

# **GAP ANALYSIS TECHNICAL BULLETIN 2**

## **Natural Terrestrial Cover Classification: Assumptions and Definitions**

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## INTRODUCTION

The purpose of this paper to further discuss the assumptions and definitions used for the natural terrestrial cover component of the National Gap Analysis land and water cover classification system for the United States. A full description of the Gap Analysis concept and process is described by Scott and others (1993).

The overall cover classification system for Gap Analysis consists of three primary categories, each of which is subsequently classified according to the following systems (in a few cases with some modifications):

- a) *natural terrestrial cover* is classified by the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 1973) system (as modified for the United States by Driscoll and others (1983, 1984) and by this bulletin, see below);
- b) *natural aquatic cover* is classified by the system of Cowardin and others (1979); and
- c) *cultural, or developed, cover* is classified by the system of Anderson and others (1976).

The Gap Analysis cover classification system has been constructed to both fit with other major land inventory projects, such as the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program, and to serve the needs of the National Gap Analysis mission. The first three levels of the classification system are presented in Table 1. A discussion of assumptions and definitions for the natural terrestrial cover component of this classification system follows.

## CLASSIFICATION OF EXISTING NATURAL TERRESTRIAL COVER

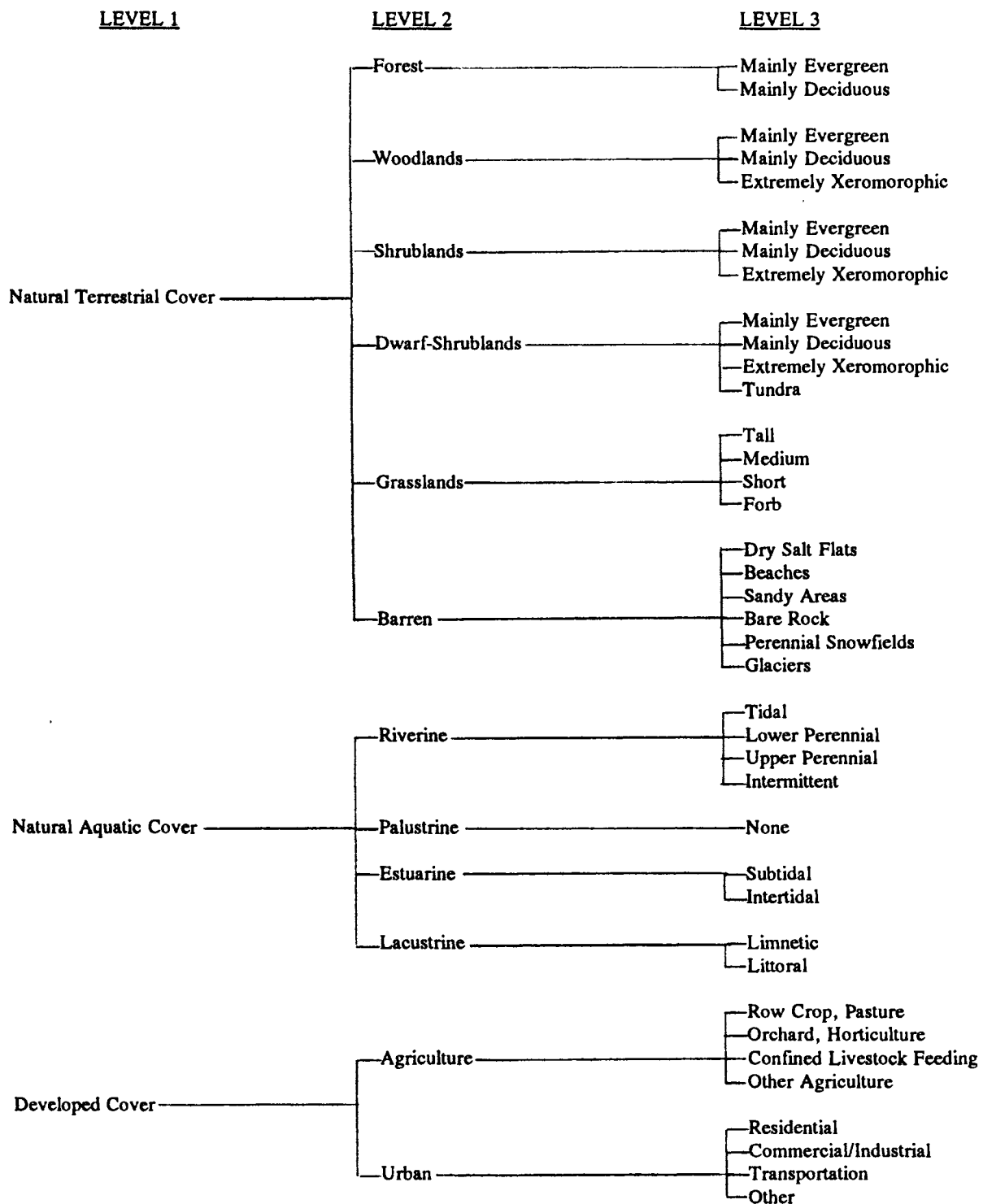
Gap Analysis seeks to map the extent and distribution of *existing* vegetation and barren areas in order to: a) determine species and natural community representation within areas being managed for biodiversity conservation; b) provide spatial data that can be used to model wildlife habitat distributions; and c) provide a

single temporal data set for later comparison.

To do this, areas of similar plant species composition and structure must be delineated, identified, classified and labeled. For natural terrestrial cover the Gap Analysis project has chosen the UNESCO (1973) format, with the addition of lower levels and class distinction criteria parallel to those developed by Driscoll and others (1983, 1984; an Interagency Agreement related to classifications and inventories of natural resources, between USDA Forest Service and Soil Conservation Service, and USDI Bureau of Land Management, Fish and Wildlife Service and Geological Survey). Furthermore, although our primary concern with natural terrestrial cover is vegetation, we have added barren as a class-level category to the UNESCO format (Table 1). For an example of the UNESCO format see Table 2.

This classification scheme is used because it offers an accepted and useful hierarchical grouping that is based primarily on the physiognomic, or the structural expression of plant cover relative to environment as well as groupings by floristic composition. The physiognomic and floristic classification approach is important for Gap Analysis because it can be related to animal habitat in terms of plant species assemblages, vegetation structure, climate, and plant morphology. For a thorough discussion of the UNESCO classification scheme and the physiognomic approach to vegetation classification (including a key to Raunkiaer plant life forms) see Mueller-Dombois and Ellenberg (1974). See Appendix A for a chart showing the vegetation classifications to the formation level for the United States. Generating a classification listing to the cover type level for the entire United States, similar to the one Bourgeron and Engelking (1992) did for the western states is a Gap Analysis goal being pursued in cooperation with The Nature Conservancy.

Table 1. A land and water classification system for Gap Analysis.



	<u>Category</u>	<u>Example</u>
physiognomic	Class	Woodlands
	Subclass	Mainly Evergreen Woodlands
	Group	Evergreen Needle-Leaved Woodlands
	Formation	Evergreen Coniferous Woodlands with Rounded Crowns
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floristic	Cover Type	<i>Juniperus occidentalis</i>
	Community Type	<i>Juniperus occidentalis</i> / <i>Artemisia tridentata</i> (the codominant species of the plant community by canopy layers)

Table 2. UNESCO vegetation classification format.

It is important to understand that the UNESCO format as modified for the United States by Driscoll and others (1983, 1984) was originally meant only to describe *potential* vegetation at climax stage. The categories of class, subclass, group, and formation are physiognomic and therefore applicable to Gap Analysis. However, the two lower levels (the floristic part) of the modified UNESCO system developed by Driscoll and others are plant "series" and plant "associations." These terms refer to concepts of potential or climax vegetation rather than actual or existing vegetation, and their use as applied to actual vegetation has been the source of some confusion. The terms analogous to "series" and "association" which refer to existing vegetation are "cover type" and "community type" respectively. Because Gap Analysis is concerned with present-day conditions, all terms and concepts used herein refer to actual vegetation, whether in seral or climax stages of development. The two lower

level floristic categories for Gap Analysis, then, are "cover type", and "community type" (see Table 2, and the section on definitions).

## ECOREGIONS

As a point of departure, Bailey's (1976) section-level ecoregions are used to define discrete ecological units for analysis of large regions. This is not meant to preclude the use of other ecoregion schemes, rather that this is a starting point. The Bailey map of ecoregions is widely used and is predicated on clear rules of combination (Bailey, 1983). Original Gap Analysis vegetation data for any given geographic area can be readily applied to other ecoregion schemes, depending on the questions being asked. For convenience, Appendix B is a map showing section-level ecoregions and states of the U.S. Appendix C is a list of states by each of Bailey's 54 section-level ecoregions for the 48 coterminus states, Appendix D is a list of the ecoregions by each state. Readers are cautioned that

Bailey is currently revising the ecoregion map of the United States, based on better information and on an improved understanding of the integrated relationships among climate, land surface, vegetation, and scale, resulting partially from work done to map ecoregions of the continents (Bailey, 1989; personal communication).

## ASSUMPTIONS

A. All references and applications are made to actual land cover rather than historic land cover or potential climax vegetation.

B. Classifications of natural systems are imprecise; there will always be zones of transition and variants, and vegetation boundaries may not be discrete.

C. The criteria used to define classification categories (e.g., tree savannah = tree canopy cover of 11-25 % over grassland) are general. They are meant as data quality objectives (DQOs, see definitions) as a means for grouping and discussing discrete cover types, from coarse categories such as grasslands to finer categories such as short-grass communities composed of bunch grasses.

D. In order to create useful categories across both biotic and geographic scales, it is necessary to use both subdivisions and aggregations. Subdivision begins with a whole and divides it into smaller units according to similarities. Aggregation begins with a set of individual objects and groups them according to similarities. For example, classifications at the regional or landscape level (e.g., evergreen coniferous woodlands with rounded crowns) are based on the physiognomic subdivisions of class, subclass, group, and formation. Classifications at the minimum mapping unit level (e.g., *Juniperus occidentalis/Artemisia tridentata*) are based on a floristic aggregation of associated plant species up to the community type level (Table 2; see definitions).

E. The classification system should fit within and among existing accepted national and international land cover classification systems (e.g., UNESCO and The Nature Conservancy for mapping vegetation, U.S. Fish and Wildlife Service classification of wetlands and deepwater habitats, U.S. Geological Survey classification of land use and land cover).

F. The classification scheme is open-ended. Categories may be added to any of the hierarchical levels (e.g., class, subclass, group, formation) as long as the additions are truly an equivalent category within the given classification level.

G. The classification scheme is intended to be the super-structure upon which information can continuously be placed for meaningful analysis and interpretation. It is assumed that: (a) vegetation patterns will be forever changing; and (b) better and more detailed information will continually be developed and entered into Gap Analysis databases.

H. Although Landsat Thematic Mapper (TM) imagery and its spectral classifications are used as a base map, TM imagery is not the sole source of information for the vegetation classification. Because substantial amounts of ancillary data are used (i.e., air photos, expert knowledge, agency records, digital elevation models, field reconnaissance), the classification system and the overall map products are considered "platform independent" --that is, not constrained or defined only by what can be resolved from TM processing.

I. Because the minimum mapping unit (MMU) is 100 hectares, cover type occurrences smaller than this will not be resolved. If greater resolution is desired for certain objects of interest the MMU may be smaller, for example, an MMU of 40 hectares is often used to resolve riparian areas.

J. A variety of attributes may be attached to a given label or polygon that are not displayed in map format for Gap Analysis purposes. These attributes are kept in a data layer's attribute table, general information concerning transformations is kept in the data layer's data dictionary.

K. Map products will be useful for purposes other than Gap Analysis alone.

## DEFINITIONS

The following six definitions of class, subclass, group, formation, cover type and community type are for the six hierarchical levels of Gap Analysis natural terrestrial cover classification system (Table 2). The class level corresponds to Level 2 (Forests, Woodlands, etc...) of the overall cover classification scheme shown in Table 1. Subclass corresponds to Level 3 shown in Table 1. Group corresponds to Level 4 (not shown in Table 1), formation to Level 5, cover type corresponds to Level 6, and community type corresponds to Level 7 of the overall land cover classification system. The following is intended to provide meanings for the classification's terrestrial vegetation hierarchical categories.

**Class:** Made up of six primary categories for classifying terrestrial cover (e.g., "Woodlands" in Table 2). The first five of these classes represent vegetation cover, the sixth class represents bare ground. The separations between classes representing vegetation are based on the spacing and height of dominant vegetative growth form (see Appendix A). The criteria given are DQOs +/- 5 %.

I. **Forests:** Areas dominated by trees with a total canopy cover of 61 % or more, tree crowns usually interlocking.

II. **Woodlands:** Areas dominated by trees with a total canopy cover of 26-60 %, most tree crowns not touching each other. An herbaceous or shrub understory, or both, are usually present. An open stand of trees,

sometimes called "open forest."

III. **Shrublands:** Areas dominated by shrubs that generally exceed 0.5 meter in height when mature, with a total canopy cover of 26 % or more. A tree canopy cover of 26 % or less may be present.

IV. **Dwarf-Shrublands:** Areas dominated by shrubs rarely exceeding 0.5 meters in height when mature with a total canopy cover of 26 % or more. A tree or larger shrub canopy cover of 26 % or less may be present. This class is sometimes called heaths or heath-like.

V. **Grasslands:** Areas dominated by grass, grass-like, or forb vegetation with a tree or shrub component not exceeding 26 % cover.

VI. **Barren:** Areas where vegetation cover is less than 5 %. This includes dry salt flats, beaches, sandy areas, bare rock, perennial snowfields, and glaciers.

**Subclass:** Categories within each class comprised of areas in which the main vegetation is morphologically similar. For the classes of forests, woodlands, shrublands and dwarf-shrublands the similarities are based on:

- I. evergreen;
- II. deciduous; and
- III. xeromorphic characteristics.

For the class of grasslands the similarities are based on:

- I. grass-like plants
  - A. tall, more than 1.0 meter in height;
  - B. medium, from 0.5 to 1.0 meter in height;
  - C. short, less than 0.5 meter in height;
- II. forbs.

**Group:** Categories within each subclass which may be based on any of the following:

- I. for forests, woodlands, shrublands:
  - A. climate, e.g., tropical, temperate, subpolar;
  - B. morphology, e.g., broad-leaved sclerophyllous, needle-leaved.
- II. for dwarf-shrublands:
  - A. cover

1. closed canopy in which more than 60 % of the area is covered by dwarf-shrubs
  2. open canopy in which 26 to 60 % of the area is covered by dwarf-shrubs;
- B. associated forms of vegetation, e.g., mixed with herbaceous plants;
- C. climate, e.g., cold, drought;
- D. morphology, e.g., evergreen, deciduous.
- III. for grasslands:
- A. tree or shrub canopy less than 10 % for areas dominated by graminoids;
  - B. tree canopy or shrub canopy 11 - 25 % for areas dominated by graminoids, e.g., tree or shrub savannah;
  - C. alpine and subalpine occurrence;
  - D. areas dominated by forbs more than 1 meter in height;
  - E. areas dominated by forbs less than 1 meter in height.

**Formation:** Categories within each group comprised of areas in which the vegetation similarities are based on any of the following criteria.

- I. tree size and crown shape:
  - A. giant forests are those more than 50 meters in height having
    1. rounded crowns, e.g. *Pinus ponderosa*
    2. conical crowns, e.g. *Pseudotsuga menziesii*
    3. narrow cylindro-conical crowns, e.g., *Abies lasiocarpus*;
  - B. non-giant forests are those 5-50 meters in height having
    1. rounded crowns, e.g. *Pinus ponderosa*
    2. conical crowns, e.g. *Pseudotsuga menziesii*
    3. narrow cylindro-conical crowns, e.g., *Abies lasiocarpus*;
- II. life zone:
  - A. temperate lowland
  - B. montane
  - C. alpine
  - D. boreal

III. substrate:

- A. alluvial
  - B. serpentine
- IV. kinds of associated vegetation, e.g.,
- A. broad-leaved forest with evergreen needle-leaved trees
  - B. with or without succulents
- V. amount and kind of understory, e.g., creeping or matted dwarf-shrubland.

**Cover Type:** A group of plant community types having the same primary dominant species and similar physiognomy; an aggregation of plant community types.

**Community Type:** An assemblage of plant species that interact at the same time and place, of defined species composition, and physiognomy, regardless of seral stage; usually named by combining the name of the species that dominates the canopy layer with the name of the species that dominates lower vegetation layers (e.g., *Juniperus occidentalis* / *Artemisia tridentata*).

Other terms used in the classification of terrestrial vegetation for Gap Analysis and their definitions follow.

**Data Quality Objectives:** The accuracy and precision objectives for data representation of location and object attributes.

**Dominant or Codominant:** Pertaining to the plant species having the greatest relative canopy cover.

**Forb:** A non-graminoid herb.

**Natural Community:** A discrete group of plant and animal species that reoccur across a landscape.

**Natural Vegetation:** Vegetation that is regenerating without cultivation regardless of previous disturbance; not restricted to undisturbed climax vegetation.

**Shrubs:** Woody perennial plants, usually with

multiple stems, 0.5-5 meters in height at maturity.

**Trees:** Woody perennial plants, usually single stemmed with definite crown shape and reaching a height of five meters in height when mature.

**Xeromorphic:** Plants morphologically adapted to dry conditions such as with extremely scleromorphic or strongly reduced leaves, green branches without leaves or succulent stems, some with thorns.

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## APPENDIX A

### A KEY TO NATURAL TERRESTRIAL VEGETATION FORMATIONS<sup>1</sup>

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<sup>1</sup>From Driscoll, R.S., D.L. Merkel, D.L. Radloff, D.E. Snyder, and J.S. Hagihara. 1984. An ecological land classification framework for the United States. U.S.D.A. Forest Service, Miscellaneous Publication 1439, Washington, D.C. p. 21.

Class: Forest<sup>1</sup>

Class:Forest	Subclass	Group	Formation
Trees over 5 m tall forming 61 to 100 percent canopy cover	A. Mainly evergreen forest (canopy never without green foliage although some trees may shed their leaves)	1. Tropical rain forest (mainly broad-leaved evergreen trees, neither cold-nor drought--resistant)	<ul style="list-style-type: none"> <li>a. Tropical lowland rain forest</li> <li>b. Tropical submontane rain forest</li> <li>c. Tropical montane rain forest</li> <li>d. Tropical "subalpine" rain forest</li> <li>e. Tropical (rain) cloud forest</li> <li>f. Tropical alluvial rain forest</li> <li>g. Tropical swamp rain forest</li> <li>h. Tropical evergreen bog forest (classical tropical rain forests)</li> </ul>
		2. Tropical and subtropical evergreen seasonal forest (mainly broad-leaved evergreen trees with some foliage reduction in dry season)	<ul style="list-style-type: none"> <li>a. Tropical or subtropical evergreen seasonal lowland forest</li> <li>b. Tropical or subtropical evergreen seasonal submontane forest</li> <li>c. Tropical or subtropical evergreen seasonal montane forest</li> <li>d. Tropical or subtropical evergreen dry "subalpine" forest</li> </ul>
		3. Tropical and subtropical semideciduous forest (upper canopy trees drought deciduous)	<ul style="list-style-type: none"> <li>a. Tropical or subtropical semideciduous lowland forest</li> <li>b. Tropical or subtropical semideciduous montane or cloud forest</li> </ul>
		4. Subtropical rain forest (not represented in U.S.)	<ul style="list-style-type: none"> <li>a. Subtropical lowland rain forest</li> <li>b. Subtropical submontane rain forest</li> <li>c. Subtropical montane rainforest</li> <li>d. Subtropical "subalpine" rain forest</li> <li>e. Subtropical (rain) cloud forest</li> <li>f. Subtropical alluvial rain forest</li> <li>g. Subtropical swamp rain forest</li> <li>h. Subtropical evergreen bog forest (with organic surface deposits)</li> </ul>

Class: Forest - Continued

Class: Forest	Subclass	Group	Formation
5.	Mangrove forest		a. Tropical rain swamp forest (mangroves of Florida)
6.	Temperate evergreen seasonal broad-leaved forest (may not be represented in U.S.)		a. Temperate evergreen seasonal lowland forest b. Temperate evergreen seasonal submontane forest c. Temperate evergreen seasonal montane forest d. Temperate evergreen dry "subalpine" forest
7.	Winter-rain, broad-leaved scierophyllous forest (stiff, leathery-leaved trees)		a. Winter-rain evergreen scierophyllous lowland and submontane forest (over 50 m tall) ( <i>Eucalyptus</i> in Calif.) b. Winter-rain evergreen scierophyllous lowland and submontane forest (less than 50 m tall) (live-oak in Calif.)
8.	Tropical and subtropical needle-leaved forest (may not be represented in U.S.)		a. Tropical and subtropical lowland and submontane evergreen needle-leaved forest b. Tropical and subtropical montane and subalpine evergreen and needle-leaved forest
9.	Temperate and subpolar needle-leaved forest (mostly needle-leaved and scale-leaved forest)		a. Evergreen giant forest (e.g., redwood and Douglas fir) b. Evergreen forest with rounded crowns (e.g., sugar pine) c. Evergreen needle-leaved forest with conical crowns (e.g., spruce-fir) d. Evergreen forest with cylindrical crowns (boreal) (e.g., spruce forests of Alaska)

Class: Forest - Continued

Class:Forest	Subclass	Group	Formation	
B.	Mainly deciduous forest (majority of trees shed foliage as a result of drought and/or cold)	1.	Tropical and subtropical drought-deciduous forest (may not be represented in U.S.)	
		2.	Cold-deciduous forest, with evergreen trees (winter frost and freeze)	
		3.	Cold-deciduous forest, without evergreen trees (winter frost and freeze)	
	C.	Extremely xeromorphic forest (not represented in U.S.)	1.	Scierophyllous dominated forest
			2.	Thorn-forest
			3.	Mainly succulent forest
			a.	Drought-deciduous broad-leaved lowland and submontane forest
			b.	Drought-deciduous montane (and cloud) forest
			a.	Cold-deciduous forest with evergreen broad-leaved trees and climbers (e.g., magnolia)
			b.	Cold-deciduous broad-leaved forest with evergreen needle-leaved trees (e.g., maple/hemlock in New York State)
C.	Extremely xeromorphic forest (not represented in U.S.)	a.	Temperate lowland and submontane broad-leaved cold-deciduous forest (e.g., broadleaf forests of midwest)	
		b.	Montane or boreal cold-deciduous forest (e.g., broadleaf forests of the mountains)	
		c.	Cold-deciduous alluvial forest (e.g., bottomland hardwoods)	
		d.	Cold-deciduous swamp or peat forest (e.g., deciduous forest in parts of Alaska)	

<sup>1</sup>The key to the vegetation element is patterned after UNESCO 1973. The key contains a few examples of known communities in the United States.

Class: Woodland<sup>1</sup>

Class:Woodland	Subclass	Group	Formation	
Open forest (trees over 5 m tall forming 26 to 60 percent canopy cover)	A. Mainly evergreen woodland (canopy never without green foliage although some trees may shed their leaves)	1. Evergreen broad-leaved woodland	(No formations defined; includes evergreen oak woodlands)	
		2. Evergreen needle-leaved woodland	a. Evergreen needle-leaved woodland with rounded crowns (e.g., pine and juniper)	
			b. Evergreen needle-leaved woodland with conical crowns (e.g., spruce in the west)	
			c. Evergreen needle-leaved woodland with very narrow cylindro-conical crowns (e.g., some spruce in Alaska)	
		B. Mainly deciduous woodland (majority of trees shed foliage as result of drought or cold)	1. Tropical and subtropical drought-deciduous woodland (frost and freeze generally absent or moderate)	a. Drought-deciduous broad-leaved lowland and submontane woodland
				b. Drought-deciduous montane (and cloud) woodland
	2. Cold-deciduous woodland, with evergreen trees (winter frost and freeze)		a. Evergreen broad-leaved woodland	
			b. Evergreen needle-leaved woodland	
	3. Cold-deciduous woodland, without evergreen trees (winter frost and freeze)		a. Broad-leaved deciduous woodland.	
			b. Needle-leaved deciduous woodland	
	C. Extremely xeromorphic woodland (dry woodlands)	1. Scierophyllous woodland	a. Evergreen scierophyllous-dominated xeromorphic woodland	
			2. Thorn-woodland (may not be represented in U.S.)	a. Mixed deciduous-evergreen thorn woodland
b. Purely deciduous thorn woodland				
3. Mainly succulent woodland				

<sup>1</sup>The key to the vegetation element is patterned after UNESCO 1973. The key contains a few examples of known communities in the United States.

Class: Shrubland<sup>1</sup>

Class: Shrubland	Subclass	Group	Formation	
Shrubs 0.5 to 5 m tall forming 26 percent or greater canopy cover	A. Mainly evergreen shrubland (canopy never without green foliage although some shrubs may shed their leaves)	1. Broad-leaved shrubland (may not be represented in U.S.)	a. Low bamboo shrubland	
			b. Evergreen tuft-tree shrubland	
			c. Evergreen broad-leaved hemiscierophyllous shrubland	
			d. Evergreen broad-leaved scierophyllous shrubland	
			e. Evergreen suffruticose shrubland	
	B. Mainly deciduous shrubland (majority of shrubs shed foliage as result of drought and/or cold)	2. Needle-leaved and microphyllous shrubland	a. Evergreen needle-leaved shrubland (e.g., krummhoiz)	
			b. Evergreen microphyllous shrubland (sagebrush) <sup>2</sup>	
			1. Drought-deciduous shrubland, with evergreen woody plants (may not be represented in U.S. except Hawaii and island trusts and territories)	a. Temperate deciduous shrubland (e.g., serviceberry, some oaks)
				b. Subalpine or subpolar deciduous shrubland (e.g., willow, alder)
				c. Deciduous alluvial shrubland (e.g., some willow)
2. Drought-deciduous shrubland, without evergreen woody plants	d. Deciduous peat shrubland			
3. Cold-deciduous shrubland (winter frost and freeze)	a. Evergreen subdesert shrubland (e.g., creosote brush)			
C. Extremely xeromorphic (subdesert) shrubland (arid climate)	1. Mainly evergreen shrubland	b. Semideciduous subdesert shrubland (e.g. saltbush)		
		a. Deciduous subdesert shrubland without succulents		
		2. Deciduous shrubland	b. Deciduous subdesert shrubland with succulents (e.g., palo verde)	

<sup>1</sup>The key to the vegetation element is patterned after UNESCO 1973. The key contains a few examples of known communities in the United States.

<sup>2</sup>Sagebrush (*Artemisia*) shrubs are considered evergreen although one species, stiff sagebrush (*A. rigida*) is considered completely deciduous (Tisdale and Hironaka 1981.)

Class: Dwarf-Shrubland<sup>1</sup>

Class:Dwarf-Shrubland	Subclass	Group	Formation	
Shrubs less than 0.5 m tall forming 26 percent or greater canopy cover	A. Mainly evergreen dwarf shrubland (most dwarf shrubs evergreen)	1.	Closed dwarf-shrubland (over 60 percent canopy cover)	a. Evergreen caespitose closed dwarf-shrubland (e.g., alpine azalea) b. Evergreen creeping or matted dwarf-shrubland
		2.	Open dwarf-shrubland (26 to 60 percent canopy cover)	a. Evergreen cushion dwarf-shrubland (e.g., open alpine azalea)
		3.	Dwarf-shrubland mixed with herbaceous plants	a. Truly evergreen dwarf-shrub and herb mixed formation (e.g., some Alaska heath)
				b. Partially evergreen dwarf-shrub and mixed formation
	B. Mainly deciduous dwarf-shrubland	1.	Facultative drought-deciduous dwarf shrubland (foliage shed only in extreme years) (May not be represented in U.S.)	
		2.	Obligatory drought-deciduous dwarf shrubland (all or at least part of leaves shed in dry season)	a. Drought-deciduous caespitose dwarf-shrubland
				b. Drought-deciduous creeping or matted dwarf-shrubland
	3.	Cold-deciduous dwarf-shrubland (winter frost or freeze) (dwarf willow and other dwarf shrub communities of cold regions exclusive of tundra)	c. Drought-deciduous cushion dwarf-shrubland	
			d. Drought-deciduous mixed dwarf-shrubland	
	C. Extremely xeromorphic (subdesert) dwarf-shrubland (specific examples need to be determined)	1.	Mainly evergreen dwarf-shrubland	a. Cold-deciduous caespitose dwarf-shrubland
				b. Cold-deciduous creeping or matted dwarf-shrubland
				c. Cold-deciduous cushion dwarf-shrubland
				d. Cold-deciduous mixed dwarf-shrubland
1.	Evergreen subdesert dwarf-shrubland	a. Evergreen subdesert dwarf-shrubland		
		b. Semideciduous subdesert dwarf-shrubland		

Class: Dwarf-Shrubland - Continued

Subclass	Group	Formation
D.	2. Deciduous dwarf-shrubland	a. Deciduous subdesert dwarf-shrubland without succulents b. Deciduous subdesert dwarf-shrubland with succulents
	1. Tundra dwarf shrubland	a. Caespitose dwarf-shrub/moss tundra b. Creeping or matted dwarf-shrub/moss tundra
E.	2. Mainly lichen dwarf-shrubland (e.g., shrub-lichen tundra of Alaska)	
	1. Raised bog dwarf-shrubland	a. Typical bog dwarf shrubland (suboceanic, lowland and submontane) b. Montane (or "subalpine") raised bog dwarf-shrubland c. Subcontinental dwarf shrubland wooded bog
	2. Nonraised bog dwarf-shrubland	a. Blanket bog dwarf-shrubland (oceanic lowland, submontane or montane) b. String bog dwarf-shrubland

<sup>1</sup>The key to the vegetation element is patterned after UNESCO 1973. The key contains a few examples of known communities in the United States.



Class: Herbaceous Vegetation<sup>1</sup>

Class: Herbaceous Vegetation	Subclass	Group	Formation
Trees or shrubs occupy 25 percent or less of the canopy cover	A. Tall grassland (grasses or forbs over 1 m tall)	1. Tall grassland with a tree layer (tree canopy cover is 11 to 25 percent (e.g., the transition from the true tall grassland prairie to the forests; a tree savannah)	a. Woody layer broad-leaved evergreen b. Woody layer broad-leaved semi-evergreen c. Woody layer broad-leaved deciduous d. Woody layer needle-leaved evergreen and broad-leaved deciduous e. Woody layer needle-leaved evergreen
		2. Tall grassland with a shrub layer (shrub canopy cover is 11 to 25 percent) (e. g., the transition from the true tall grassland prairie and shrub land; a shrub savannah)	a. Shrub layer broad-leaved evergreen b. Shrub layer broad-leaved semi-evergreen c. Shrub layer broad-leaved deciduous
		3. Tall grassland with open layer of tuft plants, usually palms (specific examples unknown for U.S.)	a. Tall subtropical grassland with open groves of palms
		4. Tall grassland without a woody layer (tree or shrub canopy cover is 0 to 10 percent) (e.g., tall grass prairie of eastern Kansas)	a. Tall grassland consisting mainly of sod grasses b. Tall grassland consisting mainly of bunch grasses
	B. Medium tall grassland (grasses and forbs over 0.5 to 1 m tall)	1. Medium tall grassland with a tree layer (tree canopy cover is 11 to 25 percent) (as in subclass tall grassland - the tree savannah)	a. Woody layer broad-leaved evergreen b. Woody layer broad-leaved semi-evergreen c. Woody layer broad-leaved deciduous d. Woody layer needle-leaved evergreen and broad-leaved deciduous e. Woody layer needle-leaved evergreen f. Woody layer needle-leaved evergreen and broad-leaved evergreen
			2. Medium tall grassland with a shrub layer (shrub canopy cover is 11 to 25 percent) (as in subclass medium tall grassland - the shrub savannah)

Class: Herbaceous Vegetation - Continued

Class: Herbaceous Vegetation	Subclass	Group	Formation
		3. Medium tall grassland with an open layer of tuft plants, usually palms (specific examples unknown for U.S.)	a. Medium tall subtropical grassland with open groves of palms
		4. Medium tall grassland without a woody layer (tree or shrub canopy cover is 0 to 10 percent) (e.g., needlegrass; wheatgrass)	a. Medium tall grassland consisting mainly of sod grasses b. Medium tall grassland consisting mainly of bunch grasses
C.	Short grassland (grasses and forbs are 0.5 m or less tall)	1. Short grassland with a tree layer (tree canopy cover is 11 to 25 percent) (as in subclasses tall grassland and medium tall grassland - a tree savannah)	a. Woody layer broad-leaved evergreen b. Woody layer broad-leaved semi-evergreen c. Woody layer broad-leaved deciduous
		2. Short grassland with a shrub layer (Shrub canopy cover is 11 to 25 percent) (as in subclasses tall grassland and medium tall grassland - a shrub savannah)	a. Shrub layer broad-leaved evergreen b. Shrub layer broad-leaved semi-evergreen c. Shrub layer broad-leaved deciduous d. Shrub layer of mainly deciduous thorny shrubs
		3. Short grassland with an open layer of tuft plants, usually palms (unknown in U.S.)	
		4. Short grassland with an open layer of tuft plants, usually dwarf-shrubs (unknown in U.S.)	a. Tropical alpine open to closed bunch grass communities with a woody layer of tuft plants b. Tropical or subtropical alpine bunch grasses with open layer of evergreen dwarf-shrubs c. Bunch grasses with dwarf-shrubs
		5. Short grassland without a woody layer (tree or shrub canopy cover is 0 to 10 percent) (e.g., blue grass and buffalo grass communities)	a. Short grass communities composed of sod forming species b. Short grass communities composed of bunch grasses

s: Herbaceous Vegetation - Continued

Class:Herbaceous Vegetation	Subclass	Group	Formation
		6. Mesophytic grassland(alpine and subalpine meadows)(e.g., bluegrass and hairgrass communities)	a. Sod grass communities usually dominated by hemictrphytes b. Alpine and subalpine meadows of the higher latitudes
		7. Short grassland tundra (grass tundra of Alaska)	a. Bunch forming short grassland tundra b. Sod forming short grassland tundra
	D. Forb-dominated vegetation (herbaceous communities with forb cover exceeding 50 percent)	1. Tall forbs (forbs over 1 m tall) (tall forb meadows, Utah mountains)	a. Mainly perennial flowering forbs, and ferns b. Fern communities especially in humid climates c. Mainly annual forbs
		2. Low forbs (forbs 1 m or less tall) (Aleutian forb meadows, Alaska)	a. Mainly perennial flowering forbs, and ferns b. Mainly annual forbs

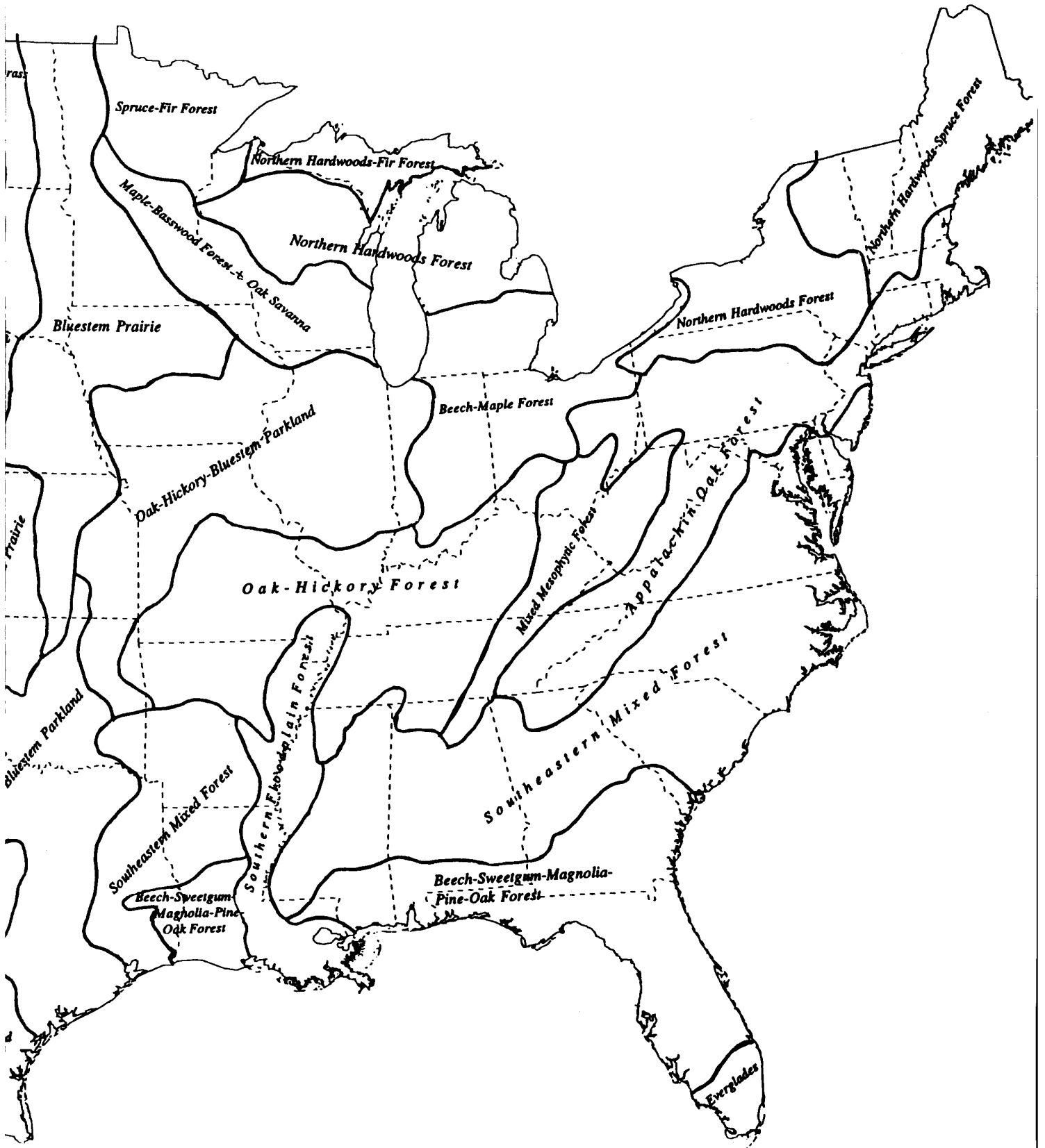
he key to the vegetation element is patterned after UNESCO 1973. The key contains a few examples of known communities in the United States.

APPENDIX B

A MAP OF BAILEY'S (1976) SECTION-LEVEL ECOREGIONS OF THE UNITED STATES



LEVEL ECOREGIONS



## APPENDIX C

### A LIST OF STATES BY EACH OF BAILEY'S SECTION-LEVEL ECOREGIONS

Spruce-Fir Forest (2111)	MN, WI.
Northern Hardwoods-Fir Forest (2112)	MI, WI.
Northern Hardwoods Forest (2113)	MI, NJ, NY, OH, PA, WI.
Northern Hardwoods-Spruce Forest (2114)	CT, MA, ME, NH, NY, VT.
Mixed Mesophytic Forest (2211)	AL, GA, KY, OH, PA, TN, VA, WV.
Beech-Maple Forest (2212)	IN, MI, NY, OH, PA.
Maple-Basswood Forest + Oak Savanna (2213)	IA, IL, MN, WI.
Appalachian Oak Forest (2214)	CT, DE, GA, MA, MD, ME, NC, NH, NJ, NY, OH, PA, RI, SC, TN, VA, WV.
Oak-Hickory Forest (2215)	AL, AR, IL, IN, KY, MO, MS, OK, TN.
Beech-Sweetgum-Magnolia-Pine-Oak Forest (2311)	AL, FL, GA, LA, MS, SC TX.
Southern Floodplain Forest (2312)	AL, AR, LA, MO, MS, TN.
Southeastern Mixed Forest (2320)	AL, AR, DE, GA, LA, MD, MS, NC, NJ, SC, TX, VA.
Willamette-Puget Forest (2410)	OR, WA.
Oak-Hickory-Bluestem Parkland (2511)	IL, IA, IN, KS, MO, OK.
Oak + Bluestem Parkland (2512)	KS, OK, TX
Mesquite-Buffalo Grass (2521)	TX, OK.
Juniper-Oak-Mesquite (2522)	TX.
Mesquite-Acacia (2523)	TX.
Bluestem Prairie (2531)	IA, KS, MN, MO, ND, NE, OK, SD. ND, NE, SD.

M = mountains, P = plateau, A = altiplano; numbers in parenthesis correspond to original map polygon labels.

Wheatgrass-Bluestem-Needlegrass Prairie (2532)	ND, NE, SD.
Bluestem-Grama Prairie (2533)	KS, NE, OK, TX.
California Grassland (2610)	CA.
Grama-Needlegrass-Wheatgrass Prairie (3111)	MT, WY.
Wheatgrass-Needlegrass Prairie (3112)	MT, ND, NE, SD, WY.
Grama-Buffalo Grass Prairie (3113)	CO, KS, NE, NM, OK, TX, WY.
Palouse Grassland (3120)	ID, OR, WA.
Sagebrush-Wheatgrass Steppe (3131)	CA, ID, NV, OR, UT, WA.
Lahontan Saltbush-Greaswood Steppe (3132)	CA, NV.
Great Basin Sagebrush Steppe (3133)	NV, UT.
Bonneville Saltbush-Greaswood Steppe (3134)	NV, UT.
Ponderosa Shrub Forest (3135)	CA, OR, WA.
Mexican Highlands Shrub Steppe (3140)	AZ, NM.
Grama-Tobosa Desert (3211)	NM.
Tarbush-Creosote Bush Desert (3212)	NM, TX.
Creosote Bush Desert (3221)	AZ, CA, NV.
Creosote Bush-Bur Sage Desert (3222)	AZ, CA.
Everglades (4110)	FL.
Douglas Fir Forest (M2111)	ID, WA.
Cedar-Hemlock-Douglas Fir Forest (M2112)	ID, MT.
Sitka Spruce-Cedar-Hemlock Forest (M2411)	OR, WA.
Redwood Forest (M2412)	CA, OR.
Cedar-Hemlock-Douglas Fir Forest (M2413)	CA, OR, WA.

M = mountains, P = plateau, A = altiplano; numbers in parenthesis correspond to original map polygon labels.



California Mixed Evergreen Forest (M2414)	CA.
Silver Fir-Douglas Fir Forest (M2415)	OR, WA.
Sierran Forest (M2610)	CA, OR.
California Chaparral (M2620)	CA.
Grand Fir-Douglas Fir Forest (M3111)	ID, OR, WA.
Douglas Fir Forest (M3112)	CO, ID, MT, UT, WY.
Ponderosa Pine-Douglas Fir Forest (M3113)	CO, NM, WY.
Juniper-Pinyon Woodland + Sagebrush-Saltbush Mosaic (P3131)	AZ, CO, UT.
Grama-Galleta Steppe + Juniper-Pinyon Woodland Mosaic (P3132)	AZ, CO, NM.
Wheatgrass-Needlegrass-Sagebrush (A3141)	MT, WY.
Sagebrush-Wheatgrass (A3142)	ID, CO, UT, WY.

M = mountains, P = plateau, A = altiplano; numbers in parenthesis correspond to original map polygon labels.

APPENDIX D

A LIST OF BAILEY'S SECTION-LEVEL ECOREGIONS BY STATE.

- AL Mixed Mesophytic Forest (2211)  
Oak-Hickory Forest (2215)  
Beech-Sweetgum-Magnolia-Pine-Oak Forest (2311)  
Southern Floodplain Forest (2312)  
Southeastern Mixed Forest (2320)
- AR Southern Floodplain Forest (2312)  
Southeastern Mixed Forest (2320)  
Oak-Hickory Forest (2215)
- AZ Juniper-Pinyon Woodlands + Sagebrush-Saltbrush Mosaic (P3131)  
Upper Gila Mountains Forest (M3120)  
Grama-Galleta Steppe + Juniper-Pinyon Woodland Mosaic (P3132)  
Mexican Highlands Shrub Steppe (3140)  
Creosote Bush-Bur Sage Desert (3222)  
Grama-Tobosa Desert (3211)  
Creosote Bush Desert (3221)
- CA Redwood Forest (M2412)  
Cedar-Hemlock-Douglas Fir Forest (M2413)  
California Mixed Evergreen Forest (M2414)  
Ponderosa Shrub Forest (3135)  
California Grassland (2610)  
Sierran Forest (M2610)  
California Chaparral (M2620)  
Creosote Bush-Bur Sage Desert (3222)  
Creosote Bush Desert (3221)  
Lahontan Saltbrush-Greaswood Steppe (3132)  
Sagebrush-Wheatgrass Steppe (3131)
- CO Grama-Buffer Grass Prairie (3113)  
Ponderosa Pine-Douglas Fir Forest (M3113)  
Douglas Fir Forest (M3112)  
Sagebrush-Wheatgrass Steppe (A3141)  
Juniper-Pinyon Woodlands + Sagebrush-Saltbrush Mosaic (P3131)  
Grama-Galleta Steppe + Juniper-Pinyon Woodland Mosaic (P3132)
- CT Appalachian Oak Forest (2214)  
CT Northern Hardwoods-Spruce Forest (2114)
- DE Appalachian Oak Forest (2214)  
Southeastern Mixed Forest (2320)
- FL Beech-Sweetgum-Magnolia-Pine-Oak Forest (2311)  
Everglades (4110)
- GA Southeastern Mixed Forest (2320)  
Appalachian Oak Forest (2214)  
Mixed Mesophytic Forest (2211)  
Beech-Sweetgum-Magnolia-Pine-Oak Forest (2311)
- IA Bluestem Prairie (2531)  
Oak-Hickory-Bluestem Parkland (2511)  
Maple-Basswood Forest + Oak Savanna (2213)
- ID Cedar-Hemlock-Douglas Fir Forest (M2112)  
Douglas Fir Forest (M2111 and M3112)  
Grand Fir-Douglas Fir Forest (M3111)  
Palouse Grassland (3120)  
Sagebrush-Wheatgrass Steppe (3131)
- IL Oak-Hickory-Bluestem Parkland (2511)  
Maple-Basswood Forest + Oak Savanna (2213)  
Oak-Hickory Forest (2215)
- IN Beech-Maple Forest (2212)  
Oak-Hickory Forest (2215)  
Oak-Hickory-Bluestem Parkland (2511)
- KS Grama-Buffer Grass Prairie (3113)  
Bluestem-Grama Prairie (2533)  
Bluestem Prairie (2531)  
Oak-Hickory-Bluestem Parkland (2511)  
Oak + Bluestem Parkland (2512)

M = mountains, P = plateau, A = altiplano; numbers in parenthesis correspond to original map polygon labels.

- KY Oak-Hickory Forest (2215)  
Mixed Mesophytic Forest (2211)
- LA Southern Floodplain Forest (2312)  
Southeastern Mixed Forest (2320)  
Beech-Sweetgum-Magnolia-Pine-Oak  
Forest (2311)
- MA Northern Harwoods-Spruce Forest (2114)  
Appalachian Oak Forest (2214)
- MD Southeastern Mixed Forest (2320)  
Appalachian Oak Forest (2214)
- ME Northern Harwoods-Spruce Forest (2114)  
Appalachian Oak Forest (2214)
- MI Northern Hardwoods Forest (2113)  
Northern Hardwoods-Fir Forest (2112)  
Beech-Maple Forest (2212)
- MO Oak-Hickory-Bluestem Parkland (2511)  
Oak-Hickory Forest (2215)  
Southern Floodplain Forest (2312)
- MN Spruce-Fir Forest (2111)  
Maple-Basswood Forest + Oak Savanna  
(2213)  
Bluestem Prairie (2531)
- MS Southern Floodplain Forest (2312)  
Southeastern Mixed Forest (2320)  
Oak-Hickory Forest (2215)  
Beech-Sweetgum-Magnolia-Pine-Oak  
Forest (2311)
- MT Grama-Needlegrass-Wheatgrass Prairie  
(3111)  
Wheatgrass-Needlegrass Prairie (3112)  
Wheatgrass-Needlegrass Sagebrush Steppe  
(A3141)  
Douglas Fir Forest (M3112)  
Cedar-Hemlock-Douglas Fir Forest (M2112)
- NC Appalachian Oak Forest (2114)  
Southeastern Mixed Forest (2320)
- ND Wheatgrass-Needlegrass Prairie (3112)  
Wheatgrass-Bluestem-Needlegrass Prairie  
(3112)  
ND Bluestem Prairie (2531)
- NE Wheatgrass-Needlegrass Prairie (3112)  
Bluestem Prairie (2531)  
Wheatgrass-Bluestem-Needlegrass Prairie  
(2532)  
Bluestem-Grama Prairie (2533)  
Grama-Buffer Grass Prairie (3113)
- NH Northern Hardwoods-Spruce Forest (2114)  
Appalachian Oak Forest (2214)
- NJ Appalachian Oak Forest (2214)  
Southeastern Mixed Forest (2320)
- NJ Northern Hardwoods Forest (2113)
- NM Grama-Galleta Steppe + Juniper-Pinyon  
Woodland Mosaic (P3132)  
Upper Gila Mountains Forest (M3120)  
Juniper-Pinyon Woodland + Sagebrush-  
Saltbush Mosaic (P3131)  
Mexican Highlands Shrub Steppe (3140)  
Grama-Tobosa Desert (3211)  
Tarbrush-Creosote Bush Desert (3212)  
Grama-Buffer Grass Prairie (3113)
- NV Sierran Forest (M2610)  
Sagebrush-Wheatgrass Steppe (3131)  
Lahontan Saltbush-Greaswood Steppe (3132)  
Great Basin Sagebrush Steppe (3133)  
Bonneville Saltbush-Greaswood Steppe  
(3134)  
Creosote Bush Desert (3221)
- NY Northern Hardwood Forest (2113)  
Appalachian Oak Forest (2214)  
Beech-Maple Forest (2212)
- OH Beech-Maple Forest (2212)  
Appalachian Oak Forest (2214)  
Mixed Mesophytic Forest (2212)  
Oak-Hickory Forest (2215)  
Northern Hardwood Forest (2113)

M = mountains, P = plateau, A = altiplano; numbers in parenthesis correspond to original map polygon labels.

- OK Grama-Buffer Grass Prairie (3113)  
 Bluestem-Grama Prairie (2533)  
 Bluestem Prairie (2531)  
 Oak + Bluestem Parkland (2512)  
 Oak-Hickory-Bluestem Parkland (2511)  
 Oak-Hickory Forest (2215)  
 Mesquite-Buffer Grass Brushland (2521)  
 Southeastern Mixed Forest (2320)
- OR Willamette-Puget Forest (2410)  
 Sitka Spruce-Cedar-Hemlock Forest (M2411)  
 Cedar-Hemlock-Douglas Fir Forest (M2413)  
 Redwood Forest (M2412)  
 Sierran Forest (M2610)  
 Silver Fir-Douglas Fir Forest (M2415)  
 Ponderosa Shrub Forest (3135)  
 Sagebrush-Wheatgrass Steppe  
 Palouse Grassland (3120)  
 Grand Fir-Douglas Fir Forest (M3111)
- PA Appalachian Oak Forest (2214)  
 Mixed Mesophytic Forest (2211)  
 Northern Hardwoods Forest (2113)  
 Beech-Maple Forest (2212)
- RI Appalachian Oak Forest (2214)
- SC Appalachian Oak Forest (2214)  
 Southeastern Mixed Forest (2320)  
 Beech-Sweetgum-Magnolia-Pine-Oak  
 Forest (2311)
- SD Wheatgrass-Needlegrass Prairie (3112)  
 Wheatgrass-Bluestem-Needlegrass Prairie  
 (3112)  
 Bluestem Prairie (2531)
- TN Appalachian Oak Forest (2214)  
 Mixed Mesophytic Forest (2211)  
 Southeastern Mixed Forest (2320)
- TX Southeastern Mixed Forest (2320)  
 Beech-Sweetgum-Magnolia-Pine-Oak Forest  
 (2311)  
 Oak + Bluestem Parkland (2512)  
 Mesquite Acacia Brushland (2523)
- TX Juniper-Oak-Mesquite Brushland (2522)  
 Mesquite-Buffer Grass Brushland (2521)  
 Bluestem-Grama Prairie (2533)  
 Grama-Buffer Grass Prairie (3113)  
 Tarbush-Creosote Bush Desert (3212)  
 Grama-Tobosa Desert (3211)
- UT Juniper-Pinyon Woodland + Sagebrush-  
 Saltbush Mosaic (P3131)  
 Douglas Fir Forest (M3112)  
 Bonneville Saltbush-Greaswood Steppe  
 (3134)  
 Great Basin Sagebrush Steppe (3133)  
 Sagebrush-Wheatgrass Steppe (3131)  
 Creosote Bush Desert (3221)  
 Grama-Galleta Steppe + Juniper-Pinyon  
 Woodland Mosaic (P3132)  
 Sagebrush-Wheatgrass (A3142)
- VA Appalachian Oak Forest (2214)  
 Mixed Mesophytic Forest (2211)  
 Southeastern Mixed Forest (2320)
- VT Northern Hardwoods-Spruce Forest (2114)
- WA Sitka Spruce-Cedar-Hemlock Forest (M2411)  
 Willamette-Puget Forest (2410)  
 Palouse Grassland (3120)  
 Cedar-Hemlock-Douglas Fir Forest (M2413)  
 Silver Fir-Douglas Fir Forest (M4215)  
 Ponderosa Shrub Forest (3135)  
 Douglas Fir Forest (M2111)  
 Cedar-Hemlock-Douglas Fir Forest (M2112)  
 Grand Fir-Douglas Fir Forest (M3111)  
 Sagebrush-Wheatgrass Steppe (3131)
- WI Northern Hardwoods-Fir Forest (2112)  
 Northern Hardwoods Forest (2113)  
 Spruce-Fir Forest (2111)  
 Maple-Basswood Forest + Oak Savanna  
 (2213)
- WV Appalachian Oak Forest (2214)  
 Mixed Mesophytic Forest (2211)

M = mountains, P = plateau, A = altiplano; numbers in parenthesis correspond to original map polygon labels.

WY Sagebrush-Wheatgrass (A3142)  
Wheatgrass-Needlegrass-Sagebrush (A3141)  
Wheatgrass-Needlegrass Prairie (3112)  
Grama-Buffalo Grass Prairie (3113)  
Ponderosa Pine-Douglas Fir Forest (M3113)  
Douglas Fir Forest (M3112)

M = mountains, P = plateau, A = altiplano; numbers in parenthesis correspond to original map polygon lables.