — The percentage of ground covered by the vertical projection of the outermost perimeter of the natural spread of foliage of plants. Small openings in the canopy are included (SRM 1989; USDA NRCS 1997). *cf.* foliar cover.

Class — See formation class.

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

Classification plot records — Plot records that contain the data necessary to inform the development or revision of the floristic units within the NVC. Such plots typically contain high quality data on floristic composition and structure, and conform to the standard articulated in Section 3.1.1 (Jennings and others 2006).

Close grown crops — Crops that are generally drill-seeded or broadcast, such as wheat, oats, rice, barley, and flax, resulting in very narrow regularly spaced, structure (adapted from NRI 2003).

Cover — See canopy cover, foliar cover.

Cropland — See agricultural vegetation.

Cross-walk — To describe and document the relationships between members of one set or series and members of another set or series. These relationships may be one-to-one, one-to-many, or many-to-many.

Cryomorphic — Pertaining to plants having structural or functional adaptations to survive cold temperatures and resist frost damage (e.g., alpine creeping dwarf-shrubs, krummholz).

Cryptogam — A plant that produces by spores or gametes rather than seed, i.e. an alga, bryophyte or pteridophyte (fern). For vegetation purposes, often extended to include lichen, which are comprised of a fungus and an alga.

Cultural vegetation — Vegetation with a distinctive structure, composition, and development determined by regular human activity (Küchler 1969).

Developed vegetation — A vegetation type that typically contains an almost continuous herbaceous (typically grass) layer, with a closely cropped physiognomy, typically through continual removal of above ground structure (e.g. cutting, mowing), and where tree cover is highly variable, or other highly manipulated planted gardens.

Diagnostic growth form — Any growth form or group of growth forms whose relative constancy or abundance differentiates one vegetation type from another. Diagnostic growth forms include dominant growth form and indicator growth form.

Division — The fourth level in the natural vegetation hierarchy, in which each vegetation unit is defined by a group of plant communities in a given continental or other broad geographic area exhibiting a common set of dominant growth forms and many diagnostic plant taxa (including character taxa of the dominant growth forms) corresponding to broad climatic and environmental characteristics. (Westhoff and van der Maarel 1973, p 664-665; Whittaker 1975).

Dominance — The extent to which a given taxon or growth form has a strong influence in a community because of its size, abundance, or cover. (Lincoln and others 1998).

Dominant growth form — Growth form with the highest percent of cover, usually in the uppermost dominant layer (in other contexts dominant growth forms can be defined in terms of biomass, density, height, coverage, etc).

Epiphyte — A vascular or nonvascular plant that grows by germinating and rooting on other plants or other perched structures, and does not root in the ground (adapted from FGDC 1997).

Existing vegetation — Vegetation found at a given location at the time of observation (Jennings and others 2006). *cf*. potential natural vegetation.

Field stratum — The layer of vegetation consisting of herbs, regardless of height, as well as woody plants less than 0.5 m in height (Jennings and others 2006).

Floating aquatic stratum — The layer of vegetation consisting of rooted or drifting plants that float on the water surface; e.g. duckweed, water-lily (Jennings and others 2006).

Foliar cover — The percentage of ground covered by the vertical projection of the aerial portion of plants. Small openings in the canopy and intraspecific overlap are excluded (SRM 1989). *cf.* canopy cover.

Forb — A non-aquatic, non-graminoid herb with relatively broad leaves and/or showy flowers. Includes both flowering and spore-bearing, non-graminoid herbs.

Formation — The third level in the natural vegetation hierarchy, in which each vegetation unit is defined by geographically widespread (global) plant communities of similar physiognomy and dominant growth forms, typically related to major topographic and edaphic conditions occurring within major climatic conditions (Whittaker 1975; Lincoln and others 1998). The formation largely corresponds to a (*cf.*) "biome."

Formation class — The first (highest) level in the natural vegetation hierarchy, in which each vegetation unit is defined by a characteristic combination of dominant growth forms adapted to a very basic set of moisture/temperature regimes.

Formation subclass — The second level in the natural vegetation hierarchy, in which each vegetation unit is defined by geographically widespread (global) plant communities of similar physiognomy and dominant growth forms, typically related to major climatic conditions (Whittaker 1975; Lincoln and others 1998).

Graminoid — A non-aquatic, flowering herb with relatively long, narrow leaves and inconspicuous flowers with parts reduced to bracts. Includes grasses, sedges, rushes, and arrowgrasses.

Ground stratum — see nonvascular stratum.

Growth form — The shape or appearance of a plant reflecting growing conditions and genetics. Growth form is usually consistent within a species, but may vary under extremes of environment (Mueller-Dombois and Ellenberg 1974). Growth forms determine the visible structure or physiognomy of plant communities (Whittaker 1973a).

Habitat — A general term referring to the locality, site and particular type of local environment occupied by an organism or community (adapted from Lincoln and others 1998).

Herb — A vascular plant without perennial aboveground woody stems, with perennating buds borne at or below the ground surface (Whittaker 1975; FGDC 1997). Includes forbs (both flowering forbs and spore-bearing ferns), graminoids, and herbaceous vines.

Herb stratum — See field stratum.

Hydromorphic — Pertaining to plants having structural or functional adaptations for living in water-dominated or aquatic habitats (adapted from FGDC 1997 and Lincoln and others 1998).

Indicator growth form — A growth form whose presence, abundance, or vigor is considered to indicate certain site conditions.

Land cover — The observed (bio) physical cover of the Earth's surface (Di Gregorio 2005).

Land use — The arrangements, activities, and inputs people undertake in a certain land cover type to produce, change, or maintain it (Di Gregorio 2005).

Layer (vegetation) — A structural component of a community consisting of plants of approximately the same height and growth form (e.g., tree overstory, tree regeneration). *cf.* stratum.

Liana — A woody, climbing plant that begins life as terrestrial seedlings but relies on external structural support for height growth during some part of its life (Gerwing 2004), typically exceeding 5 m in height or length at maturity.

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

Lithomorphic — Pertaining to plants, especially cryptogams, having structural or functional adaptations for living on rock surfaces or in rocky substrates (i.e. particle sizes larger than 2 mm diameter) or very hard surfaces, such as dense clay badlands (adapted from Lincoln and others 1998).

Macroclimate — The climate of a major geographical region primarily reflecting latitude and continental position, excluding the effects of landform and vegetation (adapted from Bailey 1988, 1996; Lincoln and others 1998; Forman and Godron 1986).

Mesoclimate — The climate of a geographic area resulting from modification of the macroclimate by the influences of landforms, altitude, aspect, and slope gradient (Bailey 1988, 1996).

Mesomorphic — Pertaining to plants requiring environmental conditions of moderate moisture and temperature or which are only partially protected against desiccation (adapted from Lincoln and others 1998).

Microclimate — The climate of the immediate surroundings or habitat resulting from modification of the mesoclimate by the influences of local topography, vegetation, and soil (adapted from Lincoln and others 1998; and Bailey 1988, 1996).

Moss stratum — See ground stratum.

Natural vegetation — Vegetation where ecological processes primarily determine species and site characteristics, that is, vegetation comprised of a largely spontaneously growing set of plant species that are shaped by both site and biotic processes (Kuchler 1969; Westhoff and Van der Maarel 1973).

Nonvascular — A plant or plant-like organism without specialized water or fluid conductive tissue (xylem and phloem). Includes mosses, liverworts, hornworts, lichens, and algae (adapted from FGDC 1997).

Nonvascular stratum — The layer of vegetation consisting of non-vascular plants growing on soil or rock surfaces. This includes mosses, liverworts, hornworts, lichens, and algae (Jennings and others 2006). Sometimes called the ground stratum.

Non-vegetated — A category used to classify lands with limited capacity to support life and typically having less than 1 percent vegetative cover. Vegetation, if present, is widely spaced. Typically, the surface of barren land is sand, rock, exposed subsoil, or salt-affected soils. Subcategories include salt flats; sand dunes; mud flats; beaches; bare exposed rock; quarries, strip mines, gravel pits, and borrow pits; river wash; oil wasteland; mixed barren lands; and other barren land (adapted from NRI 2003). Exceptions include vegetation that exhibits a distinct composition under very sparse conditions (e.g., sea rocket coastal shore vegetation, or amaranth coastal vegetation). These types rarely have greater than 1 percent cover.

Physiognomy — The visible structure or outward appearance of a plant community as expressed by the dominant growth forms, such as their leaf appearance or deciduousness (Fosberg 1961, Jennings and others 2006). *cf.* structure.

Planted/cultivated — See cultural vegetation.

Plot — In the context of vegetation classification, an area of defined size and shape that is intended for characterizing a homogenous occurrence of vegetation. *cf.* relevé.

Potential natural vegetation — The vegetation that would become established if successional sequences were completed without interference by man or natural disturbance under the present climatic and edaphic conditions (Tüxen 1956). *cf.* existing vegetation.

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

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

Reserved — A section of the FGDC standard that will be addressed or developed in subsequent versions.

Ruderal — Vegetation found on human-disturbed sites, with no apparent recent historical natural analogs, and whose current composition and structure (1) is not a function of continuous cultivation by humans and (2) includes a broadly distinctive characteristic species combination, whether tree, shrub or herb dominated. The vegetation is often comprised of invasive species, whether exotic or native, that have expanded in extent and abundance due to the human disturbances" (Curtis 1959; Ellenberg 1988; Lincoln and others 1998).

Sampling strategy — The means and criteria used to select the locations for plots (based on Tart and others 2005b; Mueller-Dombois and Ellenberg 1974; and Gauch 1982).

Seral — A vegetation type (or component species) that is nonclimax; a species or community demonstrably susceptible to replacement by another species or community (Daubenmire 1968).

Semi-natural vegetation — Vegetation in which past or present human activities significantly influence composition or structure, but do not eliminate or dominate spontaneous ecological processes (Westhoff and Van der Maarel 1973). *cf.* ruderal.

Shrub — A woody plant that generally has several erect, spreading, or prostrate stems that give it a bushy appearance. In instances where growth form cannot be determined, woody plants less than 5 m in height at maturity shall be considered shrubs. Includes dwarf-shrubs, krummholz, and low or short woody vines (adapted from FGDC 1997; and Box 1981).

Shrub stratum — The layer of vegetation consisting of woody plants more than 0.5 m tall but less than 5 m in height, such as shrubs, tree seedling and saplings, and lianas. Epiphytes may also be included in this stratum. Rooted herbs are excluded even if they are over 0.5 m in height (adapted from Jennings and others 2006).

Stand — A spatially continuous unit of vegetation with uniform composition, structure, and environmental conditions. This term is often used to indicate a particular example of a plant community (Jennings and others 2006).

Stratum — A structural component of a community consisting of plants of approximately the same height, e.g., tree, shrub, or herb strata (Jennings and others 2006).

Structure (vegetation) — (1) The spatial pattern of growth forms in a plant community, especially with regard to their height, abundance, or coverage within the individual layers (Gabriel and Talbot 1984). (2) The spatial arrangement of the components of vegetation resulting from plant size and height, vertical stratification into layers, and horizontal spacing of plants (Lincoln and others 1998; Mueller-Dombois and Ellenberg 1974). *cf.* physiognomy.

Subclass — See Formation subclass.

Submerged aquatic stratum — The layer of vegetation consisting of rooted or drifting plants that by-and-large remain submerged in the water column or on the aquatic bottom, e.g. sea grass (Jennings and others 2006).

Tree — A woody plant that generally has a single main stem and a more or less definite crown. In instances where growth form cannot be determined, woody plants equal to or greater than 5 m in height at maturity shall be considered trees (adapted from FGDC 1997). Includes dwarf trees (Tart and others 2005b) or "treelets" (Box 1981).

Tree stratum — The layer of vegetation consisting of woody plants more than 5 m in height, including mature trees, shrubs over 5 m tall, and lianas. Epiphytes growing on these woody plants are also included in this stratum (Jennings and others 2006).

Type — See vegetation type.

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

Vegetation type — A named category of plant community or vegetation defined on the basis of shared floristic and/or physiognomic characteristics that distinguish it from other kinds of plant communities or vegetation (Tart and others 2005a). This term can refer to units in any level of the NVC hierarchy.

Xeromorphic — Pertaining to plants having structural or functional adaptations to prevent water loss by evaporation (Lincoln and others 1998).

Appendix D. Growth Form Names, Codes, and Definitions

Names, definitions and codes for general and specific growth forms for use in collecting vegetation plot data (from Table E.1 of FGDC 2008) (see also Whittaker 1975:359; Tart and others 2005b; Box and Fujiwara 2005).

Table D.1—General Growth Forms

Growth Form Code	Name and Definition
T	**Tree** - A woody plant that generally has a single main stem and a more or less definite crown. In instances where growth form cannot be readily determined, woody plants equal to or greater than 5 m in height at maturity are to be considered trees (adapted from FGDC 1997). Excludes krummholz (wind-stunted trees), but includes small trees or "treelets" (Box 1981). Tall multi-stemmed woody plants with strong canopy structure and that will exceed 5 m would be included here (e.g. mature, multi-stemmed *Quercus ellipsoidalis* in the United States or some Australian mallee eucalypts).
S	**Shrub** - A woody plant that generally has several erect, spreading, or prostrate stems that give it a bushy appearance. In instances where growth form cannot be readily determined, woody plants less than 5 m in height at maturity are to be considered shrubs (adapted from FGDC 1997). Includes krummholz (wind-stunted trees), but excludes small trees, (Box 1981). Includes dwarf-shrubs (less than 30 cm), low or short woody vines, and arborescents (woody plants that branch at or near ground-level but grow to low tree heights). (Box 1981). Some multi-stemmed, bushy woody species ("scrub") that reach up to 10 m may be included here, such as Australian mallee comprised of *Eucalyptus viridis* and *Eucalyptus dumos*a).
H	**Herb** - A vascular, non-woody plant without perennial aboveground woody stems, with perennating buds borne at or below the ground surface. (Whittaker 1975; FGDC 1997). Includes forbs (both flowering forbs and spore-bearing vascular plants), graminoids, and herbaceous vines.
N	**Nonvascular** - A plant or plant-like organism without specialized water or fluid conductive tissue (xylem and phloem). Includes mosses, liverworts, hornworts, lichens, and algae (adapted from FGDC 1997). Also called thallophytes or "nonvascular cryptogams," (that is, excluding the vascular cryptogams; see Herb) (Box 1981).
E	**Epiphyte** - A vascular or nonvascular plant that grows by germinating and rooting on other plants or other perched structures, and does not root in the ground (adapted from FGDC 1997).
L	**Liana** - A woody, climbing plant that begins life as terrestrial seedlings but relies on external structural support for height growth during some part of its life (Gerwing 2004), typically exceeding 5 m in height or length at maturity. Non-woody climbers are treated as "Herb."

General Growth Form Code	Specific Growth Form Code	Name and Definition
	Table D.2—Specific Growth Forms	
T	TBD	**Broad-leaved deciduous tree** - *A tree with a branching crown, leaves that have well-defined leaf blades that are generally of at least microphyll size (>225 mm^2, or 0.35 in^2)* [a] *and that seasonally loses all of its leaves and becomes temporarily bare-stemmed* (adapted from FGDC 1997; Box 1981). Includes monopodial and sympodial growth forms.
	TBE	**Broad-leaved evergreen tree** - *A tree with a branching crown, leaves that have well-defined leaf blades that are generally of at least microphyll sized (>225 mm^2 or 0.35 in^2) and that has green leaves all year round*. (FGDC 1997, Box 1981). Includes monopodial and sympodial growth forms, and woody-like bananas (*Musa* spp.).
	TBES	**Sclerophyllous tree** - *A type of broad-leaved evergreen tree with leaves that are stiff and firm, and retain their stiffness even when wilted*. The leaves are typically relatively small (microphyll to small mesophyll in size) and sometimes rather linear, (FGDC 1997; Whittaker 1975; Box 1981).
	TN	**Needle-leaved tree** - *A tree with slender, often cylindrical, elongated leaves or with small overlapping leaves.* Includes scale-leaved and needle-leaved trees, deciduous and evergreen, needle-leaved trees, such as *Abies, Larix, Picea, Pinus, Thuja* (FGDC 1997; Box 1981).
	TU	**Succulent tree** – *A tree or arborescent plant with fleshy stems or leaves with specialized tissue for the conservation of water* (FGDC 1997). Includes Cacta-ceae, *Yucca brevifolia* (Joshua trees), euphorbias, and others over 5 meters in height at maturity. An "arborescent stem-succulent" (Box 1981). Some Dracae-naceae may fit here.
	TM	**Small-leaved tree** - *A tree with very small leaves (<225 mm^2, or 0.35 in^2)*, or even leafless, sometimes armed with spines*. Includes both evergreen and de-ciduous small-leaved trees, such as *Acacia greggii*, *Mimosa* spp. (adapted from "thorn tree" by Whittaker 1975) .
	TP	**Palm tree** - *An evergreen, broad-leaved, flowering, non-sporing, tree, typically with a simple, unbranched stem and terminal, rosulate crown of large, pinnate or fan-shaped leaves. A type of rosette tree*. Palms are the primary taxa (but see Dracaenaceae, some Pandanaceae, etc.; Box 1981). *Hyphaene thebaica is an example of a branched palm tree.*
	TF	**Tree fern** - *An evergreen, broad-leaved, spore-bearing tree (or arborescent fern) with a simple, unbranched stem and terminal, rosulate crown of large fronds.* A type of rosette tree, including taxa from Cyatheaceae (Box 1981).
	TG	**Bamboo tree**- *A woody-stemmed, arborescent grass that is equal to or greater than 5 m in height at maturity.* Only applies to woody-stemmed bamboos. Includes the "Arborescent grasses" (Box 1981). Other more typically woody grasses, such as *Arundo, Saccharum*, currently excluded, and treated as Herb-graminoid.

S	SD	**Dwarf-shrub –** *A mature caespitose, creeping, matted, or cushion-forming shrub that is generally small-leaved and is typically less than 30 cm tall at maturity due to genetic and/or environmental constraints* (adapted from Mueller-Dombois and Ellenberg 1974).
	SBD	**Broad-leaved deciduous shrub** - *A shrub that is typically more than 30 cm tall at maturity with leaves that have well-defined leaf blades that are generally of at least microphyll size (>225 mm^2, or 0.35 in^2* and seasonally loses all of its leaves and becomes temporarily bare-stemmed* (FGDC 1997).
	SBE	**Broad-leaved evergreen shrub** - *A shrub that is typically more than 30 cm tall at maturity with leaves that are generally of at least microphyll sized (>225 mm^2, or 0.35 in^2)* and has green leaves all year round* (adapted from FGDC 1997; Box 1981).
	SBES	**Sclerophyllous shrub** - *A type of broad-leaved evergreen shrub, typically with relatively small, leaves that are stiff and firm, and retain their stiffness even when wilted* (FGDC 1997; Whittaker 1975).
	SN	**Needle-leaved shrub** - *A shrub that is typically more than 30 cm tall at maturity with slender, elongated leaves or with small overlapping leaves that usually lie flat on the stem (*FGDC 1997). Includes scale-leaved as well as needle-leaved shrubs, and deciduous as well as evergreen.
	SU	**Succulent shrub –** *A fleshy shrub that is typically more than 30 cm tall at maturity with specialized tissue for the conservation of water* (adapted from FGDC 1997 and the Thorn shrub of Whittaker 1975). Includes cacti less than 5 meters in height at maturity. Includes both the "Typical Stem succulents" and "Bush succulents" (Box 1981). Includes Aloe, Agave.
	SM	**Small-leaved shrub** - *A shrub that is typically more than 30 cm tall at maturity with very small leaves (<225 mm^2, or 0.35 in^2)*, or even leafless, sometimes armed with spines, usually having compound, deciduous leaves that are often reduced in size*. Includes *Larrea tridentata, Prosopis glandulosa, Acacia neovernicosa, Senna, Calliandra* (Jennings and others 2006; Whittaker 1975).
		Bamboo shrub- *A woody-stemmed, shrubby grass that is less than 5 m in height at maturity.* Only applies to woody-stemmed bamboos. Includes *Arundo, Saccharum*, *Sinarundinaria* spp (=*Yushania* spp.).
	SP	**Palm shrub** - *An evergreen, broad-leaved, typically unbranched shrub that is typically more than 30 cm tall at maturity with a simple stem and terminal, rosulate crown of large, pinnate or fan-shaped leaves*. Includes palms and palm-like plants, such as espeletia.
H	HA	**Aquatic herb** - *A flowering or non-flowering herb structurally adapted to live floating or submerged in an aquatic environment*. Does not include emergent plants such as cattails and sedges. (FGDC 1997; Jennings and others 2006). Includes flowering and non-flowering, and forb and graminoid aquatic herbs. Further subdivision may be warranted if ecologically meaningful.
	HF	**Forb** - *A non-aquatic, flowering or spore-bearing, non-graminoid herb.*
	HFF	**Flowering forb** - *A forb with relatively broad leaves and showy flowers*. Does not include graminoids, ferns, or fern-allies.
	HFE	**Spore-bearing forb** - *A non-flowering, spore-bearing forb.* Includes non-aquatic, non-woody ferns, clubmosses, spikemosses, horsetails, and quillworts.
	HFS	**Succulent forb** - *A flowering forb with a fleshy stem and often with reduced leaves.* Includes *Salicornia* and others.
	HG	**Graminoid** - *A non-aquatic, flowering herb with relatively long, narrow leaves and inconspicuous, reduced flowers.* Includes grasses, sedges, rushes, and arrow-grasses. Aquatic graminoids are treated with aquatic herbs.

N	NB	**Bryophyte** - *A nonvascular, non-flowering, photosynthetic plant that bears leaf-like appendages or lobes and attaches to substrates by rhizoids.* Includes mosses, liverworts, and hornworts (Abercrombie and others 1966).
	NA	**Alga** - *A nonvascular, photosynthetic plant with a simple form ranging from single- or multi-celled to a filamentous or ribbon-like thallus with relatively complex internal organization* (Abercrombie and others 1966).
	NL	**Lichen** - *An organism generally recognized as a single plant that consists of a fungus and an alga or cyanobacterium living in symbiotic association* (FGDC 1997). Technically, lichen is not a plant, but is often treated together with moss as a type of nonvascular growth form.
E	E	**Epiphyte** - *A vascular or nonvascular plant that grows by germinating and rooting on other plants or other perched structures, and does not root in the ground* (adapted from FGDC 1997). This growth form may be used as a modifier of other growth forms, e.g., HFF(Flowering forb).
L	L	**Liana** - *A woody, climbing plant that begins life as terrestrial seedlings but relies on external structural support for height growth during some part of its life* (Gerwing 2004), typically exceeding 5 m in height or length at maturity. Non-woody climbers are treated as a type of "Herb."

[a] *cf*. Gillison (2013, Table 12.3), who defines microphylls as 225-2025 mm^2, and nanophylls as 25-225 mm^2.

Appendix E. Growth Forms from Box and Fujiwara (2005)

Main Terrestrial Plant Life Forms. This classification from Box and Fujiwara (2005, Table 4.2) represents an expanded version of the original model of 90 plant 'ecophysiognomic' types and their worldwide climatic envelopes (Box 1981). Physiognomic groupings are shown on the left, numbers of types and short descriptions of the 114 actual types are shown on the right. Box and Fujiwara (2013) provide a revised and expanded set of types.

Growth Forms		# of Types	Descriptions
Trees			
Evergreen (broad-leaved)	Laurophyll	4	tropical, tropical-montane, subtropical/warm-temperate, cool-maritime
	Gymnosperm	1	(sub)tropical broad/linear-leaved
	Microphyll	1	(sub)tropical coriaceous
	Sclerophyll	4	(sub)tropical, warm-temp., mediterranean, tall-temperate
Deciduous (broad-leaved)	Raingreen	3	monsoon-mesomorphic, montane, xero-microphyll
	Bottle Trees	1	tropical (raingreen)
	Summergreen	2	nemoral, short-summer
Needle-leaved	(evergreen)	6	tropical-xeric, heliophilic long-needled, submediterranean, temperate, cool-laurophyll, boreal/montane
Small Trees			
Evergreen	Laurophyll	4	tropical, cloud-forest, subtropical/warm-temperate, cool-maritime
	Sclerophyll	1	tropical macro-sclerophyll
Deciduous		2	raingreen, summergreen
Needle-leaved		1	dwarf-needle/scale-leaved
Tuft-Trees and Treelets		3	palm trees, bottle palms, palm treelets
Arborescents			
Evergreen	Laurophyll	2	tropical, extra-tropical
	Sclerophyll	1	tropical/subtropical
Deciduous		2	raingreen, summergreen
Stemgreen		2	mesic-microphyll, xeric/leafless
Tuft-Arborescents		4	tree-ferns, tropical-alpine, coriaceous, sclerophyll/succulent
Krummholz (needle-leaved)		2	evergreen, summergreen
Shrubs			
Evergreen	Laurophyll	2	tropical, subtropical/warm-temperate

Growth Forms		# of Types	Descriptions
	Sclerophyll	2	mediterranean, hot-desert
	Succulent	1	
	Needle-Leaved	1	
Semi-evergreen xeric		1	temperate
Summergreen		2	nemoral-mesomorphic, xeromorphic
Dwarf-Shrubs			
Evergreen		4	mediterranean, temperate, maritime-heath, boreal/tundra
Summergreen		1	boreal/tundra
Xeromorphic		1	leptophyll/leafless
Cushion-form		2	mesic-evergreen, xeromorphic
Rosette-Shrubs		2	trunkless palms, xeric leaf-succulent
Stem-Succulents		5	columnar, branched-arborescent, typical, frutescent, cryptic
Semi-Shrubs		3	mesomorphic, xeromorphic, xylopodial-xeromorphic
Graminoids			
Broad-leaved (bamboos)		2	arborescent, dwarf
Tall		3	cane-graminoids, typical-tall, tall-tussock
Short		5	spreading, bunch, short-tussock, sclerophyll, desert-grasses
Forbs			
Evergreen		3	tropical-arborescent, tropical, temperate
Deciduous	Raingreen	2	typical, cold-desert
	Summergreen	3	tall, typical, spring-ephemeral
Xeromorphic		2	succulent, cushion-form
Ephemeral		2	desert-ephemeral, cold-desert
Ferns		3	evergreen, raingreen, summergreen
Vines	Lianas	1	tropical-evergreen
	Vines	3	evergreen, raingreen, summergreen
	Epiphytic	1	
Epiphytes	Rosette	2	large-tropical, stenophyll
	Stem-Succulent	1	
	Shrublet	1	wintergreen-shrublet
	Herbs	3	tropical-forb, fern, small-fern
Cryptogams		2	mat-forming, xeromorphic

Appendix F. Comparisons to Other Formation-Level Classifications

F.1. Main World Terrestrial Biome Types (Box and Fujiwara 2005)[a]

(These biomes types are recognized by most modern treatments of world vegetation).

- Tropical rain forest (including montane and cloud forests)
- Tropical deciduous forest, woodland, and thorn scrub
- Tropical savanna (i.e. grassland)
- Deserts
  - Warm deserts (subtropical)
  - Cold-winter deserts (continental)
- Mediterranean forest, scrub, and shrublands
- Temperate forests
  - Deciduous broad-leaved forest
  - Evergreen broad-leaved forest (incl. laurel forest, warm-temperate mixed forest)
  - Temperate rain forest
- Conifer forests
  - Boreal (including deciduous)
  - Montane conifer forest (temperate montane and subalpine)
- Grasslands (temperate)
- Tundra and alpine vegetation
  - Polar and temperate-alpine tundra
  - Tropical alpine vegetation
- Terrestrial wetlands (swamp, marsh, bog, fen)

[a]Box, E.O. and K. Fujiwara. 2005. Vegetation types and their broad-scale distribution. Page 106–128 in: van der Maarel, E. Vegetation ecology. Blackwell Publishing. Malden, MA.

F.2. World Wildlife Fund Major Habitat Types (Olson 2001) [a]
Tropical & Subtropical Moist Broadleaf Forests
Tropical & Subtropical Dry Broadleaf Forests
Tropical & Subtropical Coniferous Forests
Temperate Broadleaf & Mixed Forests
Temperate Coniferous Forests
Boreal Forests/Taiga
Tropical & Subtropical Grasslands, Savannas, & Shrublands
Temperate Grasslands, Savannas, & Shrublands
Flooded Grassland & Savannas [temperate and tropical]
Montane Grassland & Savannas [temperate and tropical]
Polar
Mediterranean Forests, Woodlands, & Shrub
Deserts & Xeric Shrublands
Mangroves
Lake
Rock & Ice

[a] David M. Olson, Eric Dinerstein, Eric D. Wikramanayake, and others 2001. Terrestrial ecoregions of the world: A new map of life on earth. BioScience 51(11): 933-938.

F.3. Formations (Biomes) - (Whittaker 1975)

Forests and Woodlands

1. Tropical rain forest
2. Tropical seasonal forest
3. Temperate rain forest
4. Temperate deciduous forest

5a. Temperate evergreen forest — broadleaf
5b. Temperate evergreen forest — needleleaf
5c. Temperate evergreen forest — sclerophyll [Mediterranean]
6. Taiga & subarctic-subalpine needle-leaved forest
7. Elfin woodland
8. Tropical broadleaf woodland

9a. Thornwood— woodland
9b. Thornwood--scrub
10a. Temperate woodland — needleleaf
10b. Temperate woodland — sclerophyll
10c. Temperate woodland — deciduous broadleaf

Shrublands

11a. Temperate shrubland — deciduous
11b. Temperate shrubland — heath
11c. Temperate shrubland — sclerophyll [Mediterranean]
11d. Temperate shrubland — subalpine, needleleaf
11e. Temperate shrubland — subalpine, broadleaf

Grasslands and Alpine Vegetation

12. Savanna [tropical grassland]
13. Temperate grassland
14. Alpine shrubland
15. Alpine grassland

Cold and Warm **Deserts** and Tundra

16. Tundra
17. Warm semidesert scrub

18a. Cool semidesert — open scrub
18b. Cool semidesert — dry grassland

19. Arctic-alpine semidesert
20. True desert
21. Arctic-alpine desert

Swamps, Marshes and Bogs

22. Cool temperate bog
23. Tropical freshwater swamp forest
24. Temperate freshwater swamp forest
25. Mangrove swamp
25. Saltmarsh

Marine and Aquatic

[26-29 are aquatic]

29. Marine rocky shores
30. Marine sandy beaches
31. Marine mudflats

Whittaker, R.H. 1975. Communities and ecosystems. 2nd edition. MacMillan, New York. (pp. 135-161).

Formations of Australia (Specht and Specht 2001) [a,b]

Australian types
Closed forests (rainforests) - tropical north-eastern Australia
Closed forests (rainforests) —subtropical eastern Australia
Closed forests (rainforests) —temperate south-eastern Australia
Semi-deciduous closed forests —monsoonal northern Australia
Semi-deciduous closed forests —subtropical eastern Australia
Eucalypt open forests and woodlands —monsoonal northern Australia
Eucalypt open forests and woodlands —subtropical eastern Australia
Eucalypt open forests and woodlands —temperate south-eastern Australia
Eucalypt open forests and woodlands —montane south-eastern Australia
Eucalypt open forests and woodlands —temperate south-western Australia
Eucalypt open forests and woodlands —Australia wetland forests
Mallee eucalypt open-scrubs —monsoonal northern Australia
Mallee eucalypt open-scrubs —subtropical eastern Australia
Mallee eucalypt open-scrubs —temperate south-eastern Australia
Mallee eucalypt open-scrubs —temperate south-western Australia
Heathlands and related shrublands —monsoonal northern Australia
Heathlands and related shrublands —subtropical eastern Australia
Heathlands and related shrublands —temperate south-eastern Australia
Heathlands and related shrublands —montane south-eastern Australia
Heathlands and related shrublands —temperate south-western Australia
Tussock grasslands
Acacia vegetation —subhumid, subtropical eastern Australia
Acacia vegetation —Ausralian Arid Zone
Hummock grasslands —Australian Arid Zone
Chenopod low shrublands —southern Australia Arid Zone
Aquatic vegetation —tropical and subtropical northern Australia
Aquatic vegetation —temperate southern Australia
Coastal dune vegetation
Coastal wetland vegetation (mangroves, salt marshes, and brackish wetlands)

[a] Specht, R.L. and A. Specht. 2001. Australia, ecosystems of.pages 307–324, in: S.A. Levin, ed. Encyclopedia of Biodiversity, Vol. 1. Academic Press, New York.

[b] Floristic groups are also provided for each formation.

F.5. Australian Native Vegetation (NWLRA 2001)

Vegetation profile fact sheets were developed for each type listed below, as provided by the NWLRA (National Land and Water Resources Audit Advisory Council). 2001. Australian native vegetation assessment 2001. National Land and Water Resources Audit. Canberra, Australia.

- Rain forest and vine thickets
- Eucalypt and tall open forests
- Eucalypt open forests
- Eucalypt low open forests
- Eucalypt woodlands
- Acacia forests and woodlands
- Callitris forests and woodlands
- Casuarina forests and woodlands
- Melaleuca forests and woodlands
- Other forests and woodlands
- Eucalypt open woodlands
- Tropical Eucalypt woodlands/grasslands
- Acacia open woodlands
- Mallee woodlands and shrublands
- Low closed forests and closed shrublands
- Acacia shrublands
- Other shrublands
- Heath
- Tussock grasslands
- Hummock grasslands
- Other grasslands, herblands, sedgelands and rushlands
- Chenopod shrublands, samphire shrubs and forblands
- Mangroves, tidal mudflats, samphires, claypans, sand, rock, salt lakes, lagoons and freshwater lakes

F.6. European Vegetation Survey (2002)[a]
A. Coastal mud-flats and brackish waters
B. Saltmarsh, sand-dune and sea-cliff vegetation
C. Rock crevice, scree and boulderfield vegetation
D. Freshwater aquatic vegetation
E. Springs, shoreline, and swamp [marsh] vegetation
F. Bogs and fens
G. Temperate grasslands, heaths, and fringe vegetation
H. Dry grasslands and semi-deserts
I. Oromediterranean grasslands and scrub
J. Montane tall-herb, grassland, fell-field and snowbed vegetation
K. Mediterranean garrigue, maquis, mattoral, tomillar and phyrygna
L. Temperate broadleaved forests and scrub
M. Montane heaths and coniferous forests
N. Weed communities

[a] Rodwell, J.S., J.H.J. Schamineé, L. Mucian, S. Pignatti, J. Dring and D. Moss. 2002. The diversity of European vegetation. An overview of phytosociological alliances and their relationships to EUNIS habitats. ECLNV. Report ECLNV nr. 2002/054. National Reference Centre for Agriculture, Nature and Fisheries, Wageningen, NL. 168 p.

Appendix G. Examples of Descriptive Methods for Describing Physiognomy — Structure

Küchler's method for structural description of vegetation

Küchler's (1967), method is a good example of the Descriptive-Mapping Physiognomic Approach (I). See also below for variations based on Dansereau (1951) and Beard (1981). These methods do not represent classifications, as such; rather, classifications are produced by combining the categories, sometimes *a priori* (e.g., Specht 1974), but more often, *a posteriori*, based on the process of mapping (e.g., Beard 1981).

Life-Form Categories			
Basic Life Forms		Special Life Forms	
Woody Plants		Climbers (lianas)	C
Broadleaf evergreen	B	Stem succulents	K
Broadleaf deciduous	D	Tuft plants	T
Needleleaf evergreen	E	Bamboos	V
Needleleaf deciduous	N	Epiphytes	X
Aphyllous	O		
Semi-deciduous (B+D)	S	Leaf Characteristics	
Mixed (D+E)	M	hard (sclerophyll)	h
Herbaceous Plants		soft	w
Graminoids	G	succulent	k
Forbs	H	large (>400 cm2)	l
Lichens, mosses	L	small (<4 cm 2)	s
Structural Categories			
Height (Stratification)		Coverage	
> 35 m	8	continous (>75 percent)	c
20–35 m	7	interrupted (50–75 percent)	i
10–20 m	6	parklike, in patches (25–50 percent)	p
5–10 m	5	rare (6–25 percent)	r
2–5 m	4	barely present, sporadical (1–5 percent	b
0.5–2	3	almost absent, extremely scarce(<1 percent)	a
0.1–0.5	2		
<0.1	1		

Other Examples

Dansereau (1951) has six categories, instead of four. Basic Life Forms is separated into two parts: Basic Life-forms (trees, shrubs, herbs, bryophytes, epiphytes, lianas) and Function (deciduous, semi-deciduous, evergreen, evergreen-succulent or leafless); Leaf Characteristics is separated into Leaf Shape and Size (needle, graminoid, small, large-broad, compound, thalloid) and Leaf Texture (filmy, membranous, sclerophyll, succulent-fungoid). Height and Coverage categories are similar to Küchler.

Beard (1981) provides an example amended specifically for Australia that consists of three categories: (1) Physiognomy of Dominant Stratum (Tall Trees >25 m tall, Medium Trees 10–25 m tall, Low Trees <10 m tall, Shrubs >1 m tall, Dwarf shrubs <1 m tall, Bunch Grasses, Hummock grass, Forbs, Lichens&Mosses, Succulents); (2) Floristics (Eucalyptus, Acacia, Triodea, Heterogenous); and (3) Density (Dense canopy, Mid-dense canopy, Incomplete Canopy, Rare but Conspicuous, Barren-vegetation largely absent, Scattered).

Beard, J.S. 1981. Classification in relation to vegetation mapping. Pages 97–106 in: A.N. Gillison and D.J. Anderson. Vegetation classification in Australia. CSIRO and Australian National University Press, Canberra, Australia 229 pp.

Appendix H. Key to bioclimatic maps of the world—Rivas Martinez & Rivas-Saenz

	In territories with a northern latitude of >72 or a southern latitude of > 56°. In territories outside this latitude and with an altitude of less than 200 m (1): annual positive temperature Tp < 380	Polar
	In territories with an altitude of less than 200 m (1): annual positive temperature TP > 380.	2
2	In territories with an altitude of less than 200 m (1). continentality index lc < 11, positive temperature of the summer quarter Tps > 320, mean annual temperature < 6°, annual positive temperature 320–720	Boreal
	Does not meet the conditions	3
3	In territories with an altitude of less than 200 m (1), depending on the continentality index lc, the values of the mean annual temperature T and the annual positive temperature Tp must be as follows: for lc < 21: T < 5.3° and Tp < 720; for lc = 21 – 28: T < 4.8° and Tp < 740; for lc > 28: T < 3.8° and Tp < 800	Boreal
	Does not meet the conditions	4
4	Summer with no water deficit; ombrothermic index of the hottest two months in the summer quarter los2 > 2 or the summer ombrothermic index resulting from the compensation losc4 > 2	Temperate
	Does not meet the conditions	Mediterranean

If the location is situated at an altitude of over 200 m, the temperature values need to be calculated theoretically, increasing T by 0.6°, M by 0.5°, and It or Itc by 13 units for every 100 m over that altitude; if it is situated to the north of parallel 48° N or to the south of parallel 51° S, the values of the mean annual temperature and the annual positive temperature Tp must also be calculated by increasing T by 0.4° and Tp by 12 units for every 100 m over this altitude. When Ic ≥ 21 (continental) or when It or Itc < 120 the thermotype is calculated based on the annual positive temperature, and the theoretical values of Tp at 200 m, increasing 55 units every 100 m over this altitude.

Abbreviations: See Rivas Martinez and others (1999)

Tp = Yearly positive temperature. In tenths of degrees C, sum of the monthly average temperature of those months whose average temperate is above 0 ^{o}C.

Tps = Summer positive temperature. Positive temperature of the summer quarter.

Ic = Continentality Index (year thermic interval). Ic = Tmax – Tmin. In degrees C, the number expresses the range between the average temperatures of the warmest month (Tmax) and the coldest (Tmin) months of the year. (Hyperoceanic Ic = 0-11, Oceanic = 11-21, Continental = 21=65).

Iosc = Summer compensated ombrothermic Index.

Appendix I. Key to Formation Class (Level 1)

The user should be aware of the following features of the classification, as it relates to the key:

- Classifies existing vegetation, regardless of its relation to site potential or land use.
- Includes all existing vegetation—natural (forests, grasslands, etc) and cultural (lawns, orchards, etc).
- Applies to all vegetated areas, vascular and nonvascular, where cover is greater than 1 percent.
- Typically defines high level types using a “combination of growth-forms” approach to classify vegetation, rather than simply structure
- A number of thresholds are appearing with some regularity in the definition of classes, and it is worth noting them here to assess their merits and their role in the key
    - >10 percent tree cover (mesomorphic forest types, xeromorphic woodland types)
    - <10 percent vascular plant cover (lithomorphic or cryptogamic vegetation types)
    - <10 percent emergent plant cover (aquatic vegetation types)
    - +50 percent (or simple majority) when two or more co-equivalent growth forms are present.
- Wetlands are not a class because wetlands often lack distinctive growth forms at the highest level; but all major wetland types are recognized at level 3. For some users a separate key focused on wetland may be desirable.

Within the shrub and herb vegetation class, shrublands are distinguished from grasslands when shrubs have >25 percent cover, or if both shrubs and herbs are <25 percent, then shrubs exceed herb cover.

Finally, this key should always be used in conjunction with the description of the types. As Rodwell (1991) stated, *“With something as complex and variable as vegetation, no key can pretend to offer an infallible shortcut to diagnosis… [Keys] should therefore be seen as simply a crude guide to identifying the types of woodland and scrub in the scheme and must always be used in conjunction with the data tables and community descriptions.”*

Selecting the Area to Key

For general survey work, where a sampling design is not being used, simply select a uniform and representative area in the site, which may be as small as a plot (typically 20 x 20 m (0.04) or larger, such as 0.5 ha (1 acre) or more. When the goal is to assign the vegetation type of a large area (e.g., 0.5 ha or more), several plots or assessments can be done, and the most typical type present may be assigned to the plot, patch, or polygon. Occasionally, very distinct vegetation and ecological patches may occur at smaller scales, such as a localized seep, or sloping fen, and if such patches are to be noted, the area to be keyed should be restricted to that patch.

This key provides ecological guidance on identification of vegetation types. It is not meant to determine policy.

After keying out a class, read brief description on the next page (*Brief Descriptions of Formation Classes*) to verify the placement. Fuller descriptions are available at usnvc.org and natureserve.org/explorer/classeco.htm. Terms used in the key are defined in Appendix C (Glossary) and Appendix D (Growth forms).

Areas with less than 1 percent total vascular plant cover are not considered in the key. Areas in deep water, although theoretically classifiable with this key, will also be classified in coordination with lake, river and ocean classifications[1].

1\. Vegetation structure and/or composition determined by a spontaneously growing set of plant species shaped by ecological processes 2

1\. One or more layers of the vegetation's structure and/or composition determined by regular human activity such as planting, tilling, cropping, mowing, and/or irrigating (see C7).....................................**Agricultural & Developed Vegetation (C7)**

2\. Mesomorphic tree height equal to or taller than other growth forms and mesomorphic tree cover >10 percent[2] ....**Forest & Woodland (C1)**

[1] The USNVC will coordinate classification of freshwater aquatic vegetation with the U.S. wetland and deep water classification standard (Cowardin 1979) and the draft Coastal and Marine Ecological Classification Standard (CMECS). For example, water bodies that are deeper than 2 m and >8 ha in size are treated as lakes, and aquatic vegetation may be treated as part of a lake type.

[2] Dixon et al. (2014) suggest that in temperate zones, trees typically have less than 10 percent canopy cover, are less than 5 m tall and single-layered, or in tropical regions, trees typically have less than 40 percent canopy cover, are less than 8 m tall, and single layered.

2. Mesomorphic tree height shorter than other growth forms (any percentage), or mesomorphic tree cover <10 percent[2]... 3

3. Habitats having flooded conditions; hydromorphic plant cover >1 percent, emergent plant cover <10 percent ....**Aquatic Vegetation**[3] **(C5)**

3. Habitats various, temporary surface water may be present; hydromorphic plant cover variable or absent, emergent plant cover >10 percent................................. 4

4. Vegetation on rocky substrates (bedrock, cliff, talus, scree) and with cryptogams (including lichens, mosses, algae, ferns) >1 percent and vascular plant cover predominantly mesomorphic growth forms, but <10 percent. ....
.... **Open Rock Vegetation (C6)**

4. Vegetation on rocky substrates and with cryptogams >1 percent, and vascular plant cover predominantly cryomorphic or xeromorphic growth forms and <10 percent, OR vegetation on other substrates and cryomorphic, mesomorphic[4] (except tree cover), xeromorphic (including nonvascular) plant cover >1 percent; 5

5. Cryomorphic shrub and herb plant cover is the plurality of cover, cold temperature conditions limiting; height 0.3 m in polar and temperate alpine regions, various in tropical high mountain regions...... **Polar & High Mountain Scrub & Grassland (C4)**

5. Xeromorphic or mesomorphic plant cover is the majority of the cover; cold temperature conditions not limiting; height >0.3 m... 6

6. Xeromorphic tree, shrub, and herb plant cover (e.g., succulents) is the majority of cover; water strongly limiting.. **Desert & Semi-Desert (C3)**

6. Mesomorphic shrub and herb plant cover is the majority of the cover, water less limiting..**Shrub & Herb Vegetation (C2)**

---

[3] See footnote 1.

Brief Definitions of Formation Classes

Forest & Woodland [Mesomorphic Tree Vegetation] (C01)

Tropical, temperate and boreal forests and woodlands, and open tree savannas*, characterized by mesomorphic tree growth forms (including *broad-leaved, needle-leaved, sclerophyllous, krummholz*, *palm, bamboo trees*, and *tree ferns*), typically with at least 10 percent cover, irregular horizontal spacing and canopy structure; and spanning climatic and moisture conditions from humid, to seasonally dry, and wet to dry, respectively. Includes native forests as well as managed and some plantation forests where human management is infrequent.

*Tropical savanna thresholds may differ from temperate savannas.

Shrub & Herb Vegetation [Mesomorphic Shrub & Herb Vegetation] (C02)

Grasslands, shrublands, marshes, bogs and fens characterized by mesomorphic shrub and herbaceous plant growth forms (including *broad-leaved, needle-leaved, sclerophyllous*, and *rosette shrubs*, *forbs* and *graminoids*) with mesomorphic trees typically less than 10 percent cover, irregular horizontal spacing, and a varied canopy structure, typically >0.3 m tall; climatic and moisture conditions vary from humid to seasonally dry, and wet to dry, respectively.

Desert & Semi-Desert [Xeromorphic Scrub & Herb Vegetation] (C03)

Cool and warm deserts and semi-deserts characterized by xeromorphic growth forms (including *succulent* [e.g., cacti, euphorbias], *small-leaved shrubs* and *trees*, *forbs* and *graminoids*) with sparse, irregular horizontal spacing and an open to sparse and varied canopy structure, typically >0.3 m tall; climatic and moisture conditions vary from dry to very dry. Includes open rocky habitats (barrens, polar desert) of polar tundra.

Polar & High Mountain Scrub and Grassland [Cryomorphic Scrub, Herb & Cryptogam Vegetation] (C04)

Polar, alpine and tropical high montane habitats characterized by cryomorphic growth forms (including *dwarf-shrubs*, *forbs*, *graminoids, lichens* and *bryophytes*) with sparse to dense horizontal spacing and a short, open to closed canopy structure, typically <0.3 m tall; climatic and moisture conditions vary from dry to very dry. Includes open rocky habitats of alpine vegetation.

Aquatic Vegetation [Hydromorphic Vegetation] (C05)

Open freshwater and saltwater wetlands characterized by aquatic growth forms, either rooted with leaves rising up to or near the surface, or floating freely on or below the water surface; emergent cover <10 percent. Stands typically have surface water, generally up to 2 m in depth, along ocean, lake, pond, and river margins in freshwater, tidal, or intertidal habitats.

Open Rock Vegetation [Cryptogam — Open Mesomorphic Vegetation] (C06)

Open rocky habitats (such as cliffs, talus, scree, pavement, cobbles, lava, or boulder fields) characterized by cryptogam and open mesomorphic growth forms (including *lichens, bryophytes, algae or ferns*), and mesomorphic, herb, shrub, and tree growth forms less than 10 percent cover, with very sparse horizontal spacing and a very open canopy structure. Typically found in tropical, temperate, and boreal regions. Excludes rocky habitats of polar, alpine, and cool and warm desert and semi-desert vegetation.

Agricultural & Developed Vegetation [Anthromorphic Vegetation] (CCL01)

Agricultural lands (including row crops, intensive pastures, orchards, vineyards, plowed or harvested fallow fields, rice paddies, and farm ponds) and Developed lands (vegetation of urban, suburban, and rural cities and villages; typically lawns, parks, gardens, golf courses, and urban ponds).

Appendix J. Examples of Divisions

1.B.2. Cool Temperate Forest & Woodland Divisions

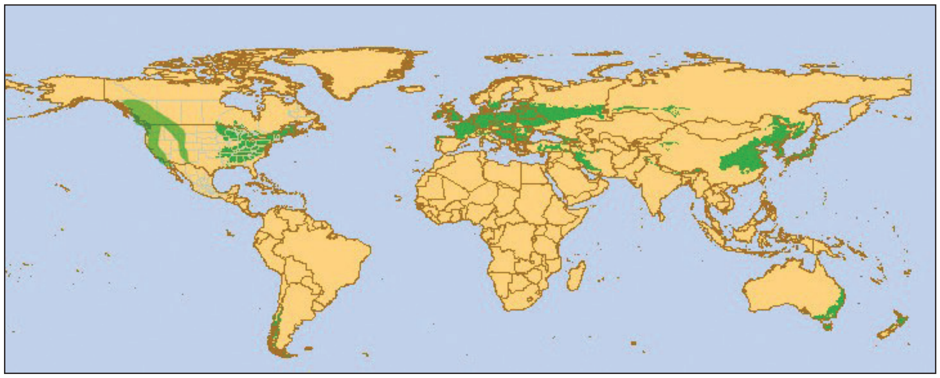

Figure J.1—Distribution of the Cool Temperate Forest formation, based on ecoregions where *Cool Temperate Forest* is or was the dominant vegetation. Map is based on Olson and others (2001), and modified from a map by M. Jennings.

DIVISIONS

North America

- Eastern North American Forest & Woodland
- Western North American Cool Temperate Woodland & Scrub
- Rocky Mountain Cool Temperate Forest & Woodland
- Vancouverian Cool Temperate Forest

South America

- 1.B.2.Ee Valdivian Cool Temperate Forest
- 1.B.2.Ef Magellanian Cool Temperate Forest

Eurasia

- Western Eurasian Cool Temperate Forest & Woodland
- Central Eurasian Cool Temperate Forest & Woodland
- Eastern Asian Cool Temperate Forest & Woodland

Australian-New Zealand

- Southern New Zealand-Tasmanian Cool Temperate Forest & Woodland?
- Southeast Australian Cool Temperate Forest & Woodland

2.A.1. Tropical Lowland Grassland, Savanna & Shrubland Divisions

Grassland and Shrubland divisions taken from Dixon et al. (2014). See also Faber-Langendoen and Josse (2010)

2.A.1.Ea Caribbeo-Mesoamerican Lowland Shrubland, Grassland & Savanna
2.A.1.Eb Amazonian Shrubland & Savanna
2.A.1.Ed Brazilian-Parana Lowland Shrubland, Grassland & Savanna
2.A.1.Er Colombian-Venezuelan Lowland Shrubland, Grassland & Savanna
2.A.1.Es Guianan Lowland & Upland Grassland, Savanna & Shrubland
2.A.1.Ff West-Central African Mesic Woodland & Savanna
2.A.1.Fg Eastern & Southern African Dry Savanna & Woodland
2.A.1.Fh Mopane Savanna
2.A.1.Fi Sudano-Sahelian Dry Savanna
2.A.1.Fn Miombo & Associated Broadleaf Savanna
2.A.1.Fo Eastern African Moist Woodland & Savanna
2.A.1.Fp Malagasy Dry Forest & Scrubland
2.A.1.Fq Malagasy Subhumid Woodland & Savanna
2.A.1.Ij Indo-Malayan Mesic Savanna & Grassland
2.A.1.Lk Australian Tropical Savanna
2.A.1.Ol Polynesian Lowland Shrubland, Grassland & Savanna
2.A.1.Om Eastern Melanesian Lowland Shrubland, Grassland & Savanna

2.B.1. Mediterranean Scrub & Grassland Divisions

Grassland and Shrubland divisions taken from Dixon et al (2014. See also Faber-Langendoen and Josse (2010)

2.B.1.Ei Chilean Mediterranean Scrub, Grassland & Forb Meadow
2.B.1.Ej Chaco-Espinal Scrub & Grassland
2.B.1.Fh South African Cape Mediterranean Scrub
2.B.1.Le Australian Mediterranean Scrub
2.B.1.Na Californian Scrub
2.B.1.Nb Californian Grassland & Meadow
2.B.1.Pc Mediterranean Basin Scrub
2.B.1.Pd Mediterranean Basin Montane Grassland & Scrub
2.B.1.Pg Mediterranean Basin Dry Grassland
2.B.1.Pk Northern African Mediterranean Scrub
2.B.1.Pl Mediterranean Alpine Grassland & Scrub

2.B.2. Temperate Grassland & Shrubland Divisions

Grassland and Shrubland divisions taken from Dixon et al. (2014). See also Faber-Langendoen and Josse (2010).

2.B.2.Ek Pampean Grassland & Shrubland
2.B.2.En Madrean Grassland & Shrubland
2.B.2.Eo Patagonian Grassland & Shrubland
2.B.2.Fm Southern African Montane Grassland
2.B.2.Li Australian Grassland & Shrubland
2.B.2.Lj New Zealand Grassland & Shrubland
2.B.2.Na Western North American Grassland & Shrubland
2.B.2.Nb Great Plains Grassland & Shrubland
2.B.2.Nc Eastern North American Grassland & Shrubland
2.B.2.Nd Western North American Interior Sclerophyllous Chaparral
2.B.2.Ne Southeastern North American Grassland & Shrubland
2.B.2.Pf European Grassland & Heath
2.B.2.Pg Western Eurasian Grassland & Shrubland
2.B.2.Ph Eastern Eurasian Grassland & Shrubland

To learn more about RMRS publications or search our online titles:

www.fs.fed.us/rm/publications

www.treesearch.fs.fed.us