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"ECOREGIONS OF THE UNITED STATES" BY ROBERT G. BAILEY U.S. FOREST SERVICE 1976

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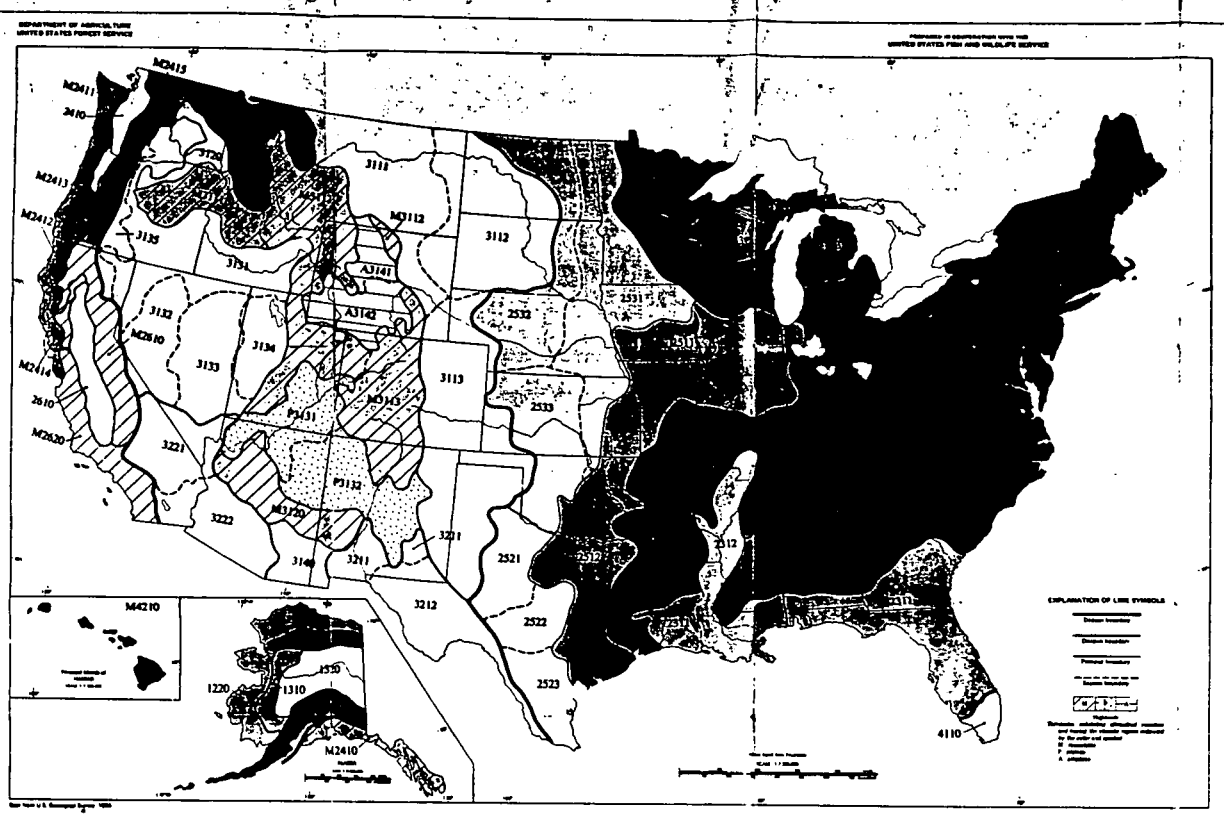
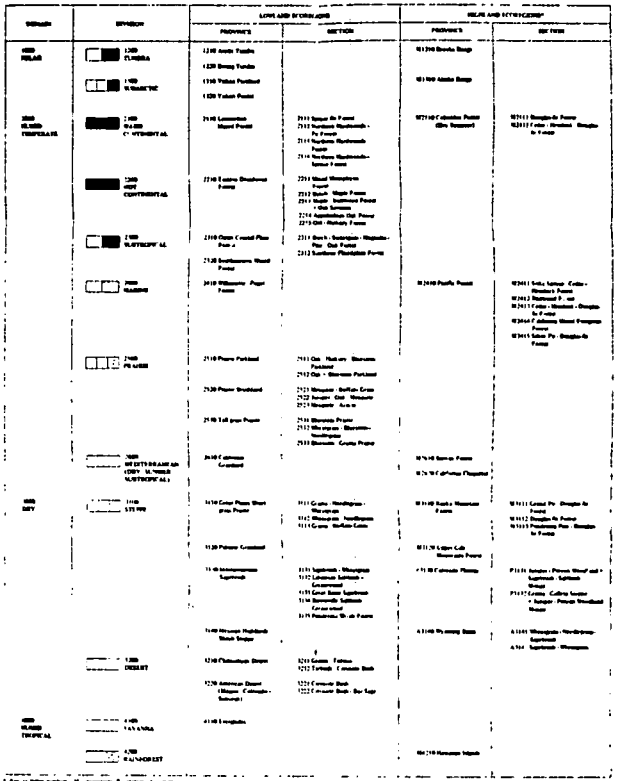
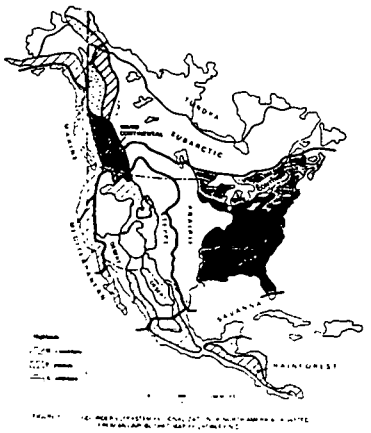




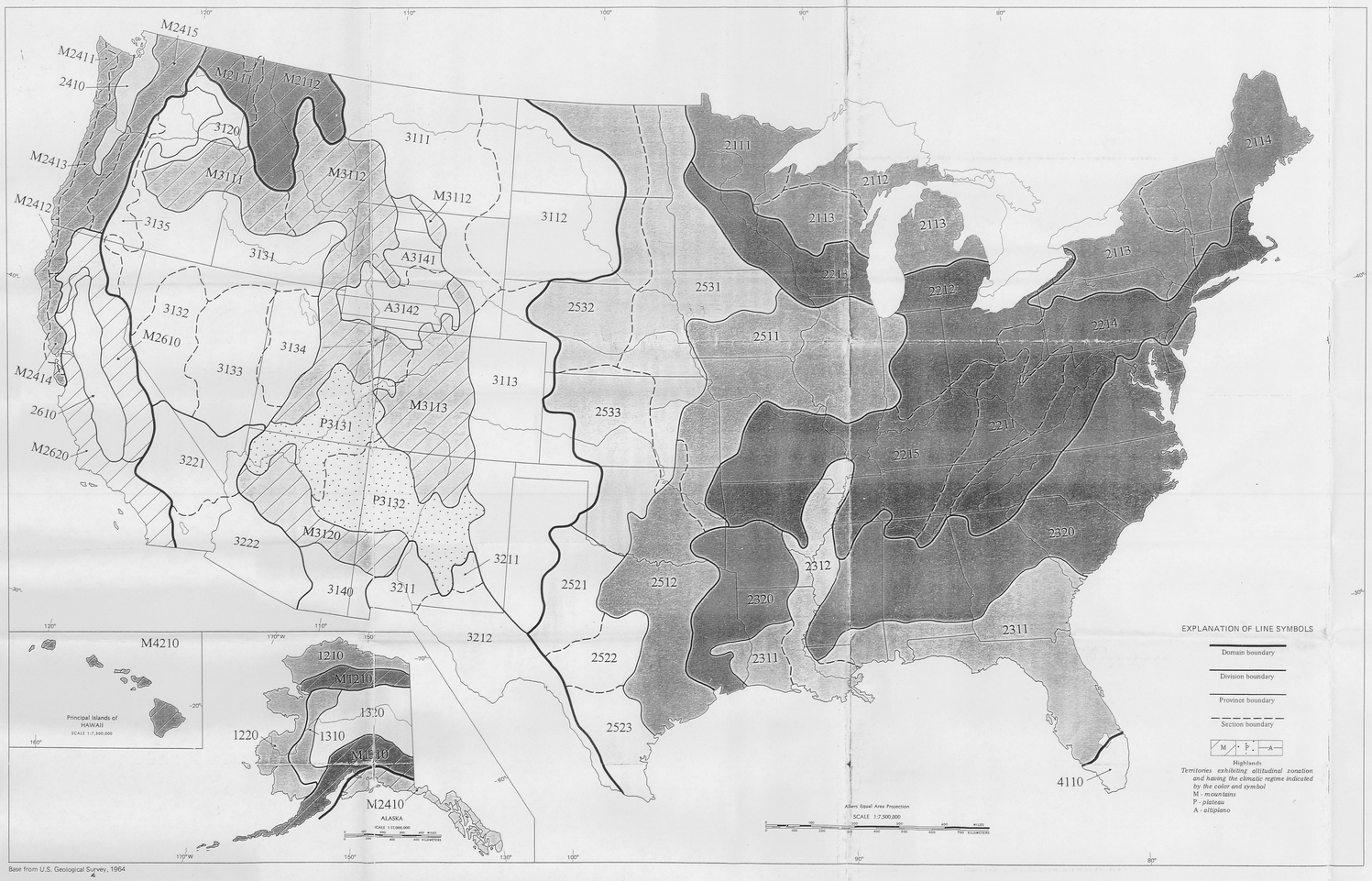


ECOREGIONS OF THE UNITED STATES

By
Robert G. Bailey
1976

DEPARTMENT OF AGRICULTURE
UNITED STATES FOREST SERVICE

PREPARED IN COOPERATION WITH THE
UNITED STATES FISH AND WILDLIFE SERVICE



EXPLANATION OF LINE SYMBOLS

Domain boundary

Division boundary

Province boundary

Section boundary

Highlands

Territories exhibiting altitudinal zonation and having the climatic regime indicated by the color and symbol
M - *mountains*
P - *plateau*
A - *altiplano*

Base from U.S. Geological Survey, 1964

EXPLANATION

DOMAIN	DIVISION	LOWLAND ECOREGIONS		HIGHLAND ECOREGIONS*	
		PROVINCE	SECTION	PROVINCE	SECTION
1000 POLAR	1200 TUNDRA	1210 Arctic Tundra		M1210 Brooks Range	
		1220 Bering Tundra			
	1300 SUBARCTIC	1310 Yukon Parkland		M1310 Alaska Range	
		1320 Yukon Forest			
2000 HUMID TEMPERATE	2100 WARM CONTINENTAL	2110 Laurentian Mixed Forest	2111 Spruce-fir Forest 2112 Northern Hardwoods–Fir Forest 2113 Northern Hardwoods Forest 2114 Northern Hardwoods–Spruce Forest	M2110 Columbia Forest (Dry Summer)	M2111 Douglas-fir Forest M2112 Cedar–Hemlock–Douglas-fir Forest
	2200 HOT CONTINENTAL	2210 Eastern Deciduous Forest	2211 Mixed Mesophytic Forest 2212 Beech–Maple Forest 2213 Maple–Basswood Forest + Oak Savanna 2214 Appalachian Oak Forest 2215 Oak–Hickory Forest		
	2300 SUBTROPICAL	2310 Outer Coastal Plain Forest	2311 Beech–Sweetgum–Magnolia–Pine–Oak Forest 2312 Southern Floodplain Forest		
		2320 Southeastern Mixed Forest			
	2400 MARINE	2410 Willamette–Puget Forest		M2410 Pacific Forest	M2411 Sitka Spruce–Cedar–Hemlock Forest M2412 Redwood Forest M2413 Cedar–Hemlock–Douglas-fir Forest M2414 California Mixed Evergreen Forest M2415 Silver Fir–Douglas-fir Forest
	2500 PRAIRIE	2510 Prairie Parkland	2511 Oak–Hickory–Bluestem Parkland 2512 Oak + Bluestem Parkland		
		2520 Prairie Brushland	2521 Mesquite–Buffalo Grass 2522 Juniper–Oak–Mesquite 2523 Mesquite–Acacia		
		2530 Tall-grass Prairie	2531 Bluestem Prairie 2532 Wheatgrass–Bluestem–Needlegrass 2533 Bluestem–Grama Prairie		
	2600 MEDITERRANEAN (DRY–SUMMER SUBTROPICAL)	2610 California Grassland		M2610 Sierran Forest M2620 California Chaparral	
3000 DRY	3100 STEPPE	3110 Great Plains Short-grass Prairie	3111 Grama–Needlegrass–Wheatgrass 3112 Wheatgrass–Needlegrass 3113 Grama–Buffalo Grass	M3110 Rocky Mountain Forest	M3111 Grand Fir–Douglas-fir Forest M3112 Douglas-fir Forest M3113 Ponderosa Pine–Douglas-fir Forest
		3120 Palouse Grassland		M3120 Upper Gila Mountains Forest	
		3130 Intermountain Sagebrush	3131 Sagebrush–Wheatgrass 3132 Lahontan Saltbush–Greasewood 3133 Great Basin Sagebrush 3134 Bonneville Saltbush–Greasewood 3135 Ponderosa Shrub Forest	P3130 Colorado Plateau	P3131 Juniper–Pinyon Woodland + Sagebrush–Saltbush Mosaic P3132 Grama–Galleta Steppe + Juniper–Pinyon Woodland Mosaic
		3140 Mexican Highlands Shrub Steppe		A3140 Wyoming Basin	A3141 Wheatgrass–Needlegrass–Sagebrush A3142 Sagebrush–Wheatgrass
	3200 DESERT	3210 Chihuahuan Desert	3211 Grama–Tobosa 3212 Tarbush–Creosote Bush		
		3220 American Desert (Mojave–Colorado–Sonoran)	3221 Creosote Bush 3222 Creosote Bush–Bur Sage		
4000 HUMID TROPICAL	4100 SAVANNA	4110 Everglades			
	4200 RAINFOREST			M4210 Hawaiian Islands	

* Key to letter symbols: M - mountains, P - plateau, A - altiplano

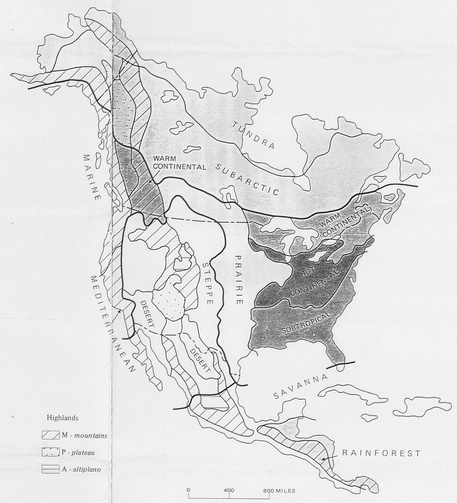


FIGURE 1.–SECOND-ORDER ECOSYSTEM REGIONALIZATION OF NORTH AMERICA. ADAPTED FROM AN UNPUBLISHED MAP BY CROWLEY N.D.

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INTRODUCTION

To manage land as heterogeneous as that the Forest Service deals with, we must be able to classify it as to its capability and availability to produce different goods and services. To manage forest, range, and related land on a national, regional, and local scale, requires a classification system that is objective, that covers the whole country, and that is hierarchical in nature. To be objective, the system should be based on observed properties. The same method of classifying land in California should be used in Maine and in Florida. The system should be hierarchical, allowing for both broad levels of generalization and highly specific levels, to allow for aggregation of data at different levels to meet decisionmaking needs at regional, state, and national levels.

The classification should be developed from existing knowledge. In some instances, it may not be possible initially to characterize lower levels of the hierarchy because of lack of on-the-ground knowledge. Where this is the case, management planning must be based upon existing knowledge at higher levels—even though lack of knowledge at the lower levels may restrict the accuracy of management planning in local areas. As research and management gain additional knowledge and experience, the lower classification levels can be defined.

Because land is a complex of surface attributes, in other words, an ecosystem, the classification should reflect spatial patterns as well as properties. How a piece of land will behave cannot be predicted fully in terms of local controls or single factors acting in isolation, but is in part determined by relationships with adjoining areas. There is thus intrinsic advantage of assessing land in terms of interacting units at various scales of grouping. The process of grouping objects on the basis of spatial relationships rather than solely on similarity of taxonomic properties is called *regionalization*.

PURPOSE

There are a number of different kinds of regions depending upon objective or purpose. Just as a region based on agriculture is an agricultural region, one based on ecosystems is an ecosystem region or *ecoregion*.

To date, most work based on the ecosystem concept of resource management is at a detailed level. There are at least two reasons why a regional view of the ecosystems is important: (1) to permit detailed data to be aggregated into more generalized units for decisionmaking at higher levels; (2) to provide an integrating frame of reference needed to fully interpret the more detailed information.

This map was developed to meet these needs. Maps based on classification of climatic types, vegetation associations, and soil groups have been widely used, but no comparable broad-scale synthesis of these maps has been commonly accepted. This map is an attempt to fill that gap.

Other broad-scale classifications have tended toward systems that are biotic on the one hand and abiotic on the other, leaving such factors as landform as criteria. In trying to use these classifications, it is apparent that they are inadequate because they are not truly holistic, as ecosystem classification requires.

The approach here is to reconcile the biotic and abiotic classifications into a single geographical classification that is relatively objective. The scheme is based on a major division of all lands into lowlands and highlands. Within the classification, bioclimatic criteria are used to determine the upper rungs of the hierarchy, and geologic and geomorphic criteria are taken into account mainly at the lower levels. This map shows only the upper levels.

This map of the ecoregions of the United States is not intended to be a final classification. It is intended to elicit comments from users on format, style, and overall adequacy as a planning aid and educational device. Such comments will be reviewed and incorporated into the design of future versions.

PRINCIPLES OF ECOSYSTEM REGIONALIZATION

Each ecoregion covers a continuous geographical area and is characterized by the occurrence of one or more important ecological associations that differ, at least in proportional area covered, from the associations of adjacent regions. In general, ecoregions are characterized also by distinctive flora, fauna, climate, landform, soil, vegetation, and ecological climax. Within such a region, ecological relationships between plant species and soil and climate are essentially similar, and similar management treatments give comparable results. Thus, they are also considered biological productivity regions of specific potentials.

The term "ecoregion" was proposed by Crowley (1967). Other conceptually similar terms include "physiographic region," "landscape," "natural region," "biophysical unit" (Lacate 1969), "biogeodimatic zone" (Krajina 1965), "land system" (Wertz and Arnold 1972), "site region" (Hills 1960), and "biotic province" (Dice 1943). Ecoregion seems preferable since it most closely parallels ecosystem. As used here, the term designates biogeographical units of any size or rank.

The classification scheme used on this map is an adaptation derived mostly from Crowley (1967) and has four levels of generalization (Table 1).

A *stratum* is a subcontinental area of broad climatic similarity, such as lands having the dry (B) climates of Köppen (Trewartha 1943) or Thornthwaite (1931).

A *division* is a subdivision of a domain determined by isolating areas of differing vegetation and regional climates, generally at the level of the basic climatic types of Köppen. Usually, the zonal soils are related. Figure 1 illustrates a regionalization of North America performed at this level and Table 2 lists their characteristics.

A *province* is a subdivision that corresponds to a broad vegetation region having a uniform regional climate and the same type or types of zonal soils. For example, the Boreal Forest Province is the ecoregion characterized by the subarctic continental-boreal coniferous forest-podzol ecosystem. Generally, each province is characterized by a single climax association, but two or more climaxes may be represented within a single province. This often happens on mountains where each altitudinal zone may have a different climax.

Mountain regions represent special problems. The middle and upper slopes of mountain regions do not have the same climate as the adjacent lowlands, but rather have the same climatic *regime* as those lowlands. From the climatic regime of a mountain area, one may infer (1) what the lower altitudinal zones will be and (2) the seasonal pattern of precipitation and temperature in all zones. For example, in a mountain region having a semiarid steppe regime, the steppe zone will occupy the adjacent lowlands and perhaps the lower su.py slopes; then there will be a subumid prairie or parkland zone; they will follow the montane zone, and so on. By contrast, in a mountain region having a humid climatic regime such as the warm-summer continental, the valley bottoms will be humid and the montane zone will be the lowest zone present. A mountain range in a Mediterranean climatic regime will have a maximum of precipitation in winter in all zones, just as does the adjacent windward lowland. For the purposes of this classification, highland ecoregions such as mountains, plateaus, and high-elevation plains (altiplano), in which a high degree of altitudinal zonation occurs, are considered separate provinces. They are classified according to the climatic regime of the lowlands in which they occur.

A *section* is a subdivision of a province and is based on local climatic variation. The section is characterized by a single climax association and reflects climatic nuances within the broad regional climate. Variation in potential vegetation as mapped by Küchler (1964) is used as the principle indicator of a section.

No attempt was made to identify ecosystems below the level of section on this map. A tentative hierarchy defining levels below this level is presented in Table 1.

The concept of "ecoregion" differs from that of "biome" (Shelford 1963), for a biome is coincident with its climaxes. Every area having the same climax, however far from the main area of the climax, belongs to the same biome. An ecoregion, on the other hand, is always continuous (except on marine islands). Ecologic communities having characteristics similar to those of a particular region may exist far beyond its boundaries, thus belonging to a different ecoregion.

Each ecoregion comprises both the climax communities and all the successional stages within its geographical area and so includes the fresh-water communities. However, it does not include marine communities that may lie adjacent to its shores.

The boundaries between adjacent ecoregions are usually difficult to locate precisely. Frequently one region merges gradually into another. Any line separating the two must then be drawn more or less arbitrarily. A convenient way of roughly fixing the boundary between two adjacent regions is to draw the line where the dominant associations of the two regions cover approximately equal area.

As stated, an ecoregion may best be thought of as a geographical area over which the environmental complex, produced by climate, topography, and soil, is sufficiently uniform to permit development of characteristic types of ecologic associations. Some ecologic communities are able to modify the natural undeveloped habitat and, to a certain extent, manufacture their own environment. Through ecologic succession, they tend to spread from their place of origin to adjacent areas. Accordingly, we may also think of an ecoregion as a center of ecologic dispersal.

The area covered by a particular ecoregion varies from time to time, not only because of the production of new habitats through ecologic succession, but also because of slow but more or less permanent climatic changes. Any major change in topography will alter the local climate. Other climatic variations of a world-wide nature are believed to be continually in progress. Climatic changes generally affect the geographic distribution of the ecologic units concerned. The ecoregions themselves are slowly evolving, and, occasionally, a new one may appear or an old one become extinct. Consequently, regional boundaries are not stationary. Instead, slowly but constantly they are changing their position.

The classification of ecoregions should properly be based upon the distinctiveness and distribution of various ecologic associations. Unfortunately, available data on the associations of the United States that include both plants and animals are inadequate for this purpose. Actually, the classification of ecoregions presented here is based to a large extent on macro-climate as expressed by potential vegetation. Animals are dependent directly or indirectly upon plants for food and often for shelter and breeding places. Even where plants do not control the distribution of animals, they often indicate the characters of climate and soil upon which animals are dependent. Accordingly, for the present, vegetation offers the most satisfactory basis for distinguishing the *major* ecologic communities of the country.

The geographic distribution of the ecoregions described here is correlated in varying degrees with climatic types, physiographic provinces and agricultural regions (Atwood 1940), and also with soil types (Soil Survey Staff 1970). This correlation is not surprising when we consider that climate, physiography, and soil all affect one another, and that the distribution of plants and animals is dependent upon all these environmental factors.

The names assigned to each region retain the names of the most obvious vegetation indicator, such as, mixed forest, broadleaf forest, and desert. As a rule, designations of the geographic situations, such as Eastern Deciduous Forest, California Grassland, are added. On the map, color tints designate types of ecoregions by climatic zones. Highlands are shown by line pattern over the color corresponding to the lowland zone. One or two basic colors have been selected for each ecoregion domain and divisions within domains are shown in tones of the basic color. For example, green tones are used for the humid temperate domain and orange-red for the dry. Darker tones are used for humid, oceanic types, and lighter ones for drier, interior types.

DEVELOPMENT OF THE MAP

In developing the map, a large number of geographical and ecological index works was consulted. The selected references do not cover all the sources from which this map was drawn. The references supplement the information presented here, and lack of space prevents the inclusion of many important papers. A number of persons intimately acquainted with different regions have given valuable advice and criticism.

Particularly useful in delimiting climatic regions were the climatic map of the world, modified from the Köppen classification by Trewartha (1943) at a scale of 1:75,000,000, and the climatic map of North America by Thornthwaite (1931) at a scale of 1:20,000,000. These maps were used with some modification to identify domains and divisions. The regions at the level of section were delimited from a number of sources, especially from an examination of Küchler's map of "Potential Natural Vegetation" at a scale of 1:3,168,000 (Küchler 1964). Küchler's map was generalized and modified to delineate provinces and sections.

APPLICATIONS AND REFINEMENTS

Any biogeographic classification must be arbitrary in part and many compromises must be made if the diverse ecologic relationships of the country are to be brought together into a single system. Biogeographers and ecologists have not agreed on the classification system best suited to the needs of all who may use organized information about the distribution of ecosystems. It may be impossible to devise a system equally well suited to the diverse needs of users in widely separated fields, but agreement, at least on major units, of ecologic classification is desirable.

This map of the ecoregions of the United States is offered as an experiment in classifying the major ecologic divisions of the country. By regionalizing, the variation in the environment is reduced to manageable proportions. In addition, regionalization provides a framework for organizing our knowledge of ecosystems and for extrapolation of knowledge from one area for application in the management of another one. Such a classification and map can serve as a valuable reference work for land use and resources assessment and for planning on a nationwide scale. Also, they are especially important in coordinating more detailed work. Further, they can contribute substantially to tying together regional legends and standardizing symbols, nomenclature, and ways of making detailed ecosystem maps consistent with regional and national maps.

An effort has been made throughout to have categories reflect the most significant aspects of ecosystems consistent with scale. However, the author is acutely aware that this is not always possible. Classification is severely hampered by lack of data or inconsistencies of data available in many areas. Of necessity, arbitrary decisions sometimes have been made. Additional work may suggest better terminology or more accurate delimitation; however, considering the level of generalization of the map, it is doubtful that such delimitation would alter the pattern appreciably. It is hoped that future work will test and revise the classification and refine it in lower levels.

The author is preparing (1976) a separate text more fully describing the methodology and the units shown on this map.

ACKNOWLEDGMENTS

While accepting full responsibility for the map, particularly for any errors or deficiencies, I wish to acknowledge the work of Professor John M. Crowley of the University of Montana, who advanced the concept of ecoregions for North America, upon which this more detailed work is based; Professor Edwin H. Hammond; Mr. Kermit N. Larson, Dr. Charles T. Cushwa, and Dr. Ed F. Schlatterer have lent encouragement and helpful suggestions since the map was begun; Mr. John H. Wiketorn and Dr. Robert D. Pfister also given counsel, and their advice has been most appreciated. Finally, a special note of thanks is extended to Mr. William A. Wertz and Mr. John F. Arnold who originally proposed this project.

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*Table 1.–A HIERARCHY FOR ECOSYSTEMS**
[Adapted from Crowley (1967) and Wertz and Arnold (1972)]

Name	Defined as including:
1. Domain	Subcontinental area of related climates
2. Division	Single regional climate at the level of Köppen's types (Trewartha 1943)
3. Province	Broad vegetation region with the same type or types of zonal soils
4. Section	Climatic climax at the level of Küchler's potential vegetation types (1964)
5. District	Part of a section having uniform geomorphology at the level of Hammond's land-surface form regions (1964)
6. Landtype associations	Group of neighboring landtypes with recurring pattern of landforms, lithology, soils and vegetation associations
7. Landtype	Group of neighboring phases with similar soil series or families with similar plant communities at the level of Daubenmire's habitat types (1968)
8. Landtype phase	Group of neighboring sites belonging to the same soil series with closely related habitat types
9. Site	Single soil type or phase and single habitat type or phase

* This table is not intended to define the levels precisely, but merely to indicate the general character of the classification.

Table 2.- GENERAL ENVIRONMENTAL CHARACTERISTICS OF FIRST- AND SECOND-ORDER ECOREGIONS.

DOMAIN	DIVISION	TEMPERATURE	RAINFALL	VEGETATION	SOIL*
Polar	Tundra	Mean temperature of warmest month < 10° C	Water deficient during the cold season	Moss, grasses and small shrubs	Tundra soils (Entisols, in upintrazols and associated Histosols)
	Subarctic	Mean temperature of summer is 10° C, of winter -3° C	Rain even throughout the year	Forest, parklands	Podzols (Spodosols and associated Histosols)
Humid Temperate	Warm Continental	Coldest month below 0° C, warmest month < 22° C	Adequate throughout the year	Seasonal forests, mixed coniferous - deciduous forests	Gray-Brown Podzolic (Spodosols, Alfisols)
	Hot Continental	Coldest month below 0° C, warmest month > 22° C	Summer maximum	Deciduous forests	Gray-Brown Podzolic (Alfisols)
	Subtropical	Coldest month between 18° C and -3° C, warmest month > 22° C	Adequate throughout the year	Coniferous and mixed coniferous - deciduous forest	Red and Yellow Podzolic (Ultisols)
	Marine	Coldest month between 18° C and -3° C, warmest month < 22° C	Maximum in winter	Coniferous fore.	Brown Forest and Gray-Brown Podzolic (Alfisols)
	Prairie	Variable	Adequate all year, excepting dry years, maximum in summer	Tall grass, parklands	Prairie soils, Chernozems (Mollisols)
	Mediterranean	Coldest month between 18° C and -3° C, warmest month > 22° C	Dry summer, rainy winters	Evergreen woodlands and shrubs	Mostly immature soils
Dry	Steppe	Variable, winters cold	Rain < 50 cm/yr	Short grass, shrubs	Chestnut, Brown soils and Sierozems (Mollisols, Aridisols)
	Desert	High summer temperature, mild winters	Very dry in all seasons	Shrubs or sparse grasses	Desert (Aridisols)
Humid Tropical	Savanna	Coldest month > 18° C, annual variation < 12° C	Dry season with < 6 cm/yr	Open grassland, scattered trees	Latosols (Oxisols)
	Rainforest	Coldest month > 18° C, annual variation < 3° C	Heavy rain, min 6 cm/month	Dense forest, heavy undergrowth	Latosols (Oxisols)

* Names in parentheses are Soil Taxonomy orders (Soil Survey Staff 1970).