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An Ecological Land Classification Framework for the United States

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An Ecological Land Classification Framework for the United States

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The ecological land classification framework described consists of hierarchical classifications of vegetation and soil; a method of linking a wetlands and deep water habitat classification system to upland vegetation and soil hierarchies; landform definitions used to describe the setting for the soil, vegetation, and wetlands elements; and procedures for integrating the elements into ecological units.

Keywords: Land classification, plant community classification, climax vegetation, potential natural vegetation, soil classification, integrated classification

Preface

Classifications label and show relationships among items, as contrasted with inventories, which produce information. The process of developing a classification, including review, testing, and modification, is complex. The system should ultimately provide for uniform site identification and characterization for different renewable resource inventory, assessment, and planning levels.

The land classification system described here consists of hierarchial classification frameworks for vegetation and soils, linkage of an aquatic habitat classification system to terrestrial vegetation and soil, landform definitions, and a process for combining separate hierarchies into ecological units. Relationships among ecological units and geographical ecosystem associations also are presented. The classification system presented builds on previous work by Driscoll and others (1983). This classification system was developed by the Resources Evaluation Techniques Program of the U.S. Department of Agriculture Forest Service's Rocky Mountain Forest and Range Experiment Station in cooperation with the U.S. Department of Agriculture Soil Conservation Service and the U.S. Department of Interior Bureau of Land Management, Geological Survey, and Fish and Wildlife Service. The National Governor's Association Council of State Planning Agencies provided assistance. Authors and their agencies were involved to varying degrees in conceptualizing, writing, reviewing, and revising this report.

Richard S. Driscoll, Forest Service, provided overall guidance in preparing the report. He synthesized ecological philosophies to develop the framework for the classification system; prepared those sections dealing with ecology, classification, and integration; and coordinated the contributions and reviews of others.

Daniel L. Merkel, Soil Conservation Service, assisted materially in conceptualizing the framework; constantly made certain the information was understandable and potentially usable; kept others informed on what the classification is and why it was developed; coordinated the review process and comments; and assisted substantially in writing drafts and the final manuscript.

James S. Hagihara, Bureau of Land Management, provided substantial technical assistance in assuring the classification system was understandable and applicable, in developing examples and writing drafts of integrated units, in evaluating review comments, and in developing and maintaining technology transfer. He was also fully responsible for securing resources and coordinating field evaluations of the classification system.

Dale E. Snyder, Soil Conservation Service, was responsible for developing the landform terms and parts of the section on integration, and for evaluating and adjusting the manuscript to review comments on soils and integration.

David L. Radloff, Forest Service, contributed substantially to the ecological sections of the manuscript by reviewing and revising those sections for more complete understanding.

This document does not constitute final acceptance of the classification system by the cooperating agencies. Testing and evaluation are currently underway. The framework should be considered an intermediate step in an evolutionary process. The system will be modified as experience is gained in the use of land classification for land management planning and in regional and national assessments or appraisals.

Contents

Introduction

Classification groups things that are similar and separates things that are dissimilar. Any classification forms a framework for organizing knowledge about things. Most classifications include devisions or levels to form hierarchical organization. The specific structure of a classification is strongly influenced by its intended use, either expressed or implied. Classification is not an inventory in itself; it is a framework for partitioning heterogeneous populations into more manageable and homogeneous subunits. Within this framework, inventories can be conducted to obtain required data and information about specific objects. Also, classification structures data and permits rapid analysis of complex situations.

Baily and others (1978) discussed different approaches and kinds of land and resource classifications. Federal laws emphasized the need for a uniform classification system. These include The Forest and Rangeland Renewable Resources Planning Act of 1974 as amended by The National Forest Management Act of 1976, The Federal Land Policy and Management Act of 1976, and The Soil and Water Resources Conservation Act of 1977. These laws require several Federal agencies to assess the condition and status of the Nation's lands and renewable natural resources on a periodic basis. They also require exchange of information about the resources to develop assessments of resource conditions and status. In some States and localities, land use planning is required by law; in others, by administrative policy.

To assess natural resources on a periodic basis, Federal agencies must be able to define the inherent biological potential of the land. This classification was developed to accomplish this. The classification is based on relatively permanent land features instead of land use.

There are two general kinds of ecological classifications for natural resources—integrated and component or ecosystem element. An integrated classification unites elements of the land—vegetation, soil, landforms, climate, and water—to form a coordinated entity. The systems developed and proposed by Austin (1981), Bailey (1980a), and Wiken and Ironside (1977) are examples of integrated classifications. The underlying principle of integrated classification is to develop a system that expresses the interactive character of the land's elements as a unit in relation to surrounding land units in a spacial hierarchy (Rowe 1972). A key feature of this approach is developing the classification based on the known functional relationships among the land elements. The units derived express what is theorized to be ecologically important in the landscape. Two basic assumptions are that data and information are available or can be obtained to develop the system, and the interrelationships among the land's elements are well understood in defining the integrated units.

An ideal integrated ecological land classification system might be a single hierarchy whose units are defined in terms of all identifiable environmental factors and the interactions among them. This ideal can only be approximated. To develop such a hierarchy requires a high level of understanding of the interrelations among land elements—and an equally high level of agreement among users on specific criteria selected to define units at each hierarchical level.

Ecosystem element classification describes parts of the land—the soil, vegetation, landform, water, and climate—to form a hierarchical classification of each separately. The soil classification system used in the United States (USDA, Soil Conservation Service 1975) is an example of an element classification. Küchler (1964) presented a map of the potential natural vegetation of the United States. Penfound (1967) described a vegetation classification system of the United States. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) presented an open-ended worldwide vegetation classification system (UNESCO 1973).

The principle of the element approach to land classification is to deal initially with each element as an entity, defining and describing the classes on the basis of primary characteristics. Thus, the element approach to land classification allows users to apply only those elements and levels that are needed for an intended use. Not all elements have to be applied for every management application. Nor is the most detailed level of classification required if some more general level is sufficient.

The element approach to land classification is an approximation of integrated land classification because of the way each element classification is developed. Each element hierarchy represents in fact an integration of physical and biological factors. For example, effects of moisture and temperature are considered in the classifications of plant communities and soils, such as boreal forests (forests developed in cool climates) and Aridisol soils (soils formed in aridic climates). Further integration is accomplished by selecting classification criteria from several element hierarchies and combining them to extend the scope of the integration.

This stage of integration, as compared to the ones previously discussed (Austin 1981, Bailey 1980a, Wiken and Ironside 1977), is descriptive. Characteristics from more than one element are combined to define a new unit. This unit is specifically defined and is assumed to represent a homogeneous ecological unit. These combined-attribute units are termed "ecological units." An ecological unit is a specific class by which individual units of land are described and identified by physical and biological features. These classes are composed of two or more elements. Because they share common environmental features, all representatives of an ecological unit should behave in a predictable manner to both natural changes and resource management practices.

An ecological unit is not necessarily a contiguous unit of land that can be mapped. An ecological unit may occur in scattered pieces throughout the landscape. Wherever areas belonging to the same ecological unit occur, environmental conditions are assumed to be equivalent. Spatial association of ecological units permits integration of them by mapping. Describing land on the basis of individual elements, then combining the elements, if desired, allows for more complete land and resource analysis.

The classification framework reported here is based on earlier efforts. ECOCLASS[1] outlined a methodology for classifying ecosystems using a component mapping approach. ECOCLASS identified three components: potential vegetation; land system (Wertz and Arnold 1972); and aquatic system. In ECOCLASS, habitat type—land area characterized by a single climax plant association (Daubenmire 1952)—was included as a unit of the vegetation system. The ECOCLASS land systems included landform, lithology, relief, climate, soil, and vegetation as criteria for a single integrated hierarchy of land units.

Modified ECOCLASS[2] replaced habitat type with plant association in the vegetation system. The land system was separated into two components—landform and soil. Neither ECOCLASS nor Modified ECOCLASS clearly distinguished between taxonomic and mapping concepts of classification.

Driscoll and others[3] recommended a national land classification system for renewable resource assessments that incorporated many concepts of Modified ECOCLASS. This classification was designed to assist in describing the natural vegetation of the forest and rangeland base of the United States.

Cowardin and others (1979) developed a new classification system for wetlands and deep water habitats. The system is an integrated five-level hierarchy that incorporates soil, vegetation, and hydrology. The most general level, system, includes five classes—marine, estuarine, riverine, lacustrine, and palustrine. Subsystems are based largely on depth and duration of submergence by water. Classes and subclasses are based on substrate or general life form of dominant vegetation. The lowest level, dominance type, is based on dominant species of plants or animals. Regional differences important to wetland ecology are described through a regionalization that combines a system developed by Bailey (1980a) with the five classes.

Bailey's (1980a) classification system is a nine-level integrated hierarchy based on climate, vegetation, land-surface form, and soil. The upper levels are based on macroclimatic regimes. The midlevels integrate broad soil classes, broad vegetation types, land-surface features, and expressions of climatic-geomorphic processes. The lower levels deal with soil series and plant associations.

The UNESCO vegetation classification (UNESCO 1973) is an open-ended physiognomic (life form and appearance) ecological system. The five highest units are closed forest, woodland, scrub, dwarf-scrub and related communities, and herbaceous vegetation. These units are based on outward appearance of the stand and plant height characteristics. The midlevels are based on descriptors such as evergreen-deciduous, needle-leaved, broad-leaved, and climatic tolerances. The lower levels include general kinds of associated vegetation.

The classification framework described here builds on the concepts of these and other efforts (Daubenmire 1978, Küchler 1967, Mueller-Dombois and Ellenberg 1974). It is based on research, associated literature, and experience with both integrated and element classifications. The overall framework is a family of systems designed to provide the flexibility required to assist in making resource management decisions. It is dynamic because it allows additional levels or improved class criteria to be added. It provides a standard language that communicates, identifies, and names classes, and defines some criteria for natural renewable inventorying and mapping.

This classification framework was developed with four requirements in mind:

- The classification system should be based as much as possible on relatively permanent land features and,

[1]ECOCLASS Task Force. ECOCLASS—A method for classifying ecosystems. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; [Mimeo]. 1973. 52 p.

[2]Modified ECOCLASS Committee. Modified ECOCLASS—a method for classifying ecosystems. U.S. Department of Agriculture, Forest Service, Region 2, Region 3, and Rocky Mountain Forest and Range Experiment Station, ad hoc committee; [Mimeo]. 1977. 87 p.

[3]Driscoll, Richard S.; Russell, John W.; Meier, Marvin C. Recommended national land classification system for renewable resource assessments. Unpublished report on file at U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo. 1978. 44 p.

to the extent possible, provide compatibility and consistency with existing classification systems (Hirsch and others 1978).

- The classification system should be hierarchical so that through aggregation and disaggregation it can provide decisionmaking information at several administrative or geographic levels (Nelson and others 1978).
- The classification system should be capable of functioning in readily accessible, computer-operated information systems (Frayer and others 1978).
- The classification system should be based on ecological principles and measurable or readily inferable features of the land, so that units of the classification are identifiable by on-the-ground examination.

The basic framework of the classification system is as follows:

Soil element	Vegetation element	Water (aquatic) element[4]
Order	Class	System
Suborder	Subclass	Subsystem
Great group	Group	Class
Subgroup	Formation	Subclass
Family	Series	Dominance type
Series	Association	

Information within each class level becomes increasingly specific from the highest to the lowest levels of the hierarchies. The lowest levels of the hierarchies and combinations of them are well suited for detailed project planning; higher levels are more appropriate for State, regional, or national assessments and planning.

The soil system is *Soil Taxonomy* (USDA, Soil Conservation Service, 1975) used by the National Cooperative Soil Survey throughout the United States. It is also used in other nations and is closely related in concept and development to other modern soil classification systems (Buol and others 1980). Soil surveys provide the physical setting of described and classified soils, including geographic location, physiographic position, topography, parent material, and moisture and temperature regimes.

The vegetation system is patterned after a worldwide vegetation classification developed by UNESCO (UNESCO 1973) and has been provisionally described in relation to the United States by Driscoll and others (1983). It consists of two parts: the identification and description of potential natural vegetation (Kuchler 1967, Tuxen 1957) defined according to modern ecological principles (Daubenmire 1978, Mueller-Dombois and Ellenberg 1974); and the identification of successional communities related to climax vegetation by describing secondary succession and relating it to soils (Shiflet 1973). Appendix A presents the top four levels of the vegetation element of this classification system.

No fully developed and evaluated classification system exists that classifies water according to its ability to support life on and in the water. However, a new hierarchical classification of wetlands and deep water habitats (Cowardin and others 1979) presents a hierarchy that defines general water systems at the highest level and sorts them according to specific dominance types of vegetation or animals directly associated with wetlands at the lowest level. Water regime, water chemistry, vegetation, and soil modifiers were used to develop the system. These modifiers lead to an interpretation of water as a life support system. The dominance type of vegetation provides the direct link to nonwetland ecosystems and is presented as an element of the ecological land classification framework.

In the absence of a complete landform classification hierarchy, definitions of landform and geologic terms important for describing the land are presented in appendix B. They deal with land surface configuration, surficial material, and genesis. These terms, with legal or other location descriptions, should be used as appropriate to describe the physical location of plant communities and soils of those elements.

Integration relates to determining relationships among individual elements; for example, relating vegetation and soils to landform and climate. These relationships are important in establishing basic geographic units and defining their biotic potentialities. The objective is to provide for interpretation and to describe ecological units (Driscoll and others 1983) that appear synonymous to habitat types (Daubenmire 1978). Aggregation of these units provides regional zonations under the general influence of macroclimate and land surface features (Bailey 1980a, Wiken and Ironside 1977).

Soil Element

The soil taxonomy system developed by the USDA, Soil Conservation Service (1975) is complete with respect to the framework, format, and definitions of most categories and classes. It is a hierarchical system in which soils are precisely defined by observable and measurable soil properties. The properties are determined by parent material being acted upon over time by organisms, relief, and climate. Brief descriptions of the six categories of the soil taxonomy follow.

Orders—There are currently 10 orders defined by the presence or absence of identifiable horizons that reveal or have marks of the major soil-forming processes, such as accumulation of organic matter, availability of water for plant growth, or translocation of clays.

Suborders—There are currently 44 suborders defined by important properties that influence soil development and plant growth, such as wetness, parent material, and temperature.

Great groups—There are currently 189 great groups defined by similarities in kind, arrangement, and distinctiveness of horizons, as well as close similarities in moisture and temperature regimes, and base status.

Subgroups—There are currently 1,008 subgroups defined by characteristics already described for the higher

[4]From Cowardin and others (1979).

classes. However, they are subordinate characteristics; their presence modifies the dominant soil-forming processes.

Families—There are currently 6,111 families defined by physical and chemical characteristics that affect soil use and response to management. Particle size, mineralogy, temperature regime, and depth of root penetration are examples.

Series—There are about 14,800 series recognized by the kind, thickness, number, and arrangement of horizons. The range of properties, such as particle size, used to define series may be more restrictive than those used at the family level.

Phases of classes within any category are sometimes developed to serve specific purposes in individual soil surveys. They are not part of the soil taxonomic hierarchy. Any property or combination of properties that does not duplicate limits for a taxonomic class can be used to differentiate phases. The choices of properties and limits are determined by the purpose of the particular soil survey and by how consistently the phase criteria can be applied. Some of the features commonly used in defining phases in soil surveys are: texture of the surface layer; presence of rock fragments, such as gravel or stones; slope; physiographic position; salinity; kind of substratum; degree of past erosion; and flooding potential.

Vegetation Element

The vegetation element embodies the modern concepts of climax plant communities that distinguish between original (pristine climax) and potential natural vegetation. The purpose for dealing with climax vegetation or its facsimile is to establish natural vegetation potential. Knowledge of potential natural vegetation provides a basis for determining the natural biological potential of an area. Natural plant communities with their individual species evolve over long periods of time to adapt to specific habitat conditions. The adaptation takes place through adjustments of the individual plants for light, heat, space, moisture, nutrients, and wild animals. These adjustments eventually evolve to a plant community structure in which individual species are regenerating, competition for basic elements is quite stabilized, and a future different community is unpredictable except when disturbances such as logging, excessive grazing, and fire significantly change the community structure. The recognition of these phenomena by trained plant ecologists establishes some guidelines for land management decisions. For example, reforestation of a species within a specific area where it does not naturally occur, should usually be avoided, although exceptions may sometimes be justified.

The rest of this section establishes the differences among climax, original, natural, and potential natural vegetation; it is a brief synthesis based on work by Tuxen (1956, 1975) as translated by Küchler (1967) and implied and applied by Mueller-Dombois and Ellenberg (1974) and Daubenmire (1978).

Climax (pristine) plant communities, defined by early writers, were communities that developed over thousands of years to establish stabilized groupings of plants (Weaver and Clements 1938). These groupings constitute **original vegetation** that exists in the landscape unaffected by recent human activities and that is in balance with the regional biotic and abiotic forces of its site. Because much of the earth's surface has been affected by recent human activity, the original vegetation is often chiefly of historic and geologic interest.

The **natural vegetation** of today, as compared to original vegetation, exists in landscapes that have not been converted to agricultural or urban uses. Most areas of natural vegetation have been impacted to a greater or lesser degree by human activities. However, in many parts of the world, including the United States, natural vegetation exists where human activity has been minimal, and the vegetation is in balance with the biotic and abiotic forces of the site. A future plant community is unpredictable in the absence of major disturbances. Thus, **potential natural vegetation** is related to "climax" vegetation, provided "climax" is used in this modern context. Two assumptions are necessary to obtain potential natural vegetation: first, that human disturbances that cause basic vegetation change are removed from the scene, and second, that the resulting succession of plant communities is telescoped into a single moment to exclude effects of major climatic changes and earth-shaping events, such as vulcanism or diastrophism. Removing humans from the scene does not exclude their marks in the successional pattern toward potential natural vegetation. For example, cheatgrass (*Bromus tectorum*) was introduced from Eurasia about 1850, spread profusely throughout the arid and semiarid Western United States, and became firmly established under a wide variety of environmental conditions. The species is an exotic in the area, but has naturalized because of its adaptive capabilities. Therefore, cheatgrass should be regarded as part of the potential natural community (Driscoll 1964b).

Another kind of situation to establish potential natural vegetation of an area must be considered where human influence has been extensive and dramatic. The reduction or removal of human activity from the scene and the projection of vegetation succession to a relatively stable end point under existing climatic, biotic, and abiotic conditions would probably not result in establishment of potential natural vegetation as previously described. Frequently, human-induced natural plant communities become remarkably stable and appear to be self-regenerating. These relatively stable communities, although different from a perceived potential natural community, represent the highest stage of predictable succession, and should be considered a quasi-potential natural community for the area since the future would be predicted with a high degree of uncertainty. For example, portions of the large expanse of existing coniferous forest communities in the Southeastern United States have been perceived to be a substage of a deciduous forest region (Dice 1943, Weaver and Clements 1938). Intensive agriculture such as cotton farming, harvesting of deciduous tree species, and intensive forest management for coniferous species has led to remarkably stable communities. Even if humans were removed from the scene, the return of deciduous trees would likely be minor, if at all, depending on the timespan. These communities must be considered the highest stage of natural succession and represent the potential of the area.

Climax communities were described by early investigators (Weaver and Clements 1938) according to zonality; communities developed under "normal" conditions of prevailing and generalized climates. Other communities, developed under restricted conditions within a zone, such as steep slopes or restricted drainage, were regarded as nonclimax. It is now recognized that many climaxes representing potential natural vegetation exist under conditions differing from zonal situations. These conditions are recognized by using edaphic, topographic, fire, and zootic adjectives. These modifiers indicate the nature of influences that determine the resulting stable communities which differ materially from the "normal" situation (Daubenmire 1968).

A description of the hierarchy and a discussion of the linkage between potential natural vegetation and successional communities follows. Successional communities as used here refers to those communities which develop after disturbances such as logging or grazing and the outcome of the successions are predictable potential natural communities.

Description of the Hierarchy

The vegetation element is a six-level hierarchy (see above). The levels are class, subclass, group, formation, series, and association. The upper four levels are patterned after a world vegetation classification system (UNESCO 1973). These levels are based primarily on growth form and outward appearance, modified at some levels by moisture and temperature regimes. Some criteria of the upper levels have been modified to facilitate consistent identification of potential natural communities in the United States. These levels (class, subclass, group, and formation) are shown in appendix A. The two lower levels, series and association, are based on more detailed analyses of the plant communities including plant dominance and community structure. Therefore, the highest level of the classification is based on general classes of vegetation; the lowest level of the classification is based on discrete plant communities.

Descriptions of the six categories of the potential natural vegetation element follow.

Classes—There are five mutually exclusive classes based on dominant growth form and cover.

I. Forest: Communities formed by trees[5] with a canopy cover of 61 percent or more at maturity, tree crowns usually interlocked. This class includes forested wetlands.

II. Woodland: Communities composed of trees with a canopy cover of 26 to 60 percent at maturity. A herbaceous and/or shrub understory is usually present. This class includes woodland wetlands and the "open-forest" described by some authors.

III. Shrubland: Communities composed of woody perennial shrubs, individual plants generally with multiple stems, 1.6 to 16 ft (0.5 to 5 m) tall at maturity, with 26 percent or more canopy cover. This class includes shrub wetlands. A tree canopy cover 25 percent or less may be present.

IV. Dwarf-shrubland: Communities with 26 percent or more canopy cover of perennial woody plants rarely exceeding 1.6 ft (0.5 m) in height at maturity. This class is sometimes called heaths or heathlike formations and includes dwarf shrub wetlands. Tree or shrub canopy cover 25 percent or less may be present.

V. Herbaceous vegetation: Communities dominated by grass, grasslike, or forb vegetation with or

[5]For the purposes of this classification, a tree is a woody perennial, usually single-stemmed plant that has a definite crown shape and characteristically reaches a mature height of at least 16 ft (5 m); this size requirement may be altered where ecological research or experience provides a basis for adjustment. In high altitude, high latitude, or xeric situations, the tree height limit may be only 10 ft (3 m). In tropical situations tree height may be from 27 to 33 feet (8 to 10 m). Some species of oak (*Quercus*), juniper (*Juniperus*), willow (*Salix*) and other plants may grow either as trees or shrubs.

without a tree or shrub component at maturity. This class includes emergent and floating aquatic herbs. The tree or shrub canopy cover, if present, is 25 percent or less at maturity.

Subclasses—There are currently 19 subclasses. Discrimination between tree and shrub communities at this level are based on morphologic characters, such as evergreen and deciduous habit, or on adaptations to temperature and water. The separations for herbaceous vegetation are made on the basis of morphology and relative height of graminoid (grasses and grasslike) or forb vegetation. (Tall graminoid or forb vegetation is more than 3 ft (1 m) tall; medium is from 1.6 to 3 ft (0.5 m to 1 m) tall; and short is less than 1.6 ft (0.5 m) tall.)

Groups—There are currently 65 groups. The separations are based on the following criteria: forests are subdivided by generalized climatic regimes (for example, tropical, temperate, subpolar) and morphologic features; woodlands are subdivided mainly by leaf morphology; shrublands are subdivided by leaf morphology and climatic factors; dwarf-shrublands are subdivided by cover, associated life forms, ecological features, and other characteristics; and the grasslands are subdivided by plant height and associated life-form layers.

Formations—There are currently 150 formations defined in the United States. Criteria for separating plant communities at the formation level include tree crown shape, kinds of associated vegetation, amount and kind of understory vegetation, and a variety of ecological and environmental features. All formations of the United States have not been identified or described. The listing will be completed as additional research and experience defines them.

Series—The UNESCO system does not include this level of classification but provides for further subdivisions below the formation level to account for more definitive classes. The series is the first of these subdivisions and includes specificity of physiognomy and structure of the vegetation. Procedures for recognizing the series level for forest vegetation are illustrated by Pfister and Arno (1980) and for shrublands and grasslands by Mueggler and Stewart (1980). Series are usually characterized by individual dominant plant species of the communities. In some instances, where dominance may be uncertain, characterization is based on codominance. The vegetation of a large portion of the United States, especially in the West, has been classified to the series level. Examples include ponderosa pine (*Pinus ponderosa*), big sagebrush (*Artemisia tridentata*), loblolly pine (*Pinus taeda*), and bluebunch wheatgrass (*Agropyron spicatum*).

Associations—Associations, subdivisions of series, are plant communities of definite floristic composition, representing a uniform appearance and occurring within uniform habitat conditions (Daubenmire 1968). They frequently occur in discontinuous patterns throughout the landscape, depending on local relief and other abiotic features. Associations are groupings of plants that have attained dynamic equilibrium with local existing environmental conditions. Herbaceous, shrubby, and tree species contribute to the identification, definitions, and description of associations. Associations are conventionally named for conspicuous dominant species in different vegetation layers. Codominance can be explicitly recognized by including more species in the association name. A diagnostic indicator species may be used in the association name to provide a clearer link between the association characteristic and the name.

The first name in an association is the apparent dominant or codominant plant species in the tallest life form.[6] The second name in the association may be a dominant species in a different layer, or diagnostic nondominant species. A third species name may be applied when three vegetation layers conspicuously contribute to the structure of the community, and it is needed for unambiguous identification. For example, if a plant community includes ponderosa pine (*Pinus ponderosa*) as the dominant species in the highest life-form layer, antelope bitterbrush (*Purshia tridentata*) as the dominant species in the next layer, and Idaho fescue (*Fescue idahoensis*) as the dominant diagnostic species in the lowest layer, the potential natural association would be named *Pinus ponderosa/ Purshia tridentata/Festuca idahoensis*. Examples of the nomenclature for all levels of the vegetation element expressed as potential natural classes are shown in table 1.

For a developed plant community taxonomy at the series and association level, identification keys often help identify the communities (Mueggler and Stewart 1980, Steele and others 1981). Where vegetation has been disturbed by logging, grazing, or similar events, potential natural communities can be inferred by comparing the areas to similar sites where soil-vegetation correlations have been developed with potential natural communities (Shiflet 1973). Working approximations of potential natural vegetation to permit use of the classification at some levels can also be developed by using existing literature

[6]Species in a tallest life form with 25 percent or less canopy cover are not used for naming purposes in this classification. The tallest species in a plant community not contributing to diagnostic characteristics for identification of major classes should not be used in naming the plant communities.

Table 1—*Examples of potential natural vegetation climax classifications in the central Rocky Mountains. Adapted from Hess, K., III. Phyto-edaphic study of habitat types of the Arapaho-Roosevelt National Forests, Colorado. Fort Collins, CO: Colorado State University; 1981. 558 p. Ph.D. Dissertation and 1980 field data collected by the Resources Evaluation Techniques Program, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.*

Part I. Dominated by Woody Vegetation

Class	Closed forest	Woodland		Shrubland		Dwarf-shrubland
Subclass	Mainly evergreen forest	Mainly evergreen woodland		Mainly deciduous shrub		Mainly deciduous dwarf shrubs
Group	Temperate and subpolar needle-leaved	Needle-leaved		Cold deciduous		Cold deciduous
Formation	Evergreen needle-leaved forest with conical crowns	Evergreen needle-leaved woodland with rounded crowns		Subalpine or subpolar deciduous shrubland caespitose dwarf		Cold deciduous shrubland
Series	*Picea engelmannii-Abies lasiocarpa* (Engelmann spruce-subalpine fir)	*Pinus ponderosa* (ponderosa pine)		*Salix planifolia* (planeleaf willow)		*Salix arctica* (arctic willow)
Association	*Picea engelmannii-Abies lasiocarpa/Vaccinum scoparium* (Engelmann spruce-subalpine fir/grouse whortleberry	*Pinus ponderosa/Purshia tridentata/Carex rossii* (ponderosa pine/antelope bitterbrush/Ross sedge)	*Pinus ponderosa/Cercocarpus montanus/Agropyron griffithsii* (ponderosa pine/true mountainmahogany/Griffiths wheatgrass)	*Salix planifolia/Carex scopulorum* (planeleaf willow/mountain sedge)	*Salix planifolia/Calamagrostis inexpansa* (planeleaf willow/northern reedgrass)	*Salix arctica/Geum rossii* (arctic willow/golden avens)

Part II. Dominated by Herbaceous Vegetation

Class	Herbaceous vegetation					
Subclass	Medium-tall			Short		Forb vegetation
Group	With a shrub layer		Without a woody layer	With a shrub layer		Low
Formation	Shrub layer small-leaved evergreen		Medium-tall grassland consisting mainly of bunch grass	Shrub layer broad-leaved deciduous		Mainly perennial flowering forbs and ferns
Series	*Festuca ovina* (Sheep fescue)	*Poa compressa* (Canadian bluegrass)	*Deschampsia ceaspitosa* (tufted hairgrass)	*Carex rupestris* (rock sedge)	*Carex rupestris* (rock sedge)	*Silene acaulis* (moss silene)
Association	*Festuca ovina/Artemisia tridentata* (sheep fescue/big sagebrush)	*Poa compressa/Artemisia cana* (Canadian bluegrass/silver sagebrush)	*Deschampsia caespitosa/Trifolium parryi* (tufted hairgrass/Parry clover)	*Carex rupestris/Salix artica* (rock sedge/arctic willow)	*Carex rupestris/Artemisia scopulorum* (rock sedge/alpine sagewort)	

(see, for example, Küchler 1964). These approximations should be developed for local, State, or regional areas by vegetation classification specialists most familiar with the local vegetation. They also should be formally described as approximations for current use and recognized as a framework for future development.

Successional Communities in Relation to Potential Natural Vegetation

A knowledge of existing vegetation, its distribution, and status helps land managers make management decisions on use of vegetation resources. Inventory identifies and determines the distribution of existing vegetation on the landscape. Existing vegetation may be natural, cultural, or agricultural plant communities. Natural vegetation consists of indigenous species and introduced species that have naturalized to an area to the extent that they may be considered a part of the natural vegetation. Cultural vegetation includes communities of introduced plants where management objectives may be for perpetuation of introduced stands or nonindigenous species using extensive rather than agronomic practices. Rangeland seedings with introduced species or areas of aforestation are examples of cultural vegetation. Agricultural vegetation includes plant communities established and managed under agronomic principles such as fertilization and irrigation, and used primarily for production of food, fiber, or feed crops.

Successful plant communities are classified by identifying secondary successional (seral) stages of potential natural vegetation. Ecologists and other vegetation specialists link successional plant communities to potential natural vegetation by making generalized inferences from surrounding natural vegetation, using soils information correlated with potential natural vegetation and making inferences for similar soils, referring to maps such as those presented by Küchler (1964), or referring to historical records.

Ground examination and remote sensing are used to classify and inventory existing natural plant communities and interpret their link as successional communities to potential natural vegetation. Shiflet (1973) has adequately discussed how existing plant communities are interpreted and related to climax communities or potential natural vegetation using soils and related information. Generally, the process includes searching the landscape to find, measure, and classify the highest seral stage of natural vegetation and describing its setting in relation to soils, topography, and climate. Using inventory procedures, the existing plant community is measured together with its associated soils, topography, and general climate. The soils, topography, and climate of the existing plant community are then compared to similar features of previously defined potential natural vegetation, and the linkage is established based on similarities of abiotic features.

Remote sensing, including satellite imagery and aerial photography, records the existing vegetation. The more detailed the level of classification to be identified through remote sensing, the greater the resolution and scale of remote sensing data that will be required. For example, associations or seral stages of associations would not be positively identified directly by any current remote sensor data for two reasons: photographic remote sensors do not "see" entirely through layered vegetation to "record" the layers of vegetation required for association classification and identification; and the identification of individual plant species required to classify associations is generally not possible through remote sensing. Satellite imagery would be most successful in classifying the class levels of the vegetation hierarchy. Low-, medium-, and high-altitude aerial photography would provide information for classification at the series through subclass levels respectively, provided land surface modifiers such as slope and aspect, and film image characteristics such as color, texture, and tone are used as photointerpretation aids. The expectations and limitations of remote sensing for vegetation classification and other land-surface features have been extensively discussed by Aldrich (1979). Anderson and others (1976) presented a land-use and land-cover classification system for application with remote sensor data.

Although knowledge of successional communities is needed, it, in itself, does not always reflect inherent site potential. Existing natural vegetation occurs as infinite secondary successional stages, which are related to time elapsed since such disturbance as timber harvesting, livestock grazing, or unnatural wildlife population concentrations. Secondary successional stages of vegetation are abundantly represented in most areas of the United States. Plant communities representing late successional stages or potential natural communities are less common and in some areas rare. These areas can and should be located (Braun 1964, Mueggler and Stewart 1980, Steel and others 1981) to define the inherent biological potential of the land and develop the relationships between successional communities and potential natural vegetation.

Only the potential natural vegetation or a high seral stage of vegetation reliably reveals the natural biological potential of an area. Therefore, classifications based on potential natural vegetation are powerful, integrated expressions of the inherent natural biological capability of areas. Consequently, the classification of these kinds of communities provides a means of interpreting the relationships among existing vegetation communities. It also permits identification of potential trends in vegetation succession toward or away from potential natural vegetation, and provides for either functional or interdisciplinary management decisions.

A matrix (fig. 1) illustrates the relationships between some existing successional communities and potential natural vegetation. In the examples, each row shows some successional vegetation communities that occur within particular vegetation series. The left column shows series that may support several existing vegetation communities. Acreage data for appropriate cells in the matrix can be provided by an inventory of existing vegetation where the potential natural vegetation has been identified. Knowing the position of a specific successional community within the matrix in relation to its potential enables prediction of natural succession or trends resulting from different management treatments. Also, it connotes information about the natural biological potential of the existing vegetation. Similar matrices can be developed for grasslands and shrublands.

In the context of the examples, the four principal objectives are to: identify the existing natural vegetation community obtained through inventory; interpret it in relation to potential natural vegetation for the area; evaluate management objectives and alternatives for the area; and establish management goals. For example, existing vegetation of an area with grassland potential may be a shrub-grass seral community. One management alternative may be to "hold" the existing community in its present seral stage for combined wildlife-livestock-water production, use, and protection. Another alternative may

	Existing Vegetation (Series)					
Potential Natural (Climax) Vegetation	Vegetation Series	Pinus ponderosa (Ponderosa pine)	Pseudotsuga menziesii (Douglas-fir)	Abies grandis (Grand fir)	Pinus contorta (Lodgepole pine)	Larix occidentalis (Western larch)
	Pinus ponderosa	Climax	—	—	—	—
	Pseudotsuga menziesii	Seral	Climax	—	Seral	Seral
	Abies grandis	Seral	Seral	Climax	Seral	Seral

Figure 1—*The relationships between existing vegetation (cover types) that may be inventoried and potential natural vegetation at the series level for western Montana (after Pfister and others 1977)*

be to manage the area for livestock grazing or improvement of wildlife habitat. Decisions can then be made to manipulate the existing plant community through knowledge of its natural potential by changing management objectives or land treatments to address the management goals.

Both existing vegetation and potential natural vegetation information are important and widely used. In combination, they are valuable for understanding and managing the vegetation resource and the area on which it is produced.

Water (Aquatic) Element

A water classification system should provide a framework to group open bodies of water according to their ability to support life on and in them. A system developed on this basis would reflect the inherent potential of water to serve as a habitat or as a resource. A fully developed hierarchical system that addresses local, State, regional, and national levels, however, is unavailable.

There are classification systems for river and river zones based on dominant fish species, longitudinal distribution of benthic fauna, degree of productivity, nature of source, stream order, and selected chemical and physical characteristics (Hawkes 1975, Hynes 1970, Pennak 1971). Worldwide classification systems, such as those of Illies and Botosaneau (1963) and Pennak (1971), are based on multiple characteristics that utilize more universal criteria than do local and regional systems. Classifications for lakes are generally based on geographical, hydrological, water-mixing, and trophic characteristics (Cole 1978, Hutchinson 1957, Wentz 1980, Wetzel 1975, Winter 1977). Estuaries have been classified according to topography (Pritchard 1952), salinity structure (Cameron and Pritchard 1963, Pritchard 1955), and stratification (Dyer 1973). Other classification systems incorporate water-related parameters and water bodies in a general context or through regionalized mapping (Anderson and others 1976, Bailey and others 1978, Platts 1980, Rowe 1979, West and Shute 1978). None of these classification systems deal fully with wetlands—land areas permanently wet or intermittently covered with water.

In wetlands, vegetation and soils influence the fluctuations in water regime and the chemical and physical characteristics of water. The extent and duration of water influences the development of vegetation and soils in the transition areas between permanently waterlogged and nonwaterlogged conditions. A new classification system of wetlands and deepwater habitats (Cowardin and others 1979) provides a basic framework for an aquatic classification system and provides a direct intergrade into the soils and vegetation elements (fig. 2).

Cowardin and others (1979) described wetlands as

> . . . lands transitional between terrestrial and aquatic systems, where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification, wetlands must have at least one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

In this context, wetlands include a variety of situations, including marshes, swamps, and bogs; areas of hydric soil devoid of vegetation because of high salt concentration or abrasive actions of water; areas without soil or vegetation such as gravel and sand bars and beaches; and areas near and around shorelines with nonhydric soils supporting hydrophytic vegetation.

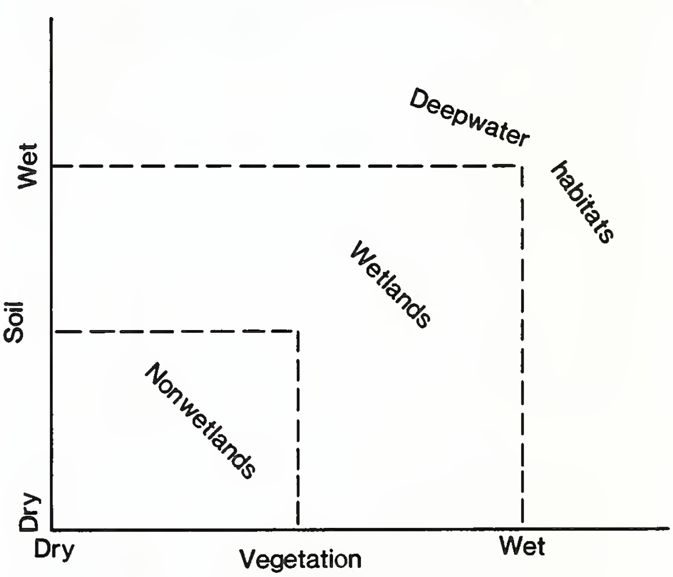

Figure 2—*The relative position of vegetation and soil from dry to wet environments in relation to water conditions and the classification system of Cowardin and others (1979). The areas under the curves are not meant to depict areal extent of the categories. The vegetation element reported herein extends from dry (xeromorphic) communities to wet (hydromorphic) communities. The soil element extends from dry (aridic) to wet (hydric) situations.*

Deep water habitats are defined by Cowardin and others (1979) as permanently flooded lands below the deepwater boundary of wetlands. Generally, this boundary lies at a depth of 6.6 ft (2 m) below the low water level, the maximum depth to which most emergent plants normally grow. However, when emergent plants occur beyond this limit, that boundary is the edge between wetlands and deepwater habitats.

Five classification levels are defined in the classification system. Brief descriptions of them follow.

Systems—There are five systems described according to similarities of general hydrologic, geomorphologic, chemical, or biological factors. The systems relate to general kinds of water bodies, such as lakes and running water.

Subsystems—There currently are 10 subsystems based on depth and submergence of the substrate by water or permanence of water.

Classes—There are currently 55 classes based on the general nature of the substrate (rock bottom or rocky shore), or on general life form of vegetation (forested wetland or wetland with emergent vegetation).

Subclasses—There are currently 23 subclasses based on specific kinds of substrate, such as bedrock, sand, or mud; or on general life form of vegetation, such as needle-leaved evergreen forest, broad-leaved deciduous forest, or floating vegetation. Subclasses in many cases are the same among classes.

Dominance types—Dominance types are based on dominant species of plants or animals supported by a specific substrate subclass within particular systems. For example, red mangrove (*Rhizophora mangle*) occurs within the broad-leaved evergreen forested wetland of the estuarine system.

Examples of subclasses and dominance types as they relate to vegetation are shown in table 2.

Modifiers are used to more precisely define the levels of the classification system. These include:

- Water regime: There are two primary modifiers, tidal and nontidal. The tidal modifiers affect the marine and estuarine systems around the coastal areas and are determined largely by oceanic tides. Nontidal modifiers affect the riverine, palustrine, and lacustrine systems and are related to fluctuations of water in inland lakes, streams, and other water systems.
- Water chemistry: There are two primary modifiers, salinity and hydrogen ion concentration (pH). Salinity is applied to all habitats, and freshwater habitats are further subdivided by pH levels.
- Soil: There are two primary modifiers, mineral and organic material. They are used with the wetlands portion of the classification system because the deepwater habitats, by definition, are never considered to have soil. Soil, as a modifier of wetlands, is necessary. The depth, temperature and moisture regimes, chemistry, and mineral and organic matter content of soil influence the kinds and amounts of vegetation and organisms wetlands can support.

The wetlands and deepwater habitats classification, as part of the framework for a national ecological land classification system, provides a skeleton for evaluating water as a life support system. Consider fish and fisheries, for example. The subclasses delineate the nature of the bottoms of lakes, rivers, and streams, according to cobble-gravel, sand, rubble, mud, organic or bedrock. These features are important for evaluating fish spawning areas and spawning success. The presence of animal organisms that live within hydric soils or in other substrates provide food for associated animals. Vegetation can be evaluated according to its potential to provide cover and food for fishes. Similar analogies can be made in relation to waterfowl, certain amphibians, mollusks, and other water dependent animals.

The linkage between the wetlands and deepwater habitats classification system and the vegetation classification previously described occurs generally at the dominance type level of wetlands and the series level of this vegetation classification. For example, a vegetation series in the forest class of Alaska includes black spruce (*Picea mariana*) and is described as occurring on wet, boggy sites with poorly drained organic soils (Viereck and Dyrness 1980). A dominance type in the palustrine system of Cowardin and others (1979) is black spruce (*Picea mariana*). Another example would be a vegetation series of smooth cordgrass (*Spartina alterniflora*) in the subclass of the medium tall grassland occurring in salt marshes along the eastern and southern coasts of the United States. A species of dominance type of the same plant occurs in the persistent emergent wetland of the estuarine system of Cowardin and others (1979).

In wetland, if soils are present, they are hydric. A list of hydric soils is being prepared by the Soil Conservation Service. This list forms the linkage between the soil and wetlands elements of the classification system.

The new wetlands and deepwater habitats classification is generalized. It is open ended and incomplete below the class level; only examples are given for dominance types. The system is insufficiently detailed at the dominance type level to provide for detailed project planning. Other levels corresponding, for example, to the series and association levels of the vegetation element need to be developed. However, the system, as currently described,

Table 2—*Examples of systems, classes, subclasses, and dominance types as related to vegetation (from Cowardin and others 1979)*

System	Class	Subclass	Examples of dominance types
Estuarine	Aquatic bed	Algal	Rockweed *(Fucus vesiculosus)*
		Rooted vascular	Eelgrass *(Zostera marina)*
		Floating	Water hyacinth *(Eichhornia crassipes)*
	Emergent wetland	Persistent	Smooth cordgrass *(Partina alterniflora)*
		Nonpersistent	Samphire *(Salicornia europea)*
	Scrub-shrub wetland	Needle-leaved evergreen	Sitka spruce *(Picea sitchensis)*
		Broad-leaved evergreen	*Mangrove (Conocarpus erectus)*
		Needle-leaved deciduous	Bald cypress *(Taxodium distichum)*
		Broad-leaved deciduous	Marsh elder *(Iva frutescens)*
		Dead	None
	Forested wetland	Needle-leaved evergreen	Sitka spruce *(Picea sitchensis)*
		Broad-leaved evergreen	Red mangrove *(Rhizophora mangle)*
		Needle-leaved deciduous	Bald cypress *(Taxodium distichum)*
		Broad-leaved deciduous	Red ash *(Fraxinums pennsylvanica)*
		Dead	None
Riverine	Aquatic bed	Aquatic moss	Moss *(Fissidens adiantoides)*
		Rooted vascular	Riverweed *(Podostemum ceratophyllum)*
		Floating	Bladderwort *(Utricularia vulgaris)*
	Streambed	Vegetated	Old witch grass *(Panicum capillare)*
	Rocky shore	Bedrock	Liverwort *(Marsupella emarginata)*
		Rubble	Lichen *(Dermatocarpon fluviatile)*
	Unconsolidated shore	Vegetated	Cocklebur *(Zanthium strumarium)*
	Emergent wetland	Nonpersistent	Horsetail *(Equisetum fluviatile)*
Lacustrine	Aquatic bed	Aquatic moss	Moss *(Fontinalis antipyretica)*
		Rooted vascular	Widgeon grass *(Ruppia maritima)*
		Floating	Duckweed *(Lemna minor)*
	Unconsolidated shore	Vegetated	Goosefoot *(Chenopodium rubrum)*
	Emergent wetland	Nonpersistent	Pickerelweed *(Pontederia cordata)*
Palustrine	Aquatic bed	Aquatic moss	Moss *(Fissidens julianus)*
		Rooted vascular	White water lily *(Nymphaea odorata)*
		Floating	Water fern *(Salvinia rotundifolia)*
	Unconsolidated shore	Vegetated	Summer cypress *(Kochia scoparia)*
	Moss-lichen wetland	Moss	Peat moss *(Sphagnum fuscum)*
		Lichen	Reindeer moss *(Cladonia rangiferina)*
	Emergent wetland	Persistent	Common cattail *(Typha latifolia)*
		Nonpersistent	Arrow-arum *(Peltandra virginica)*
	Scrub-shrub wetland	Needle-leaved evergreen	Atlantic white cedar *(Chamaecyparis thyoides)*
		Broad-leaved evergreen	Coastal sweetbells *(Leucothoe axillaris)*
		Neele-leaved deciduous	Tamarack *(Larix laricina)*
		Broad-leaved deciduous	Speckled alder *(Alnus rugosa)*
		Dead	None
	Forested wetland	Needle-leaved evergreen	Black spruce *(Picea mariana)*
		Broad-leaved evergreen	Sweet bay *(Magnolia virginiana)*
		Needle-leaved deciduous	Bald cypress *(Taxodium distichum)*
		Broad-leaved deciduous	Red maple *(Acer rubrum)*
		Dead	None

does provide an initial framework for a hierarchical classification of wet habitats. Additional research and development is needed to develop aquatic habitat types in the context of terrestrial habitat types following the concepts of Daubenmire (1952).

Landform Descriptors

Landform, as used here, deals with shape or configuration of land surface, materials of the upper few meters, and the genesis or geologic/geomorphic process by which the landform developed. Landforms are major ecosystem elements since they influence the nature and behavior of other ecosystem elements (Bailey 1981). For example, the steepness and aspect of a slope influence the kind of vegetation of an area and the way water flows through a watershed. Understanding of an ecosystem is enhanced when landform characteristics are described and their effects upon and interaction with other parts of the ecosystem are evaluated. Landform information alone can be used in some preliminary planning, for example, in planning activities such as road building for timber harvest.

In the absence of a detailed landform classification hierarchy, a glossary of landform and geologic terms is presented in appendix B. The terms, with definitions, are arranged alphabetically. Following the definitions are several block diagrams of landform features and lists of glossary terms organized according to shape, materials, and genesis of landforms. Appropriate landform descriptors are needed when describing the physical and geographical setting of a plant community or soil.

Combining (Integrating) the Elements

Developing and using classification systems of ecosystem elements alone allows evaluation of some of the many land use or land management options. For example, engineering projects, such as road and earthen dam designs, depend mainly on soil information coupled with landform descriptors. Information about vegetation and water is needed when planning for removal of vegetation or special construction features dealing with water drainage. Special consideration must be given to other elements when engineering projects might threaten specific kinds of plant or animal habitats or populations. If the user is interested only in knowing the general vegetation of an area for preplanning to determine amount, kind, and distribution for livestock grazing, wildlife habitat, or timber harvesting, the vegetation hierarchy is most important. Some planning decisions may be best assisted by knowing that a geomorphic feature, such as glacial outwash or river deposits, is a probable source of gravel.

Many resource planning and monitoring decisions, however, must be based on the whole ecosystem rather than individual elements. Only in this way can interactive effects of actions on multiple or individual resources be logically determined and predictions be made regarding alternative actions.

Ecosystems, however classified, represent a combination or integration of all ecosystem elements working together to form an entity. Likewise, the individual elements of the ecosystem are expressions of the interactions of climate, organisms, land relief, parent material (rock type), and time to form recognizable ecosystem elements. Vegetation (Major 1951) and soil (Jenny 1941) are two examples. Hence the plant community (or soil) of an area represents a first-order interaction or integration, and classification of them takes advantage of those events. For example, Mollisol soils are characteristically formed under grasslands in subhumid to semiarid climates. Vegetation of the temperate and subpolar evergreen needleleaved forest group are, by definition, developed between the tropics and frigid zones and on soils in those zones.

A second stage of "integration" or "combination" should more precisely define and describe the whole ecosystem. However, a logical statistical process to accomplish the task has not been developed. Thus, this stage of the integration process is descriptive; characteristics from more than one element describe a unit of land with specific limits of features. This integration procedure can be applied to any level of generalization to represent ecological units (ecological response units of Driscoll and others (1983)) in which response is more specific at the lower levels of the hierarchy and more general at the higher levels of the hierarchy.

Specific ecological units, including procedures for developing them, have been reported by Driscoll (1964a,b) and Mueggler and Stewart (1980). These ecological units represent areas of land that may occur in several places and are specific to kinds of vegetation associations and soil series or phases of soils. However, it must not be inferred that specific vegetation associations and soil series always have 1:1 relationships. One vegetation association may occur with more than one soil series or phase of series, and one soil series may be associated with more than one vegetation association. Ecological units are not always contiguous; they may be geographically separated as a result of local landform, climate, and topographic differences. However, by the logic with which they are described, they are expected to respond to management similarly.

An example of an ecological unit follows:

Soil	Vegetation	Landform descriptor
Order: Mollisol	Class: Herbaceous vegetation	
Suborder: Aquoll	Subclass: Medium-tall grassland	
Great Group: Natraquoll	Group: Without woody layer	
Subgroup: Typic Natraquoll	Formation: Mainly sodgrass	
Family: Fine, montmorillonitic, frigid typic Natraquoll		
Series: Heil	Series: *Agropyron smithii* (Western wheatgrass)	
	Association: *Agropyron smithii/spartina pectinata* (Western wheat-grass/Prairie cordgrass)	Shallow closed depression

The name of the above unit would be *Agropyron smithii/Spartina pectinata*-Heil-shallow closed depression ecological unit. It would be described as a western wheatgrass/prairie cordgrass association occurring in shallow closed depressions, with deep, fine textured, moderately alkaline soils with a thick, dark gray surface layer. Water occurs at or near the surface in the spring and summer. This description characterizes the ecological unit so it may be recognized whenever similar conditions exist. More detailed information about the units, such as production, amount and kind of vegetation, size of the area, depth of the soil, and other features required for management decisions may be obtained through review of existing information, including published soil surveys or other information, or through additional inventories.

A description of a broader unit, within which the above unit would be included, can be provided at a more general level. An example, using the above information, would be sodgrass communities in seasonally ponded or wet areas, receiving about 16 inches (400 mm) of precipitation per year, mostly in the spring and summer. Soils are formed in alluvium and are calcareous throughout; groundwater is shallow during most of the year, and capillary rise of water results in salt concentrations near the surface. This description characterizes an ecological unit at the formation level of vegetation. Inventory would be needed to obtain more detailed information about the unit.

Generally, elements are integrated to form ecological units by merging classes or attributes from the respective parent systems. A process using only the soil and vegetation elements is illustrated below.

Vegetation Classes

		V_1	V_2	V_3 -----	V_i
	S_1	S_1V_1			
	S_2				
Soil Classes	S_3				
	—				
	—				
	—				
	S_j				S_jV_i

With the vegetation classes identified as V_1 - - - V_i and the soil classes identified as S_1 - - - S_j, the resultant classes ($V_i S_j$) have key attributes of V_i and S_j and the ecological unit is formed. Thus, a new set of classes are recognized that defines an ecological unit rather than just parts of that unit. In application, the vegetation and soil integrations may be at any level of their parent systems.

Additional integration is often needed within an overall framework to assist in land partitioning for certain objectives. The individual element and ecological unit classification provides a basic framework for dealing with grasslands, shrublands, and forestlands, with their associated features of soil and topography as entities in themselves, to determine features such as grassland production, tree volumes, or opportunities to increase specific standing crop biomass. Spatial organization of ecological units provides an adition to the classification framework to help interpret cause and effect relationships and make analyses of interdependence of such values as wildlife, fisheries, and recreation opportunities. Also, analyses of juxtaposition and interspersion may be made to determine interrelationships among the relatively pure ecological units to management decisions. For example, few wildlife species or species groups obtain total life requirements from only the forest or grassland. Consequently, simultaneous evaluations of both are required to understand the animal/habitat relationships. Also, activities such as timber harvesting, livestock grazing, or road building in a watershed composed of a complex of ecological units, affect water in the stream and fisheries. Therefore, analysis of activities in the whole watershed is needed to assess their impacts on water quality and quantity.

Austin (1981) and Bailey (1980b) presented a generalized scheme for combining the ecological units derived by the previously discussed integration process. The procedure (Bailey 1980b), called regionalization, partitions the landscape into regional ecosystems. Regional ecosystems can represent associations of smaller ecosystems within prescribed boundaries. Climate, physiography, and physical geography as they affect plant communities and soils are used as primary criteria for describing the regionalized ecosystems and placing map boundaries. The resultant map displays regional ecosystems nested within one another in a hierarchy of spatial sizes. At any level of the hierarchy, regionalization always deals with geographically associated ecological units. Each unit constitutes a unique piece of the landscape to which specific geographic designations may be assigned.

A major contribution of regionalization is that it displays spatial patterns of ecological associations and displays by maps the juxtaposition and interspersion of ecological units. This part of the classification framework is needed to assist in wildlife habitat, fish habitat, and recreation opportunity assessments. For example, the analysis of a Western United States deer herd situation must simultaneously consider the mixture of winter range and summer range. The area would include sagebrush, submontane and montane grassland, coniferous forest, deciduous forest, and high elevation (alpine) grasslands and shrublands.

Summary

A framework for an ecological land classification system for the United States has been described. Land, within the context of this framework, is the conterminous United States, Alaska, Hawaii, and its territorial possessions.

The system defines potential natural vegetation according to modern ecological principles and patterned after UNESCO (1973) and existing vegetation which are seral (secondary successional) plant communities; soils based on *Soil Taxonomy* (USDA, Soil Conservation Survey, 1975); wetlands and deepwater habitats from Cowardin and others (1979) as an initial system to characterize wet habitats, including linkage to the vegetation and soil elements; and landforms for describing the setting of areas regardless of size, particularly vegetation and soils or vegetation or soil areas. It then describes the integration or combination of elements to form ecological units and combinations of ecological units into spatially related geographic areas.

A few examples are presented for each level of each element and for the combined or integrated elements. The lowest levels of each element are continually being described, defined, and refined. The classification framework can be revised as new information becomes available.

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Appendix A: Keys to the Upper Four Levels of the Vegetation Element

The tables in this appendix identify and define the upper four levels of the vegetation element of the national land classification framework—classes, subclasses, groups, and formations. To provide field users quick access to information they need to classify land, the five classes—forest, woodland, shrubland, dwarf-shrubland, and herbaceous vegetation—are treated on five separate tables.

No national key for the lower categories—series and associations—has yet been developed. Some of this information, however, is available locally in many areas of the country from the agencies that cooperated on this report.

The information presented in the tables relies heavily on The United Nations Educational, Scientific and Cultural Organization's *International Classification and Mapping of Vegetation, Series 6, Ecology and Conservation* published in 1973.

Table A-1—Key to the Vegetation Element of the Land Classification Framework—Class: Forest[1]

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)	a. Tropical lowland rain forest b. Tropical submontane rain forest c. Tropical montane rain forest d. Tropical "subalpine" rain forest e. Tropical (rain) cloud forest f. Tropical alluvial rain forest g. Tropical swamp rain forest h. Tropical evergreen bog forest (classical tropical rain forests)
		2. Tropical and subtropical evergreen seasonal forest (mainly broad-leaved evergreen trees with some foliage reduction in dry season)	a. Tropical or subtropical evergreen seasonal lowland forest b. Tropical or subtropical evergreen seasonal submontane forest c. Tropical or subtropical evergreen seasonal montane forest d. Tropical or subtropical evergreen dry "subalpine" forest
		3. Tropical and subtropical semideciduous forest (upper canopy trees drought deciduous)	a. Tropical or subtropical semideciduous lowland forest b. Tropical or subtropical semideciduous montane or cloud forest
		4. Subtropical rain forest (not represented in U.S.)	a. Subtropical lowland rain forest b. Subtropical submontane rain forest c. Subtropical montane rain forest d. Subtropical "subalpine" rain forest e. Subtropical (rain) cloud forest f. Subtropical alluvial rain forest g. Subtropical swamp rain forest h. Subtropical evergreen bog forest (with organic surface deposits)
		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

See footnote at end of table.

Table A-1—Key to the Vegetation Element of the Land Classification Framework—Class: Forest[1]—Continued

Class: Forest	Subclass	Group	Formation
		7. Winter-rain, broad-leaved sclerophyllous forest (stiff-, leathery-leaved trees)	a. Winter-rain evergreen sclerophyllous lowland and submontane forest (over 50 m tall) (*Eucalyptus* in Calif.) b. Winter-rain evergreen sclerophyllous 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 needle-leaved forest
		9. Temperate and subpolar needle-leaved forest (mostly needle-leaved and scale-leaved trees)	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)
	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.)	a. Drought-deciduous broad-leaved lowland and submontane forest b. Drought-deciduous montane (and cloud) forest
		2. Cold-deciduous forest, with evergreen trees (winter frost and freeze)	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)
		3. Cold-deciduous forest, without evergreen trees (winter frost and freeze)	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) d. Cold-deciduous alluvial forest (e.g., bottomland hardwoods) e. Cold-deciduous swamp or peat forest (e.g., deciduous forests in parts of Alaska)

See footnote at end of table.

Table A-1—Key to the Vegetation Element of the Land Classification Framework—Class: Forest[1]—Continued

Class: Forest	Subclass	Group	Formation
	C. Extremely xeromorphic forest (not represented in U.S.)	1. Sclerophyllous dominated forest	
		2. Thorn-forest	a. Mixed deciduous-evergreen thorn forest b. Purely deciduous thorn forest
		3. Mainly succulent forest	

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

Table A-2—Key to the Vegetation Element of the Land Classification Framework—Class: Woodland[1]

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. Mixed deciduous woodland (broad-leaved and needle-leaved)
	C. Extremely xeromorphic woodland (dry woodlands)	1. Sclerophyllous woodland	a. Evergreen sclerophyllous-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	

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

Table A-3—Key to the Vegetation Element of the Land Classification Framework—Class: Shrubland[1]

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 hemisclerophyllous shrubland d. Evergreen broad-leaved sclerophyllous shrubland e. Evergreen suffruticose shrubland
		2. Needle-leaved and microphyllous shrubland	a. Evergreen needle-leaved shrubland (e.g., krummholz) b. Evergreen microphyllous shrubland (sagebrush)[2]
	B. Mainly deciduous shrubland (majority of shrubs shed foliage as result of drought and/or cold)	1. Drought-deciduous shrubland, with evergreen woody plants (may not be represented in U.S. except Hawaii and island trusts and territories)	
		2. Drought-deciduous shrubland, without evergreen woody plants	
		3. Cold-deciduous shrubland (winter frost and freeze)	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) d. Deciduous peat shrubland
	C. Extremely xeromorphic (subdesert) shrubland (arid climate)	1. Mainly evergreen shrubland	a. Evergreen subdesert shrubland (e.g., creosote bush) b. Semideciduous subdesert shrubland (e.g., saltbush)
		2. Deciduous shrubland	a. Deciduous subdesert shrubland without succulents b. Deciduous subdesert shrubland with succulents (e.g., palo verde)

[1]The key to the vegetation element is patterned after UNESCO 1973. The key contains a few examples of known communities in the United States.
[2]Sagebrush *(Artemisia)* shrubs are considered evergreen although one species, stiff sagebrush (*A.* rigida), is considered completely deciduous (Tisdale and Hironaka 1981).

Table A-4—Key to the Vegetation Element of the Land Classification Framework—Class: Dwarf-Shrubland[1]

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 c. Drought-deciduous cushion dwarf-shrubland d. Drought-deciduous mixed dwarf-shrubland
		3. Cold-deciduous dwarf-shrubland (winter frost or freeze) (dwarf willow and other dwarf shrub communities of cold regions exclusive of tundra)	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
	C. Extremely xeromorphic (subdesert) dwarf-shrubland (specific examples need to be determined)	1. Mainly evergreen dwarf-shrubland	a. Evergreen subdesert dwarf-shrubland b. Semideciduous subdesert dwarf-shrubland
		2. Deciduous dwarf-shrubland	a. Deciduous subdesert dwarf-shrubland without succulents b. Deciduous subdesert dwarf-shrubland with succulents
	D. Tundra dwarf-shrubland	1. Mainly moss dwarf-shrubland (e.g., shrub-moss tundra of Alaska)	a. Caespiteose dwarf-shrub/moss tundra b. Creeping or matted dwarf-shrub/moss tundra
		2. Mainly lichen dwarf-shrubland (e.g., shrub-lichen tundra of Alaska)	

See footnote at end of table.

Table A-4—Key to the Vegetation Element of the Land Classification Framework—Class: Dwarf-Shrubland[1]—Continued

Class: Dwarf-Shrubland	Subclass	Group	Formation
	E. Mossy bog with dwarf-shrubs (substrate of *Sphagnum* or other mosses which cover the surface as well; specific examples to be determined)	1. Raised bog dwarf-shrubland	a. Typical raised bog dwarf shrubland (suboceanic, lowland and submontane) b. Montane (or "subalpine") raised bog dwarf-shrubland c. Subcontinental dwarf shrub-land wooded bog
		2. Nonraised bog dwarf-shrubland	a. Blanket bog dwarf-shrubland (oceanic lowland, submon-tane or montane) b. String bog dwarf-shrubland

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

Table A-5—Key to the Vegetation Element of the Land Classification Framework—Class: Herbaceous Vegetation[1]

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)	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 e. Shrub layer of mainly needle-leaved evergreen

See footnote at end of table.

Table A-5—Key to the Vegetation Element of the Land Classification Framework—Class: Herbaceous Vegetation[1]—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 conssisting 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 grama and buffalo grass communities)	a. Short grass communities composed of sod forming species b. Short grass communities composed of bunch grasses
		6. Mesophytic grassland (alpine and subalpine meadows) (e.g., bluegrass and hairgrass communities)	a. Sod grass communities, usually dominated by hemicrytophytes b. Alpine and subalpine meadows of the higher latitudes

See footnote at end of table.

Table A-5—Key to the Vegetation Element of the Land Classification Framework—Class: Herbaceous Vegetation[1]—Continued

Class: Herbaceous Vegetation	Subclass	Group	Formation
		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
	E. Hydromorphic freshwater vegetation	1. Rooted vegetation (structurally supported by water but rooted in substrate, e.g., water lilies)	a. Tropical and subtropical forb formation without seasonal contrasts b. Middle and higher latitude forb formations with seasonal contrasts
		2. Free-floating vegetation (full support by water and not rooted in substrate, e.g., water lettuce, duckweed)	a. Tropical and subtropical free-floating formations b. Free-floating formations of the middle and higher latitudes

[1]The 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: Glossary of Landform and Geologic Terms for Land Classification and Characterization

Introduction

This glossary of about 300 terms has been compiled to provide a ready reference for biologists, plant scientists, soil scientists, and others who inventory, manage, and plan the use of land and its associated resources. It may be used to describe the setting of soils and vegetation. Only generally accepted terms and definitions used to describe the setting of a locale are included; colloquialisms have been avoided. More extensive lists are in standard technical dictionaries, glossaries, and encyclopedias. Definitions of minerals and rocks, with few exceptions, are not included; they are in technical dictionaries. The purpose of this glossary is to standardize definitions used by earth and biological scientists.

A second, and equally important, purpose of this glossary is to present definitions acceptable to the suggested groups of users and other biological and earth scientists. Readers are encouraged to submit proposals for refined definitions and additional terms.

Each definition is followed by a two- or three-letter designation that indicates the reference work or individual consulted for that term. Italics signify that the source definition has been modified.

The references used most extensively for this glossary were: *Glossary of Geology* (GG) edited by Bates and Jackson (1980; *Glossary of Selected Geomorphic and Geologic Terms* (HP) by Hawley and Parsons (1980); and *Landforms of the Basin and Range Province* defined for Soil survey (FFP) by Peterson (1981). *The Dictionary of Geological Terms* (DGT) compiled by the American Geological Institute (1976), *The Classification of Wetlands and Deepwater Habitats of the United States* (FWS) by Cowardin and others (1979), *The Glossary of Soil Science Terms* (GSST) compiled by the Soil Science Society of America (1979), and Dr. Ray Daniels (RD) retired U.S. Department of Agriculture, Soil Conservation Service were also referenced.

In addition to presenting definitions in the glossary, numeric limits of slope classes have been identified. The following gradient limits and slope classes have proven useful in the National Cooperative Soil Survey; they are suggested for use in descriptions of geomorphic features.

Classes		Slope gradient limits	
Simple slopes	*Complex slopes*	*Lower*	*Upper*
		...... Percent	
Nearly level	Nearly level	0	1-3
Gently sloping	Undulating	1-3	5-8
Strongly sloping	Rolling	5-8	10-16
Moderately steep	Hilly	10-16	20-30
Steep	Steep	20-30	45-65
Very steep	Very steep	45-65	None

Diagrams depicting several landform features defined in this glossary follow the definitions.

Definitions

Ablation till—Loose permeable till deposited during the final downwasting of nearly static glacial ice. Lenses of crudely sorted sand and gravel are common. (See **glacial till** and **moraine**.) HP

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

Alluvial—Pertaining to material or processes associated with transportation or deposition by running water. HP

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

Alluvial fan—A body of alluvium, with or without debris flow deposits, whose surface forms a segment of a cone that radiates downslope from the point where the stream emerges from a narrow valley onto a less sloping surface. Common longitudinal profiles are gently sloping and nearly linear. Source uplands range in relief and areal extent from mountains and plateaus to gullied terrains on hill and piedmont slopes. (fig. B-1) *HP*

Alluvial flat—A nearly level, graded, alluvial surface. *FFP*

Alluvial plain—A landform comprised of the floodplain or of a low gradient fan-delta built by a stream. It may be modern or relict. *FFP*

Alluvial terrace—(See **stream terrace**.)

Alluvium—Unconsolidated clastic material deposited by running water, including gravel, sand, silt, clay, and various mixtures of these. HP

Alpine—Characteristic of, or resembling the European Alps, or any lofty mountain or mountain system, especially one so modified by intense glacial erosion as to contain aiguiles, cirques, horns, etc. Implies high elevation, particularly above the tree line, and cold climate. *GG & DGT*

Anticline—A unit of folded strata that is convex upward. In a single anticline, beds forming the opposing limbs of the fold dip away from its axial plane. (See **syncline** and **monocline**.) HP

Arête—A narrow, jagged mountain crest, often above the snowline, sculptured by alpine glaciers and formed by backward erosion of adjoining cirque walls. HP

Arroyo—The flat-floored channel of an ephemeral stream, commonly with very steep to vertical banks cut in alluvium (**Arroyo** is a regional term of the Southwest; a synonym for **wash**.) Note: Where **arroyo** reaches intersect zones of ground-water discharge they are more properly classed as intermittent stream channels. HP

Ash (volcanic)—Fine pryoclastic material smaller than 4.0 mm diameter. HP

Avalanche chute—The track or path formed by an avalanche. (See **avalanche track**.) GG

Avalanche track—The central channel-like corridor along which an avalanche has moved; it may take the form of an open path in a forest, with bent and broken trees, or an eroded surface marked by pits, scratches, and grooves. GG

Backslope—The geomorphic component that forms the steepest inclined surface and principal element of many hillslopes (for example, valley side, ridge side). **Backslopes** in profile are commonly steep, linear, and may or may not include cliff segments, also called 'gravity slopes" or "free faces." The term "mid-slope" may be used to designate an element without a cliff. In terms of gradational process, **backslopes** are erosional forms produced mainly by mass wasting and running water. Note: Structural geomorphologists may use the term as a synonym of **dipslope** in describing homoclinal ridges (for example, cuesta "backslope"). (See **footslope**, **shoulder**, and **hillslope**.) (fig. B-2) HP

Backswamp (flood-plain landform)—Extensive marshy, depressed areas of flood plains between the natural levee borders of channel belts and valley sides or terraces. (See **valley flat**.) HP

Badlands—Intricately stream-dissected topography characterized by a very fine drainage network with high drainage densities and short, steep slopes with narrow interfluves. Badlands develop on surfaces with little or no vegetative cover overlying consolidated or poorly cemented clays or silts, sometimes with soluble minerals such as gypsum or halite. GG

Bajada—A broad, gently-inclined, piedmont slope formed by lateral coalescence of a series of alluvial fans, and having a broadly undulating transverse profile (parallel to the mountain front) resulting from the convexities of component fans. The term is generally restricted to constructional slopes of intermontane basins in the southwest United States. (A synonym is **coalescent fan piedmont**.) (fig. B-3) HP

Ballena—A landform comprising distinctively round-topped ridgeline remnants of fan alluvium. The ridge's broadly rounded shoulders meet from either side to form a narrow crest and merge smoothly with the concave backslopes. In ideal examples, the slightly concave footslopes of adjacent ballenas merge to form a smoothly rounded drainageway. (fig. B-4) *FFP*

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

Bar and channel—The microrelief common to flood plains and relatively young alluvial terraces. With time, the microrelief becomes subdued as the higher lying bars erode into the channels. The ridge-like bars often consist of accumulations of coarse sediment, while the channels are finer textured. The relief between bar and channel is largely related to the competence of the stream. HP

Barrier beach—A narrow, elongate sand ridge rising slightly above the high-tide level and extending generally parallel with the shore, but separated from it by a lagoon or marsh; it is rarely more than several kilometers long. Synonyms are offshore barrier, offshore beach, bar beach. (See **barrier island**.) GG

Barrier flat—A relatively flat area, often occupied by pools of water, separating the exposed or seaward edge of a barrier from the lagoon behind it. GG

Barrier island—A long, narrow, sandy, coastal island, representing a broadened barrier beach that is above high tide and parallel to the shore, and that commonly has dunes, vegetated zones, and swampy terrains extending lagoonward from the beach. Also a long series of barrier beaches. GG

Basal till—Compact till deposited beneath a moving glacier, commonly clay rich, but is loamy in many places. (See **till** and **lodgment till**.) *HP*

Base level—The theoretical limit or lowest level toward which erosion of the earth's surface constantly progresses but seldom, if ever, reaches; especially the level below which a stream cannot erode its bed. The ultimate base level for the land surface is sea level, but temporary base levels may exist locally. The base level of eolian erosian may be above or below sea level; that of marine erosion is the lowest level to which marine agents can cut a bottom. HP

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

Basin floor—A general term for the nearly level to gently sloping, bottom surface of an intermontane basin (bolson). Component landforms include playas, broad alluvial flats containing ephemeral drainageways, and relict alluvial and lacustrine surfaces that rarely, if ever, are subject to flooding. Where through-drainage systems are well developed, alluvial plains are dominant and lake plains are absent or of limited extent. Basin floors grade mountainward to distal parts of piedmont slopes. (figs. B-3 and B-5) HP

Basin-floor remnant—A flattish topped, erosional remnant of any former landform of a basin floor that has been dissected following the incision of an axial stream. FFP

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

Beach plain—(See **wave-built terrace**.)

Beach ridge—A low, essentially continuous mound of beach or beach-and-dune material heaped up by the action of waves and currents on the backshore of a beach, beyond the present limit of storm waves or the reach of ordinary tides, and occurring singly or as one of a series of approximately parallel deposits. The ridges are roughly parallel to the shoreline and represent successive positions of an advancing shoreline. GG

Beach terrace—A landform that consists of a wave-cut scarp and wave-built terrace of well sorted sand and gravel of marine or lacustrine origin. In some places it occurs on a lower piedmont slope. *FFP*

Bedrock—The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface. (See **regolith**.) HP

Bench—(See **structural bench**.) HP

Berm—A low impermanent, nearly horizontal or landward-sloping bench, shelf, ledge, or narrow terrace on the backshore of a beach, formed of material thrown up and deposited by storm waves; it is generally bounded on one side or the other by a beach ridge or beach scarp. Some beaches have no berms, others have one or several. A synonym for **berm** is backshore terrace. GG

Block field—A thin accumulation of usually angular blocks, but subrounded to subangular in some places, with no fine sizes in the upper part, over solid or weathered bedrock, colluvium, or alluvium, without a cliff or ledge above as an apparent source. Blocks are often upheaved from intensive frost shattering of jointed bedrock. Block fields occur above tree line and in polar regions on slopes of less than about 9 percent (5°). A synonym for **block field** is felsenmeer. *GG*

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

Bog—Waterlogged, spongy ground, consisting primarily of mosses, containing acidic, decaying vegetation such as sphagnum, sedges and heaths, that develops into peat. (See **fen**.) *GG*

Bolson—An internally drained (closed), intermontane basin with two major landform components: basin floor and piedmont slope. The former includes nearly level alluvial plains and playa-like depressions. The latter comprises slopes of erosional origin adjoining the mountain fronts (pediments) and complex constructional surfaces (bajadas) mainly composed of individual and/or coalescent alluvial fans. Bolson is a regional term used in the Southwest. (fig. B-3) HP

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

Break (slopes)—A marked or abrupt change or inflection in a slope or profile; a knickpoint. GG

Breaks—The steep to very steep broken land at the border of an upland summit that is dissected by ravines. HP

Breccia—A coarse-grained, clastic rock composed of angular rock fragments (larger than 2 mm), commonly cemented together in a finer-grained matrix of varying composition and origin. The consolidated equivalent of rubble. (See **conglomerate**.) HP

Buried—Pertaining to landforms, geomorphic surfaces, and paleosols covered by a mantle of geologic material (for example, sedimentary or volcanic). HP

Butte—An isolated, usually flat-topped upland mass characterized by summit widths that are less than heights of bounding erosional scarps. An upland type produced by differential erosion of nearly horizontal, interbedded weak and resistant rocks, with the latter comprising caprock layers. As summit area increases relative to height, buttes are transitional to mesas. (See **plateau** and **cuesta**.) HP

Bypassed—The situation of a fan or pediment surface that once had sediment spread across it by ephemeral washes, but that is now protected from surficial stream erosion or alluviation because the drainageways crossing it are not incised. FFP

Caldera—A large, basin shaped, volcanic depression, more or less circular or cirquelike in form, the diameter of which is many times greater than that of the included volcanic vent or vents, regardless of the steepness of the walls or the form of the floor. Three major types—explosion, collapse, erosion. GG

Caliche—A general term for a prominent zone of secondary carbonate accumulation in surficial materials of warm, subhumid to arid areas formed by both geologic and pedologic processes. Finely crystalline calcium carbonate forms a nearly continuous surface-coating and void-filling medium in geologic (parent) materials. Cementation ranges from weak in nonindurated forms to very strong in types that are indurated. Other minerals (carbonate, silicate, sulphate) may be present as accessory cements. Most petrocalcic and some calcic horizons are caliche. *HP*

Canyon—A long, deep, narrow, very steep-sided valley with high and precipitous walls in an area of high local relief (for example, mountain or high plateau terrain). HP

Carolina bay—Any of various shallow, often oval or elliptical, generally marshy, closed depressions in the Atlantic coastal plain (from southern New Jersey to NE Florida, especially developed in the Carolinas). They range from about 100 m to many kilometers in length, are rich in humus, and contain trees and shrubs different from those of the surrounding areas. GG

Catsetps—(See **terracettes**.)

Channel—The bed of a single or braided watercourse that commonly is barren of vegetation and is formed of modern alluvium. Channels may be enclosed by banks or splayed across and slightly mounded above a fan surface and include bars and dumps of cobbles and stones. Channels, excepting flood plain playas, are landform elements. FFP

Cirque—Semicircular, concave, bowl-like areas with steep faces primarily resulting from erosive activity of a mountain glacier. (fig. B-6) HP & GG

Clast—An individual constituent, grain, or fragment of sediment or rock, produced by the mechanical weathering (disintegration) of a larger rock mass. HP

Clastic—Pertaining to a rock or sediment composed mainly of fragments derived from preexisting rocks or minerals and moved from their place of origin. (See **detritus**, **epiclastic**, and **pyroclastic**.) HP

Cliff—Any high, very steep, to perpendicular or overhanging face of a rock; a precipice. GG

Coalescent fan piedmont—(See **bajada**.) HP

Coastal plain—Any plain or plains of unconsolidated fluvial or marine sediment which had its margin on the shore of a large body of water, particularly the sea (for example, the coastal plain of SE United States extending for 3,000 miles from New Jersey to Texas). GG

Col—A narrow, sharp-edged pass or saddle-like depression in a mountain range between two adjacent peaks; especially a deep pass formed by the headward erosion and intersection of two cirques. Also, the highest point on a divide between two valleys. *GG*

Colluvial—Pertaining to material transported and deposited by mass wasting (direct gravitational action) and local unconcentrated runoff on and at the base of steep slopes. HP

Colluvium—Unconsolidated earth material deposited on and at the base of steep slopes by mass wasting (direct gravitational action) and local unconcentrated runoff. HP

Conglomerate—A coarse-grained, clastic rock composed of rounded to subangular rock fragments, (larger than 2 mm) commonly with a matrix of sand and finer material; cements include silica, calcium carbonate, and iron oxides. The consolidated equivalent of gravel. (See **breccia**.) HP

Constructional (geomorphology)—Owing its origin, form, position, or general character to depositional (aggradational) processes, such as accumulation of sediment to form an alluvial fan or terrace. (See **erosional**.) HP

Creep—Slow mass movement of earth material down relatively steep slopes, primarily under influence of gravity but facilitated by water saturation and frost action. HP

Crest—The commonly linear top of a ridge, hill, mountain, and the like. (See **summit**.) *FFP*

Cryoplanation—Reduction of land surfaces by processes associated with frost action. DGT

Cuesta—An asymmetric, homoclinal ridge capped by resistant rock layers of slight to moderate dip ($<10°$, $<16\%$); produced by differential erosion of interbedded resistant and weak rocks. A long, gently sloping to sloping face (dipslope), roughly paralleling the inclined beds; opposes a relatively short and steep (scarp) face cut across the tilted rocks. (See **hogback** and **mesa**.) HP

Debris—Any surficial accumulation of loose material detached from rock masses by chemical and mechanical means, as by decay and disintegration, and occuring in the place where it was formed, or transported by water or ice and redeposited. It consists of rock fragments, finer-grained earth material, and sometimes organic matter. HP

Debris flow (mudflow)—A mass movement process involving rapid flow of highly viscous mixtures of debris, water, and entrapped air. Water content may range up to 60%. A mudflow is a type of debris flow with clastic particles of sand size and finer. (See **alluvial fan.**) HP

Delta—A body of alluvium, whose surface form is nearly flat and fan shaped, deposited at or near the mouth of a river or stream where it enters a body of relatively quiet water, usually a sea or lake. HP

Deposition—The laying down of potential rock-forming or soil-forming materials; sedimentation. DGT

Desert pavement—A layer of gravel or coarser fragments on desert soil surfaces that (1) was emplaced by upward movement of fragments from underlying sediments, or (2) was formed as a lag concentrate after finer particles were removed by running water or wind (for example, a variety of erosion pavement). HP

Detritus (geology)—Rock and mineral fragments occurring in sediments that were derived from pre-existing igneous, sedimentary, or metamorphic rocks. HP

Dipslope—A slope of land surface, roughly determined by and approximately conforming with the dip of underlying bedded rocks; for example, the long, gently inclined surface of a cuesta. A synonym for **dipslope** is structural backslope. (See **scarp slope**.) HP

Divide—The line of separation between two drainage systems; the summit of an interfluve. The highest summit of a pass or gap. DGT

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

Draw—A small stream valley, generally more open and with broader floor than a ravine or gulch. HP

Drift (glacial geology)—A general term applied to all rock material (clay, silt, sand, gravel, boulders) transported by a glacier and deposited directly by or from the ice, or by running water emanating from a glacier. Drift includes unstratified material (till) that forms moraines, and stratified glaciofluvial deposits that form outwash plains, eskers, kames, varves, and glaciolacustrine sediments. The term is generally applied to Pleistocene glacial deposits in areas (such as large parts of North America and Europe) that no longer contain glaciers. *GG*

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

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

Dune (barchan)—A crescent-shaped dune with tips extending to the leeward, making this side concave in plan and the windward side convex. Barchan (parabolic) dunes tend to be arranged in chains extending in the direction of the most effective wind. HP

Dune (parna)—A dune largely composed of sand-size aggregates of clay. HP

Dune (seif)—A longitudinal dune about six times as wide as it is high and oriented parallel, rather than transverse, to the prevailing wind. HP

Eolian—Pertaining to material transported and deposited by the wind. Includes earth materials including dune sands, silty loess deposits, and clay (parna). *HP*

Ephemeral stream—A stream, or reach of a stream, that flows only in direct response to precipitation. It receives no long-continued supply from melting snow or other source, and its channel is at all times above the water table. (See **arroyo** and **intermittent stream.**) HP

Epiclastic—Pertaining to any clastic rock or sediment other than pyroclastic. Constituent fragments are derived by weathering and erosion rather than by direct volcanic processes. (See **volcaniclastic.**) HP

Erosion—The wearing away of the land surface by running water, waves, moving ice and wind, or by such processes as mass wasting and corrosion (solution and other chemical processes). The term "geologic erosion" refers to natural processes occurring over long (geologic) time spans. HP

Erosional (geomorphology)—Owing its origin, form, position, or general character to wearing-down (degradational) processes, such as removal of weathered rock debris by any mechanical or chemical processes to form, for example, a pediment or valley-side slope. (See **constructional.**) HP

Erosion pavement—A concentration of gravel or coarser fragments that remains on the soil surface as a lag after finer particles have been removed by running water or wind. (See **stone line** and **desert pavement.**) HP

Escarpment—A relatively continuous and steep slope or cliff breaking the general continuity of more gently sloping land surfaces and produced by erosion or faulting. The term is more often applied to cliffs produced by differential erosion and it is commonly used synonymously with "scarp." HP

Esker—A long, narrow, sinuous, steep-sided ridge composed of irregularly stratified sand and gravel that was deposited by a subsurface stream flowing between ice walls or in an ice tunnel of a retreating glacier, and was left behind when the ice melted. Eskers range in length from less than a kilometer to more than 160 km, and in height from 3 to 30 m. (See **glaciofluvial deposits.**) HP

Estuary—(a) The seaward end or the widened funnel-shaped tidal mouth of a river valley where fresh water comes into contact with seawater and where tidal effects are evident; for example, a tidal river, or a partially enclosed coastal body of water where the tide meets the current of a stream. (b) A portion of an ocean, as a firth or an arm of the sea, affected by fresh water; for example, the Baltic Sea. (c) A drowned river mouth formed by the subsidence of land near the coast or by the drowning of the lower portion of a nonglacial valley due to the rise of sea level. GG

Exhumed—Pertaining to formerly buried landforms, geomorphic surfaces or paleosols that have been re-exposed at the ground surface by erosion of the covering mantle. (See **relict.**) HP

Extrusive—Denoting igneous rocks derived from deep-seated molten matter (magmas) emplaced on the earth's surface. (See **intrusive** and **volcanic.**) HP

Facies (stratigraphy)—The sum of all primary lithologic and paleontologic characteristics exhibited by a sedimentary rock and from which its origin and environment of formation may be inferred; the general nature or appearance of a sedimentary rock produced under a given set of conditions; a distinctive group of characteristics that distinguished one group from another within a stratigraphic unit (for example, contrasting river-channel facies and overbank flood plain facies in alluvial valley fills). HP

Fall line—An imaginary line or narrow zone connecting the water falls on several adjacent or near-parallel rivers, marking the points where these rivers make a sudden descent from an upland to a lowland, as at the edge of a plateau; specifically, the Fall Line marking the boundaries between the ancient, resistant crystalline rocks of the Piedmont Plateau and the younger, softer sediments of the Atlantic Coastal Plain of the eastern U.S. It also marks the limit of navigability of the rivers. A synonym for **fall line** is fall zone. GG

Fan apron—A sheet-like mantle of relatively young alluvium covering part of an older fan piedmont (and, occasionally, alluvial fan) surface. It somewhere buries a pedogenic soil which can be traced to the edge of the fan apron where the soil emerges as the land surface, or relict soil. No buried soils should occur within a fan-apron mantle; rather, they separate mantles. (fig. B-5) *FFP*

Fan piedmont—The most extensive major landform of most piedmont slopes, formed by the lateral coalescence of mountain-front alluvial fans downslope into one generally smooth slope without the transverse undulations of the semi-conical alluvial fans and by accretion of fan aprons. (See **bajada.**) (figs. B-3, B-4, and B-5) FFP

Fan terrace—A relict alluvial fan, no longer a site of active deposition, incised by younger and lower alluvial surfaces. An abandoned former fan surface. HP

Fault—A fracture or fracture zone of the earth with displacement along one side in respect to the other. HP

felsenmeer—Block field. GG

Fen—Waterlogged, spongy ground containing alkaline decaying vegetation, characterized by reeds, that develops into peat. It sometimes occurs in sinkholes of karst regions. (See **bog.**) *GG*

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

Flood-plain landforms—A variety of constructional and erosional features produced by stream channel migration and flooding (for example, backswamps, braided channels and streams, flood plain splays, meander, meander belt, meander scrolls, oxbow lakes, natural levees, and valley flats). HP

Flood-plain playa—A component landform consisting of very low gradient, broad, barren, axial-stream channel segments in an intermontane basin. It floods broadly and shallowly and is veneered with barren fine textured sediments that crust. Commonly, a flood plain playa is segmented by transverse, narrow bands of vegetation, and it may alternate with ordinary, narrow or braided channel segments. FFP

Flood-plain splay—Small alluvial fans formed where a flooding stream breaks through a levee (natural or artificial) and deposits the coarser part of its load on the adjacent flood plain. (See **meander belt.**) HP

Floor—A generic term for the nearly level, lower part of a basin or valley, the bed of any body of water, for example, the nearly level surface beneath the water of a stream, lake, or ocean.

Flow (mass move)—A mass movement of unconsolidated material that exhibits a continuity of motion and a plastic or semifluid behavior resembling that of a viscous fluid; for example, creep, solifluction, earthflow, mudflow, debris flow, and sturzstrom. The mass of material moved by a flow. GG

Fluvial—Of or pertaining to rivers; produced by river action, such as a fluvial plain. HP

Fold—A curve or bend of a plenar structure such as rock strata, bedding planes, foliation, or cleavage. GG

Foothills—A steeply sloping upland with hill relief (up to 1,000 ft (300 m)) that fringes a mountain range or high-plateau escarpment. (See **hill, mountain**, and **plateau.**) HP

Footslope—The geomorphic component that forms the inner gently inclined surface at the base of a hillslope. The surface profile is dominantly concave; and in terms of gradational processes, it is a transition zone between upslope sites of erosion (backslope) and downslope sites of deposition (toeslope). (See **hillslope.**) (fig. B–2) HP

Foredune—A coastal dune or dune ridge oriented parallel to the shoreline, occurring at the landward margin of the beach, along the shoreward face of a beach ridge, or at the landward limit of the highest tide, and more or less completely stabilized by vegetation. GG

Formation (stratigraphy)—The basic rock-stratigraphic unit in the local classification of rocks. A body of rock (commonly a sedimentary stratum or strata, but also igneous and metamorphic rocks) generally characterized by some degree of internal lithologic homogeneity or distinctive lithologic features (such as chemical composition, structures, textures, or general kind of fossils), by a prevailing (but not necessarily tabular) shape, and by mappability at the earth's surface (at scales of the order of 1:25.000) or traceability in the subsurface. HP

Frost churning—A collective term suggested by Bryan (1946, p. 640) to describe the stirring, churning, modification, and all other disturbances of regolith, and other earth materials resulting from frost action. It involves frost heaving, solifluction, and differential and mass movements, and it produces patterned ground. Synonyms for **frost churning** are congeliturbation, cryoturbation, and frost stirring. GG

Frost riving—(See **frost shattering.**)

Frost shattering—The mechanical disintegration, splitting, or breakup of a rock or soil caused by the great pressure exerted by the freezing of water contained in cracks or pores, or along bedding planes; (Bryan 1946, p. 640). Synonyms for **frost shattering** include congelifraction, frost splitting, frost riving, frost bursting, frost weathering, frost wedging, gelivation, and gelifraction. GG

Geomorphic surface—A geomorphic surface represents an episode of landscape development and consists of one or more landforms (Balster and Parsons 1968). A mappable part of the land surface that is defined in terms of morphology (relief, slope, aspect, and the like), age (absolute, relative), and stability of component landforms. (See **buried, exhumed**, and **relict.**) HP

Gilgai—The microrelief of soils produced by expansion and contraction with changes in moisture. Found in soils that contain large amounts of clay which swells and shrinks considerably with wetting and drying. Usually a succession of microbasins and microknolls in nearly level areas or of microvalleys and microridges parallel to the direction of the slope. GSST

Glacial—Of or relating to the presence and activities of ice and glaciers, as glacial erosion. Pertaining to distinctive features and materials produced by or derived from glaciers and ice sheets, as glacial lakes. Pertaining to an ice age or region of glaciation. GG

Glaciation—The formation, movement, and recession of glaciers or ice sheets. A collective term for the geologic processes of glacial activity, including erosion and deposition, and the resulting effects of such action on the earths surface. GG

Glacial drift—(See **drift.**)

Glacial marine—Marine sediments that contain glacial material. A synonym for **glacial marine** is glaciomarine. GG

Glaciomarine—(See **Glacial marine.**) GG

Glacial outwash—Stratified sand and gravel produced by glaciers and carried, sorted, and deposited by water that originated mainly from the melting of glacial ice. Outwash deposits may occur in the form of valley fills (valley trains and/or outwash terraces) or as widespread outwash plains. (See **glacial drift** and **glaciofluvial deposits.**) HP

Glacial till—Unsorted and unstratified glacial drift, generally unconsolidated, deposited directly by a glacier without subsequent reworking by water from the glacier, and consisting of heterogeneous mixture of clay, sand, gravel, and boulders varying widely in size and shape. (See **ablation till** and **basal till**.) HP

Glaciofluvial deposits—Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and may occur in the form of outwash plains, valley trains, and deltas, kames, eskers, and kame terraces. (See **glacial drift** and **glacial outwash**.) HP

Glaciolacustrine deposits—Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes by water originating mainly from the melting of glacial ice. Many are bedded or laminated with varves. HP

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

Gulch—A small stream valley, narrow and steepsided in cross section, and larger than a gully. **Gulch** is a regional term of the western U.S. A more generally used synonym is ravine. (See **draw**.) HP

Gully—A very small valley with steep sides cut by running water and through which water ordinarily runs only after a rain or ice or snow melt. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to wheeled vehicles and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage. (See **gulch**, **arroyo**, **wash**, and **draw**.) HP

Hanging valley—A tributary valley whose floor at the lower end is notably higher than the floor of the main valley in the area of junction. *GG*

Headland (coast)—(a) An irregularity of land, especially of considerable height with a steep cliff face, jutting out from the coast into a large body of water (usually the sea or a lake); a bold promontory or a high cape. Synonyms include head and mull. (b) The high ground flanking a body of water, such as a cove. (c) The steep crag or cliff face of a promontory. GG

Headwall—The steep slope at the head of a valley; especially the rock cliff at the back of a cirque. GG

Hill—A natural elevation of the land surface, rising as much as 1,000 ft (300 m) above surrounding lowlands, usually of restricted summit area (relative to a tableland) and having a well defined outline; hill slopes generally exceed 15%. The distinction between a hill and a mountain is often dependent on local usage. (See **foothills**.) HP

Hillslope—The steeper part of a hill between its summit and the drainage line, valley flat, or depression floor at the base of the hill. In descending order geomorphic components of a simple hillslope may include shoulder, backslope, footslope, and toeslope. However, all of these components are not necessarily present in any given hillslope continuum. In addition, complex hillslopes may include two or more backslope to toeslope sequences. (fig. B–2) HP

Hogback—A sharp-crested, symmetric (homoclinal) ridge formed by highly tilted resistant rock layers; produced by differential erosion of interlayered resistant and weak rocks with dips greater than about 25° (45%). (See **cuesta**.) HP

Holocene—The second epoch of the Quarternary Period of geologic time, extending from the end of the Pleistocene Epoch (about 10 to 12 thousand years ago) to the present; also the corresponding (time-stratigraphic) "series" of earth materials. Two synonyms of **holocene** are post-glacial and Recent.) HP

Homoclinal (structural geomorphology)—Pertaining to strata that dip in one direction with a uniform angle. (See **cuesta** and **hogback**.) HP

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

Igneous rock—Rock formed by solidification from a molten or partially molten state; major varieties include plutonic and volcanic rocks. (See **intrusive** and **extrusive**. Examples are andesite, basalt, and granite.) HP

Interfluve—The elevated area between two fluves (drainageways) that sheds water to them. FFP

Intermittent stream—A stream, or reach of a stream, that flows for protracted periods only when it receives ground-water discharge or long-continued contributions from melting snow or other surface and shallow subsurface sources. (See **ephemeral stream**.) HP

Intermontane basin—A generic term for wide structural depressions between mountain ranges that are partly filled with alluvium and are called "valleys" in the vernacular. Intermontane basins may be drained internally (bolsons) or externally (semi-bolson). FFP

Intrusive—Denoting igenous rocks derived from molten matter (magma) which invaded pre-existing rocks and cooled below the surface of the earth. (See **extrusive**.) HP

Joint (geology)—A surface of actual or potential fracture or parting in a rock, without displacement; the surface is usually plane and often occurs with parallel joints to form part of a joint set. HP

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

Kame terrace—A terrace-like ridge consisting of stratified sand and gravel (1) deposited by a meltwater stream flowing between a melting glacier and a higher valley wall or lateral moraine, and (2) left standing after the disappearance of the ice. It is commonly pitted with "kettles" and has an irregular ice-contact slope. HP

Karst—A type of topography that is characterized by closed depressions or sink holes, and is dependent upon underground solution and the diversion of surface waters to underground routes. It is formed over limestone, dolomite, gypsum, and other soluble rocks as a result of differential solution of these materials and associated processes of subsurface drainage, cave formation, subsidence, and collapse. HP

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

Knickpoint—Any interruption or break in slope; a point of abrupt inflection in the longitudinal profile of a stream or of its valley. HP

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

Knoll—A small, low, rounded hill rising above adjacent landforms. (Synonyms for **knoll** are hillock and knob.) HP

Lacustrine deposit—Clastic sediments and chemical precipitates originally deposited in lakes and exposed when the water level is lowered or the elevation of the land is raised. *HP*

Lagoon—A shallow stretch of water partly or completely separated from a sea or lake by an offshore reef, barrier island, sandbank or spit. *GG*

Lahar—A mudflow composed chiefly of volcaniclastic materials on the flank of a volcano. The debris carried in the flow includes pyroclastic material, blocks from primary lava flows, and epiclastic material. HP

Lake plain—A nearly level surface marking the floor of an extinct lake filled in by well-sorted, fine textured, stratified sediments. *GG*

Lamination (lamina)—A sedimentary layer less than 1 cm thick. HP

Landform—Any physical, recognizable form or feature of the earth's surface, having a characteristic shape, and produced by natural causes; it includes major forms such as a plain, plateau, or mountain, and minor forms such as a hill, valley, slope, esker, or dune. Taken together, the landforms make up the surface configuration of the earth. The "landform" concept involves both empirical description of a terrain (land-surface form) class and interpretation of genetic factors ("natural causes"). HP

Landform element—A morphological part of a component landform. Hillslope landform elements may be divided into slope components. *FFP*

Landscape—(General) all the natural features, such as fields, hills, forests, and water that distinguish one part of the earth's surface from another part; usually that portion of land which the eye can comprehend in a single view, including all of its natural characteristics. (Geology) The distinct association of landforms, especially as modified by geologic forces, that can be seen in a single view. HP

Landslide—A mass-wasting process, and the landform produced, involving moderately rapid to rapid (greater than 1 ft per year) downslope transport, by means of gravitational stresses, of a mass of rock and regolith that may or may not be water saturated. HP

Land-surface form—The description of a given terrain unit based on empirical analysis of the land surface rather than interpretation of genetic factors. Surface form may be expressed quantitatively in terms of vertical and planimetric slope-class distribution, local and absolute relief, and patterns of terrain features such as interfluve crests, drainage lines, or escarpments. HP

Ledge—A narrow shelf or projection of rock, much longer than wide, formed on a rock wall or cliff face, as along a coast by differential wave action of softer rocks. A rocky outcrop; solid rock. An underwater ridge of rocks, especially near the shore; also a near shore reef. A quarry exposure or natural outcrop of a mineral deposit. GG

Levee (streams)—An artificial or natural embankment built along the margin of a watercourse or an arm of the sea, to protect land from inundation or that confines streamflow to its channel. A synonym for **levee** is earth dike. *GG*

Limestone—A sedimentary rock consisting chiefly (more than 50%) of calcium carbonate, primarily in the form of calcite. Limestones are usually formed by a combination of organic and inorganic processes and include chemical and clastic (soluble and insoluble) constituents; many contain fossils. HP

Lithification—The conversion of a newly deposited, unconsolidated sediment into a coherent and solid rock, involving processes such as cementation, compaction; desiccation, crystallization, recrystallization, and compression. It may occur concurrent with, or shortly or long after deposition. HP

Lithologic—Pertaining to the physical character of a rock. HP

Lodgment till—A basal till commonly characterized by compact fissile structure and containing stones oriented with their long axes generally parallel to the direction of ice movement. GG

Loess—Fine-grained wind-deposited material, dominantly of silt-size. HP

Marl—An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions (35 to 65% of each); formed primarily under freshwater lacustrine conditions, but varieties associated with more saline environments also occur. HP

Mass wasting (mass movement)—Dislodgement and downslope transport of earth (regolith and rock) material as a unit under direct gravitational stress. The process includes slow displacements such as creep and solifluction, and rapid movements such as landslides, rock slides and falls, earthflows, debris flows, and avalanches. Agents of fluid transport (water, ice, air) may play a subordinate role in the process. HP

Meander, meandering channel (flood-plain landforms)—A meander is one of a series of sinuous loops, with sine-wave form, in the course of a stream channel. The term "meandering" should be restricted to loops with channel length more than 1.5 to 2 times the length of the wave form. Meandering stream channels commonly have cross sections with low width to depth ratios, (fine-grained) cohesive bank materials, and low gradient. At a given bank, full discharge meandering streams have gentler slopes, and deeper, narrower and more stable channel cross-sections than braided streams. (See **flood-plain landforms**.) HP

Meander belt—The bottomland zone within which migration of a meandering channel occurs; the flood-plain area included between two imaginary lines drawn tangentially to the outer bends of active channel loops. Landform components of the meander-belt surface are produced by a combination of gradual (lateral and down-valley) migration of meander loops and evulsive channel shifts causing abrupt cut-offs of loop segments. Forms flanking the sinuous stream channel include: point bars, scars of abandoned meanders and flanking point bars, meander scrolls, oxbow lakes, natural levees and flood-plain splays. Many meander belts do not exhibit prominent natural levee or splay forms. Flood plains of broad alluvial valleys may contain one or more abandoned meander belts in addition to the zone flanking the active stream channel. HP

Meander scroll—Individual ridge-swale pairs. (See **meander belt**.) HP

Mesa—A broad, nearly flat-topped and usually isolated upland mass characterized by summit widths that are greater than the heights of bounding erosional escarpments. A tableland produced by differential erosion of nearly horizontal, interbedded weak and resistant rocks, with the latter comprising caprock layers. As summit area decreases relative to height, mesas are transitional to buttes. In the western states mesa is also commonly used to designate broad structural benches and alluvial terraces that occupy intermediate levels in stepped sequences of platforms bordering canyons and valleys. (See **plateau** and **cuesta**.) HP

Metamorphic rock—Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement at depth in the earth's crust. Nearly all such rock are crystalline. (Examples are schist, gneiss, and quartzite.) HP

Metastable slope—A slope that is relatively stable at the present time, but may become active if the environmental balance is disturbed, for instance, by road construction or destruction of vegetation. A metastable slope is often related to base levels of former geomorphic episodes. The regolith is generally moderately deep, may contain stone lines, or relict evidence of slope alluvium. slope gradients usually range from 15 to 45 percent. (See **active slope**.) HP

Mima mound—A term used in the NW U.S. for one of numerous low, circular or oval domes composed of loose, unstratified, gravelly silt and soil material, built upon glacial outwash on a hogwallow landscape; the basal diameter varies from 3 m to more than 30 m, and the height from 30 cm to about 2 m. GG

Monocline—A unit of folded strata that flexes from the horizontal in one direction only, and is not part of an anticline or syncline. This structure is typically present in plateau areas where nearly flat stata locally assume steep dips caused by differential vertical movements without faulting. HP

Moraine (glacial geology)—An accumulation of drift, with an initial topographic expression of its own, built chiefly by the direct action of glacial ice. Examples are end, ground, lateral, recessional, and terminal moraines. (See **glacial till**.) HP

Moraine end—A moraine produced at the front of an actively flowing glacier at any given time. (See **terminal** and **recessional moraines**.) HP

Moraine (ground)—An extensive, fairly even and thin layer of till, having an undulating surface; a deposit of rock debris dragged along, in, on, and beneath a glacier and emplaced by processes including basal lodgement and release from downwasting stagnant ice (by ablation). (fig. B-7) HP

Moraine (lateral)—A ridge-like moraine carried on and deposited at the side margin of a valley glacier. It is composed chiefly of rock fragments derived from valley walls by glacial abrasion and plucking, or mass-wasting. (fig. B-7) HP

Moraine (recessional)—An end moraine, built during a temporary but significant halt in the final retreat of a glacier. HP

Moraine (terminal)—An end moraine that marks the farthest advance of a glacier and usually has the form of a massive arcuate ridge, or complex of ridges, underlain by till and other drift types. (fig. B-7) HP

Mound—A low, rounded hill of earth, natural or artificial. *GG*

Mountain—A natural elevation of the land surface, rising more than 1,000 ft (300 m) above surrounding lowlands, usually of restricted summit area (relative to a plateau), and generally having steep sides (>25% slope) with or without considerable bare-rock surface. A mountain can occur as a single, isolated mass, or in a group forming a chain or range. Mountains are primarily formed by deep seated earth movements and/or volcanic action and secondarily by differential erosion. (See **hill**.) HP

Muck—Highly decomposed organic material in which the original plant parts are not recognizable. Contains more mineral matter and is usually darker in color than peat. GSST

Mudstone—Sedimentary rock formed by induration of silt and clay in approximately equal proportions.

Natural levee—A long broad low ridge or embankment of sand and coarse silt, built up by a stream on its flood plain and along both sides of its channel. They are wedge-shaped deposits, of coarsest suspended-load material, that slope gently away from the stream. (See **meander belt**.) GG & HP

Nivation—The process of excavation of a shallow depression or nivation hollow in the mountain side by removal of fine material around the edge of a shrinking snow patch or snow bank, chiefly through sheetwash, rivulet flow, and solution in melt water. More generally, the work of snow and ice beyond the limits of glacial action. GG

Nunatak—An isolated hill, knob, ridge, or peak of bedrock that projects prominently above the surface of a glacier and is completely surrounded by glacier ice. **Nunataks** are common along the coast of Greenland. GG

Outwash plain—An extensive lowland area forming the surface of a body of coarse textured, glaciofluvial material. An outwash plain is commonly smooth; where pitted, due to melt-out of incorporated ice masses, it is generally low in relief. (See **glacial outwash** and **kettles**.) (fig. B-7) HP

Outcrop—That part of a geologic formation or structure that appears at the surface of the earth. GG

Overthrust—A low angle thrust fault of large scale, with displacement generally measured in kilometers. GG

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

Oxbow lake—The crescent-shaped, often ephemeral, body of standing water situated by the side of a stream in the abandoned channel (oxbow) of a meander after the stream formed a neck cutoff and the ends of the original bend were silted up. (See **meander belt** and **oxbow**.) GG

Paleosol—A soil that formed on a landscape of the past (Ruhe 1975) with distinctive morphological features resulting from a soil-forming environment that no longer exists at the site. The former pedogenic process was either altered because of external environmental change or interrupted by burial. A paleosol (or component horizon) may be classed as relict if it has persisted in a land-surface position without major alteration of morphology by processes of the prevailing pedogenic environment. An exhumed paleosol is one that formerly was buried and has been re-exposed by erosion of the covering mantle. Most paleosols have been affected by some modification of diagnostic-horizon morphologies and profile truncation. HP

Patterned ground—A term for the more or less symmetrical forms such as circles, polygons, nets, stripes, garlands, and steps that are characteristic of, but not confined to, mantles subjected to intense frost action as in periglacial environments. It is classified according to type of pattern and presence or absence of sorting. Patterned ground occurs principally in polar, subpolar, and artic regions, but also includes features in tropical and subtropical areas. Stone polygons generally form on slopes of less than 8 percent, while garlands and stripes occur on slopes 8 to 15 percent and more than 15 percent, respectively (Parsons 1976). (fig. B-8) *HP*

Peak—Sharp or rugged upward extension of a ridge chain, usually at the junction of two or more ridges; the prominent highest point of a summit area. HP

Peat—Unconsolidated soil material consisting largely of undecomposed, or only slightly decomposed, organic matter accumulated under conditions of excessive moisture. GSST

Pediment—A gently sloping erosional surface developed at the foot of a receding hill or mountain slope. The surface may be essentially bare, exposing earth material that extends beneath adjacent uplands; or it may be thinly mantled with alluvium and colluvium, ultimately in transit from upland front to basin or valley lowland. (In hill-footslope terrain the mantle is designated "pedisediment" by Ruhe). The term has been used in several geomorphic contexts: Pediments may be classed with respect to (1) landscape position, for example, intermontane-basin piedmont or valley-border footslope surfaces (respectively, apron and terrace pediments of Cooke and Warren), (2) type of material eroded, bedrock or regolith, or (3) combinations of the above. HP

Pedisediment—A layer of sediment eroded from the shoulder and backslope of an erosional slope, that lies on and is, or was, being transported across a pediment (footslope). FFP

Peneplain—A low nearly featureless, gently undulating land surface of considerable area, which presumably has been produced by the processes of long-continued subaerial erosion (primarily a mass wasting of and sheetwash on interstream areas of a mature landscape, assisted by stream erosion) almost to base level in the penultimate stage of a humid, fluvial geomorphic cycle; also such a surface uplifted to form a plateau and subjected to dissection. A peneplain may be characterized by gently graded and broadly convex interfluves sloping down to broad valley floors, by truncation of strata of varying resistance and structure, by accordant levels, and by isolated erosion remnants rising above it. GG

Periglacial—Pertaining to processes, conditions, areas, climates, and topographic features occurring at the immediate margins of former and existing glaciers and ice sheets, and influenced by cold temperature of the ice. The term was originally introduced to designate the climate and related geologic features peripheral to ice sheets of the Pleistocene. It has been loosely defined to include frost-action effects and loess deposits that may or may not be related to glaciers. HP

Permafrost—(a) Permanently frozen material underlying the solum. (b) A perennially frozen soil horizon. GSST

Piedmont—adj. Lying or formed at the base of a mountain range; for example, a piedmont terrace or a piedmont pediment.—n. An area, plain, slope, glacier, or other feature at the base of a mountain; for example, a foothill or a bajada. In the United States, the Piedmont is a plateau extending from New Jersey to Alabama and lying east of the Appalachian Mountains. GG

Piedmont slope—The dominant gentle slope at the foot of a mountain; generally used in terms of intermontane-basin terrain in arid to subhumid regions. Main components include: (1) an erosional surface on bedrock adjacent to the receding mountain front (pediment); (2) a constructional surface comprising individual alluvial fans and interfan valleys, also near the mountain front; and (3) a distal complex of coalescent fans (bajada), and alluvial slopes without fan form. Piedmont slopes grade to either a basin-floor depressions with alluvial and temporary lake plains, or surfaces of through drainage. (See **bolson**.) (fig. B-3) HP

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

Plain—An extensive lowland area that ranges from level to gently sloping or undulating. A plain has few or no prominent hills or valleys, and occurs at low elevation with reference to surrounding areas (local relief generally less than 100 m. (See **plateau**.) HP

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

Playa—The usually dry and nearly level lake plain that occupies the lowest parts of closed depressions, such as those occurring on intermontane basinfloors. Temporary flooding occurs primarily in response to precipitation-runoff events. Playa deposits are fine grained and may or may not be characterized by high water table and saline conditions. HP

Pleistocene—The first epoch of the Quarternary Period of geologic time, following the Tertiary Pliocene Epoch and preceding the Holocene (approximately from 2 million to 10 thousand years ago); also the corresponding (time-stratigraphic) "series" of earth materials. Glacial-interglacial stage/age subdivisions in North America include, in order of increasing age, Wisonsinan-Sangamonian, Illinoian-Yarmouthian, Kansan-Aftonian, and Nebraskan. (Synonyms for **Pleistocene** are Glacial epoch and Ice Age.) HP

Pliocene—The last epoch of the Tertiary Period of geologic time, following the Miocene Epoch and preceding the (Quarternary) Pleistocene Epoch (approximately 7 to 2 million years ago); also, the corresponding (time-stratigraphic) "series" of earth materials. HP

Plutonic—Pertaining primarily to igneous rocks formed deep in the earth's crust, but also including associated metamorphic rocks.

Pluvial lake—A lake formed in a period of exceptionally heavy rainfall; a lake formed in the Pleistocene epoch during a time of glacial advance, and now either extinct or existing as a remnant. (An example of a **pluvial lake** is Lake Bonneville. See **periglacial.**) HP

Pocosin—Indian term for swamp on a hill. A large wet area on nearly level interstream divides in the coastal plain. Soils may be mineral or organic with distinctive shrub vegetation. RD

Point bar—One of a series of low, arcuate ridges of sand and gravel developed on the inside of a growing meander by the slow addition of individual accretions accompanying migration of the channel toward the outer bank. GG

Pothole (geomorphology)—Any pot-shaped pit or hole. GG

Pothole (glacial geology)—(a) Giant's kettle. (b) A term applied in Michigan to a small pit depression (1 to 15 m deep), generally circular or elliptical, occurring in an outwash plain, a recessional moraine, or a til plain. GG

Pothole (lake)—A shallow depression, generally less than 10 acres in area, occurring between dunes on a prairie (as in Minnesota and the Dakotas) often containing an intermittent pond or marsh. GG

Pyroclastic—Pertaining to fragmental materials produced by usually explosive, aerial ejection of clastic particles from a volcanic vent. Such materials may accumulate on land or under water. (See **epiclastic** and **volcaniclastic.**) HP

Quarternary—The second period of the Cenozoic Era of geologic time, extending from the end of the Tertiary Period (about 2 million years ago) to the present and comprising two epochs, the Pleistocene (Ice Age) and Holocene (Recent); also, the corresponding (time-stratigraphic) "system" of earth materials. HP

Ravine—A small stream valley; narrow, steep-sided, and commonly V-shaped in cross section; and larger than a gully. (A general synonym is gulch. See **draw.**) HP

Reef—(a) A ridgelike or moundlike structure, layered or massive, built by sedentary calcareous organisms, especially corals, and consisting mostly of their remains; it is wave-resistant and stands above the surrounding contemporaneously deposited sediment. Also, such a structure built in the geologic past and now enclosed in rock, commonly of differing lithology. (b) A mass or ridge of rocks, especially coral and sometimes sand, gravel, or shells, rising above the surrounding sea or lake bottom to or nearly to the surface, and dangerous to navigation; specifically such a feature at 10 fathoms (formerly 6) or less. GG

Regolith—All unconsolidated earth materials above the solid bedrock. It includes material weathered in place from all kinds of bedrock and alluvial glacial, eolian, lacustrine, and pyroclastic deposits. Soil scientists regard soil as only that part of the regolith that is modified by organisms and other soil-forming forces. Most engineers describe the whole regolith, even to a great depth, as "soil." (See **residuum.**) HP

Relict—Pertaining to surface landscape features (for example, landforms, geomorphic surfaces, paleosols) that have never been buried and are products of past environments no longer operative in a given area. (See **exhumed**) HP

Relief—The differences in elevation of a land surface considered collectively. GG

Residuum (residual soil material)—Unconsolidated, weathered, or partly weathered mineral material that only accumulates by disintegration of bedrock in place. (See **saprolite** and **regolith.**) HP

Ridge—A long narrow elevation of the land surface, usually sharp crested with steep sides and forming an extended upland between valleys. The term is used in areas of both hill and mountain relief (less and greater than 300 m). HP

Rubble—All accumulation of loose angular rock fragments, commonly overlying outcropping rock; the unconsolidated equivalent of a breccia. GG

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

Salt marsh—Flat, poorly drained land subject to periodic or occasional overflow by salt water, containing water that is brackish to strongly saline, and usually covered with a thick mat of grassy halophytic plants; for example, a coastal marsh periodically flooded by the sea, or an inland marsh (or salina) in an arid region and subject to intermittent overflow by water containing a high concentration of salt. GG

Sandstone—Sedimentary rock containing dominantly sand-size clastic particles. HP

Saprolite—Soft, clay-rich, thoroughly decomposed rock formed in place by chemical weathering of igneous and metamorphic rock. In soil science, the term saprolite is applied to any unconsolidated residual material underlying the soil and grading to hard bedrock below. (See **residuum**.) HP

Scarp—An escarpment, cliff, or steep slope of some extent along the margin of a plateau, mesa, terrace, or bench. A scarp may be of any height. GG

Scour (geomorphology)—The powerful and concentrated clearing and digging action of flowing air, water, or ice, especially the downward erosion by stream water in sweeping away mud and silt on the outside curve of a bend, or during the time of a flood. A place in a stream bed swept (scoured) by running water, generally leaving a gravel bottom. GG

Scoria—Vesicular, cindery, crust on the surface of andesitic or basaltic lava, the vesicular nature of which is due to the escape of volcanic gases before solidification; it is usually heavier, darker, and more crystalline than pumice. A synonym for **scoria** is cinder.) HP

Scree—A heap of rock waste at the base of a cliff or a sheet of coarse debris mantling a slope. Scree is not a synonym of talus, as scree also includes loose material on slope without cliffs. HP

Sediment—Solid clastic material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by water, wind, ice or mass-wasting and has come to rest on the earth's surface either above or below sea level. Sedimentary deposits in a broad sense also include materials precipitated from solution or emplaced by explosive volcanism, as well as organic remains (for example, peat) that have not been subject to appreciable transport. HP

Sedimentary rock—A consolidated deposit of clastic particles, chemical precipitates, and organic remains accumulated at or near the surface of the earth under "normal" low temperature and pressure conditions. Sedimentary rocks include consolidated equivalents of alluvium, colluvium, glacial drift, and eolian, lacustrine and marine deposits (for example, sandstone, siltstone, mudstone, clay-stone, and shale, conglomerate and limestone, dolomite, and coal). (See **sediment**.) HP

Semi-bolson—A wide desert basin or valley that is drained by an intermittent stream flowing through canyons at each end and reaching a surface outlet; its central playa is absent or poorly developed. It may represent a bolson where the alluvial fill reached a level sufficient to permit occasional overflow across the lowest divid. GG

Shale—Sedimentary rock formed by induration of a clay or silty clay deposit and having the tendency to split into thin layers (that is, fissility). HP

Shoal—adj. Having little depth; shallow. n. (a) A relatively shallow place in a stream, lake, sea, or other body of water; a shallows. (b) A submerged ridge, bank, or bar consisting of or covered by sand or other unconsolidated material, rising from the bed of a body of water to near the surface so as to constitute a danger to navigation; specif. an elevation, or an area of such elevations, at a depth of 10 fathoms (formerly 6) or less, composed of material other than rock or coral. It may be exposed at low water. (See **reef**.) (c) A rocky area on the sea floor within soundings. (d) A growth of vegetation on the bottom of a deep lake, occurring at any depth. GG

Shoulder—The geomorphic component that forms the uppermost inclined surface at the top of a hillslope. It comprises the transition zone from backslope to summit of an upland. The surface is dominantly convex in profile and erosional in origin. (See **hillslope**.) (fig. B–2) HP

siltstone—Sedimentary rock containing dominantly sand-size clastic particles.

Sinkhole—A closed depression formed either by solution of the surficial bedrock (for example, limestone, gypsum, salt) or by collapse of underlying caves. Complexes of sinkholes in carbonate-rock terrain are the main components of karst topography. (A synonym for **sinkhole** is doline.) HP

slope alluvium—Sediment gradually transported on mountain or hill slopes primarily by alluvial processes and characterized by particle sorting. In a profile sequence, sediments may be distinguished by differences in size and/or specific gravity of coarse fragments and may be separated by stone lines. Size-sorted, rounded, or subrounded pebbles or cobbles, and burnished peds contrast with unsorted colluvial deposits. HP

Sloughed till—Water-saturated till that has flowed slowly downhill from its original place of deposit by glacial ice. It may rest on other till, on glacial outwash, or on a glaciolacustrine deposit. NTC

Slump—The downward slipping of a mass of rock or unconsolidated material of any size, moving as a unit or as several subsidiary units, usually with backward rotation on a more or less horizontal axis parallel to the cliff or slope from which it descends. HP

Solifluction—Slow viscous downslope flow of water saturated regolith; especially the mass-wasting process occurring in areas of frozen ground, with alternate freezing and thawing of surficial materials. (fig. B–9) HP

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

Spur—A secondary divide between minor drainage systems of an area, that generally has an inverted "V" shape, and occurs considerably below the elevation of the associated ridge. HP

Steptoe—An island-like area in a lava flow. HP

Stone line—A sheet-like concentration of coarse fragments in surficial deposits. In cross-section, the line may be marked only by scattered fragments or it may be a discrete layer of fragments. The fragments are more often pebbles or cobbles than stones. A stone line generally overlies material that was subjected to weathering, soil formation, and erosion before deposition of the overlying material. Many stone lines seem to be buried erosion pavements, originally "formed by running water on the land surface and concurrently covered by surficial sediment" (Ruhe 1975). HP

Strath terrace—(See **stream terrace**.) HP

Stratified—Arranged in strata, or layers. The term refers to geologic material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata. HP

Stream terrace—One of a series of platforms in a stream valley, flanking and more or less parallel to the stream channel, originally formed near the level of the stream, and representing the dissected remnants of an abandoned flood plain, stream bed, or valley floor produced during a former stage of erosion or deposition. Erosional surfaces cut on bedrock and thinly mantled with stream deposits (alluvium) are designated "strath terraces." Remnants of constructional valley floors are termed "alluvial terraces." (See **terrace**.) HP

Structural bench (or bench)—A platform-type, nearly level to gently inclined erosional surface developed on resistant strata in areas where valleys are cut in alternating strong and weak layers with an essentially horizontal attitude. Structural benches, in contrast to stream terraces, have no geomorphic implication of former, partial erosion cycles and base-level controls, nor do they represent a stage of flood-plain development following an episode of valley trenching. HP

Summit—A general term for the top, or highest level of an upland feature such as a hill, mountain, or tableland. It usually refers to a high interfluve area of lower slope that is flanked by steeper hillslopes, (for example, mountain fronts, or tableland escarpments). Summit areas may or may not include distinct crest lines or high points that rise above their general level. (fig. B–2) HP

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

Swash zone—The sloping part of the beach that is alternately covered and uncovered by the uprush of waves, and where longshore movement of water occurs in a zigzag (upslope-downslope) manner. GG

Swamp—An area intermittently or permanently covered with water, having shrubs and trees but essentially without the accumulation of peat. GG

Swell-and-Swale topography—Topography of ground moraine having low relief, gentle slopes, and well rounded hills or hummocks interspersed with shallow depressions. HP

Syncline—A unit of folded strata that is concave upward. In a simple syncline, beds forming the opposing limbs of the fold dip toward its axial plane. (See **anticline** and **monocline**.) HP

Tableland—A general term for a broad upland mass with nearly level or undulating summit area of large extent and steep sideslopes descending to surrounding lowlands. Varieties include plateaus and mesas. HP

Talus—Rock fragments of any size or shape (usually coarse and angular) derived from and lying at the base of a cliff or very steep, rock slope. The accumulated mass of such loose broken rock formed chiefly by falling, rolling, or sliding. (See **colluvium**, **mass wasting**, and **scree**.) HP

Tephra—A collective term for all clastic volcanic materials which are ejected from a vent during an eruption and transported through the air, including volcanic ash, cinders, lapilli, scoria, pumice, bombs, and blocks. (A synonym for **tephra** is volcanic ejecta.) HP

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

Terracettes—Small, irregular, step-like forms on steep hillslopes, especially in pasture, formed by creep or erosion of surficial materials that may or may not be induced by trampling of livestock such as sheep or cattle. (Synonyms for **terracettes** are catsteps, sheep or cattle tracks, and soil ripples.) HP

Tertiary—The first period of the Cenozoic Era of geologic time, following the Mesozoic Era preceding the Quarternary (approximately from 65 to 2 million years ago); also the corresponding time-stratigraphic subdivision (system) of earth materials. Epoch/series subdivisions comprise, in order of increasing age, Pliocene, Miocene, Oligocene, Eocene, and Paleocene. HP

Thermokarst—Karstlike topographic features produced in a permafrost region by local melting of ground ice and subsequent settling of the ground. GG

Tidal flat—An extensive, nearly horizontal, marshy or barren tract of land that is alternately covered and uncovered by the tide, and consisting of unconsolidated sediment (mostly mud and sand). It may form the top surface of a deltaic deposit. Tide flat is a synonym for **tidal flat**. GG

Till (glacial)—Dominantly unsorted and unstratified drift, deposited by and underneath a glacier, and consisting of a heterogeneous mixture of clay, silt, sand, gravel, stones and boulders. (See **ablation till**, **lodgment till**, **glacial drift**, and **moraine**.) A synonym is glacial till. *GG*

Till plain—An extensive flat to undulating area underlain by glacial till. (See **till** and **moraine ground**.) HP

Toeslope—The geomorphic component that forms the outermost, gently, inclined surface at the base of a hillslope. Toeslopes in profile are commonly gentle and linear; and in terms of gradational processes, they are constructional surfaces forming the distal part of a hillslope continuum that grades to valley or closed-depression floors. (See **footslope** and **valley floor**.) (fig. B-2) HP

Topography—The relative position and elevations of the natural or human made features of an area that describe the configuration of its surface. HP

Trough (geomorphology)—(a) Any long, narrow depression in the earth's surface, such as one between hills or with no surface outlet for drainage; esp. a broad, elongate U-shaped valley, such as a glacial trough or a trench. (b) The channel in which a stream flows. GG

Trough end—The steep, semicircular rock wall forming the abrupt head or end of a glacial trough. See also: oversteepened wall. A synonym for **trough end** is trough wall. GG

Trough valley—U-shaped valley. GG

Trough wall—(See **trough end**.) GG

Tuff—A compacted deposit that is 50% or more volcanic ash and dust.

Upland (geomorphology)—Land at a higher elevation, in general, than the alluvial plain or low stream terrace; land above the footslope zone of the hillslope continuum. HP

Uplift (tectonic)—A structurally high area in the crust, produced by positive movements that raise or upthrust the rocks, as in a dome or arch. GG

Upthrust—(a) An upheaval of rock; said preferably of a violent upheaval. (b) A high angle gravity or thrust fault in which the relatively upthrown side was the active (moving) element. GG

Valley—An elongate, relatively large, externally-drained depression of the earth's surface that is primarily developed by stream erosion. (See **basin** and **intermontane basin**.) HP

Valley-border surfaces—A general grouping of valley-side geomorphic surfaces that occur in a stepped sequence graded to successively lower stream base levels produced by episodic valley entrenchment. HP

Valley fill—The unconsolidated sediment deposited by any agent (water, wind, ice, mass wasting) so as to fill or partly fill a valley. HP

Valley flat (flood-plain landform)—A general term for broad, nearly level flood-plain surfaces that are not subject to frequent inundation. (See **backswamp** and **meander belt**.) HP

Valley floor—A general term for the nearly level to gently sloping, bottom surface of a valley. Component landforms include axial stream channels, the flood-plain, and in some areas, low terrace surfaces that may be subject to flooding from tributary streams. (See **flood-**

plain landforms, **meander**, **braided channel**, and valley side.) HP

Valley side (valley wall)—The sloping to very steep surfaces between the valley floor and summits of adjacent uplands. Well-defined, steep valley sides may be termed "valley walls." Note: Scale, relief, and perspective may require use of closely related terms such as **hillslope**, mountain slope, and ridge side. HP

Valley side alluvium—A concave "slopewash" deposit at the base of a hillslope, mountain slope, terrace escarpment, or similar feature, that may or may not include the alluvial toeslope. HP

Valley train—A long narrow body of glacial outwash confined within a valley below a glacier; it may, or may not, emerge from the valley and join an outwash plain. HP

Varve—A sedimentary layer, lamina or sequence of laminae, deposited in a body of still water within 1 year; specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by meltwater streams, in a glacial lake or other body of still water in front of a glacier. HP

Volcanic—Pertaining to (1) the deep-seated (igneous) processes by which magma and associated gases rise through the crust and are extruded onto the earth's surface and into the atmosphere, and (2) the structures, rocks, and landforms produced. (See **extrusive**.) HP

Volcaniclastic—Pertaining to the entire spectrum of fragmental materials with a preponderance of clasts of volcanic origin. The term refers not only to pyroclastic materials but also to epiclastic deposits derived from volcanic source areas by normal processes of mass wasting and stream erosion. (Examples are welded tuff and volcanic breccia.) HP

Wash (dry wash)—The broad, flat-flooded channel of an ephemeral stream, commonly with very steep to vertical banks cut in alluvium. Note: When channel reaches intersect zones of ground-water discharge they are more properly classed as "intermittent stream" channels. (Regional term used in the western United States; a synonym is **arroyo**.) HP

Wave-built terrace—A gently sloping coastal feature at the seaward or lakeward edge of a wave-cut platform, constructed by sediment brought by rivers or drifted along the shore or across the platform and deposited in the deeper water beyond. GG

Wave-cut platform—A gently sloping surface produced by wave erosion, extending far into the sea or lake from the base of the wave-cut cliff. It represents both the wave-cut bench and the abrasion platform. GG

Wave-cut terrace—A synonym for **wave-cut platform**. GG

Weathering—All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents with essentially no transport of the altered material. These changes result in disintegration and decomposition of the material. (See **regolith**, **residuum**, and **saprolite**.) HP

Wind gap—A former water gap now abandoned by the stream that formed it, suggesting stream piracy or stream diversion. HP

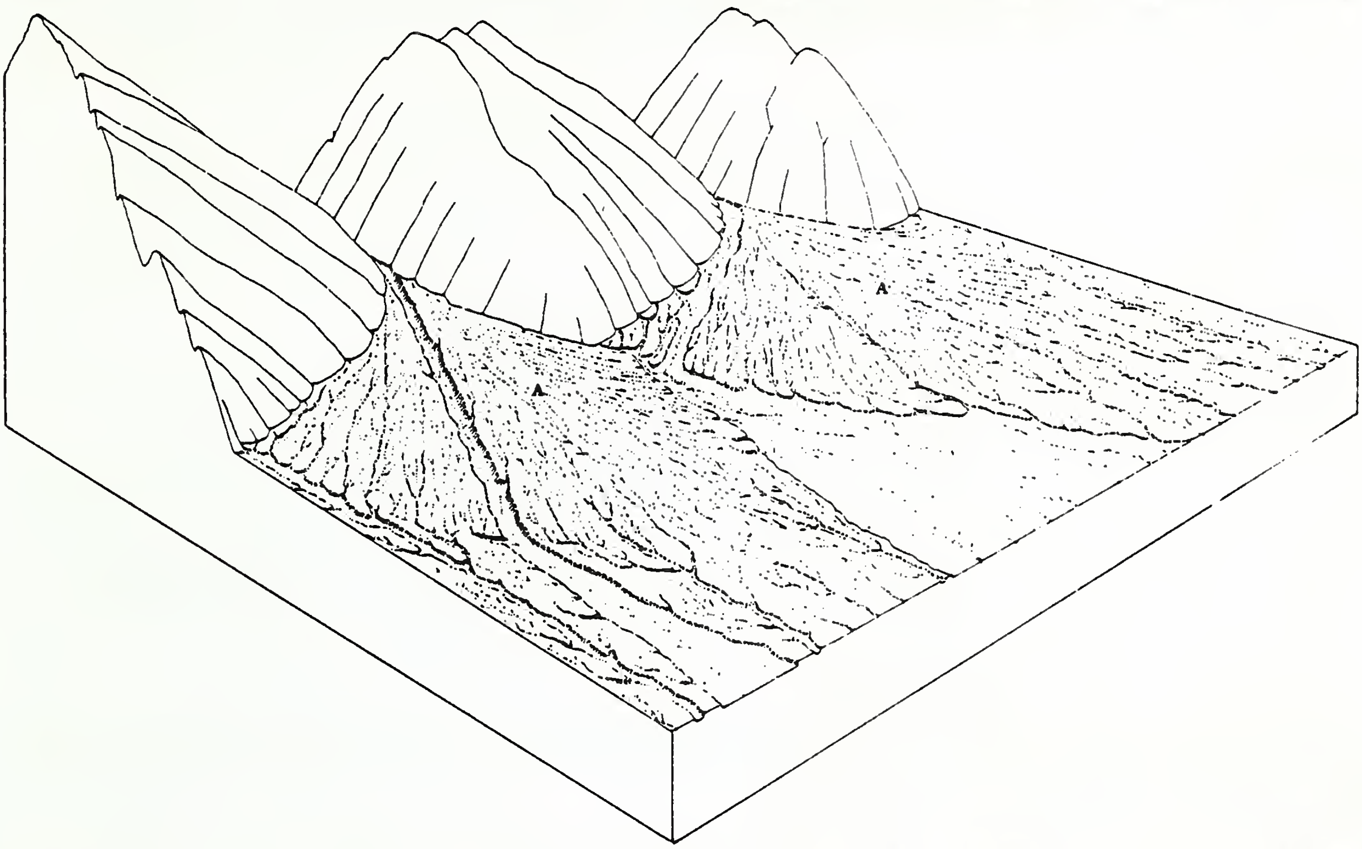

Figure B-1—*Alluvial fans* (A) at mountain front (adapted from Peterson 1981).

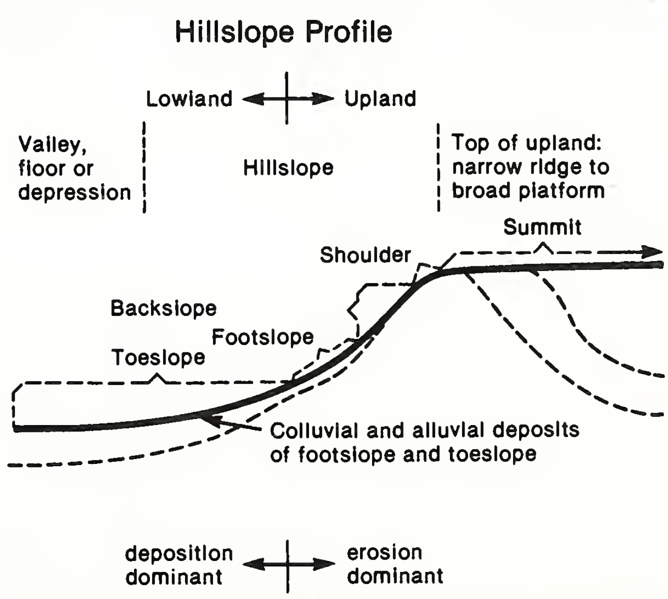

Figure B-2—Hillslope components in profile (adapted from Gile and others. 1981).

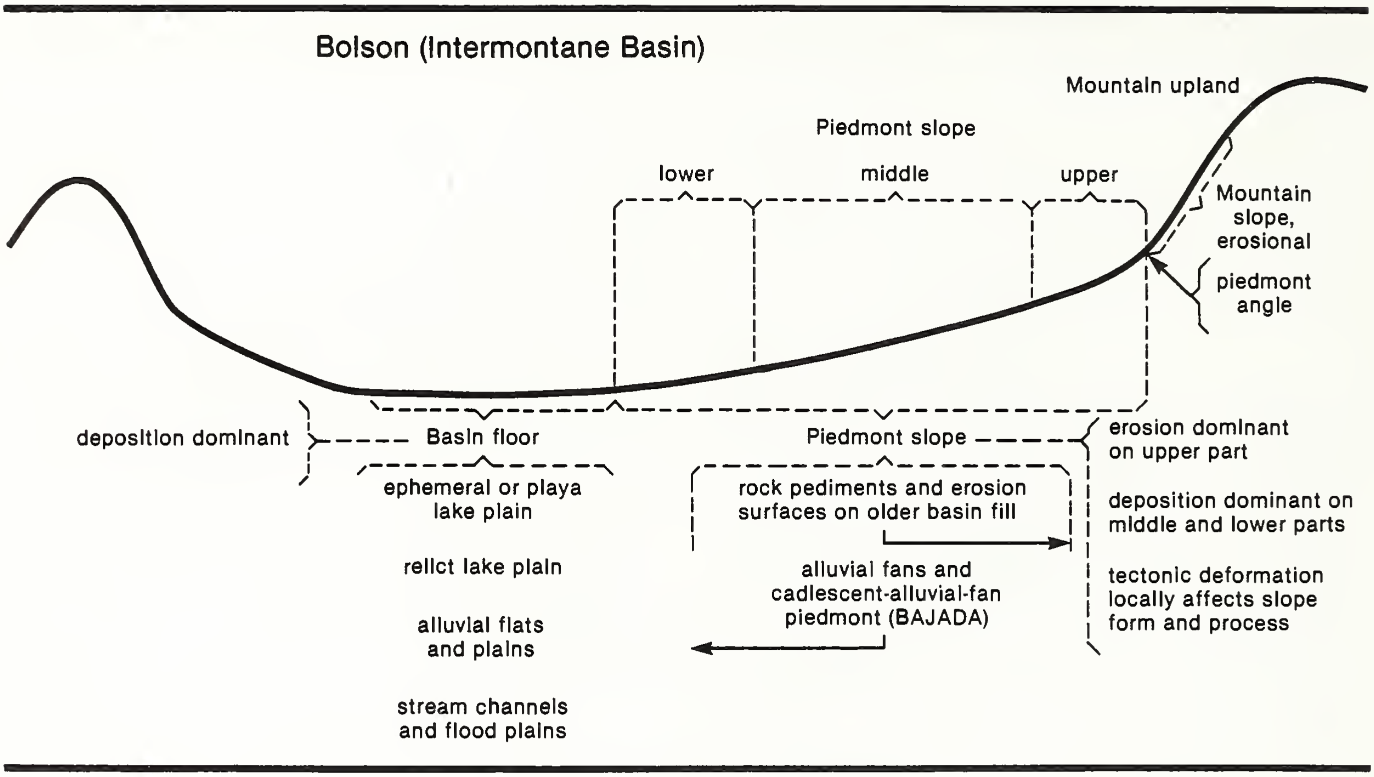

Figure B-3—Bolson and included landforms (adapted from Gile, et al. 1981).

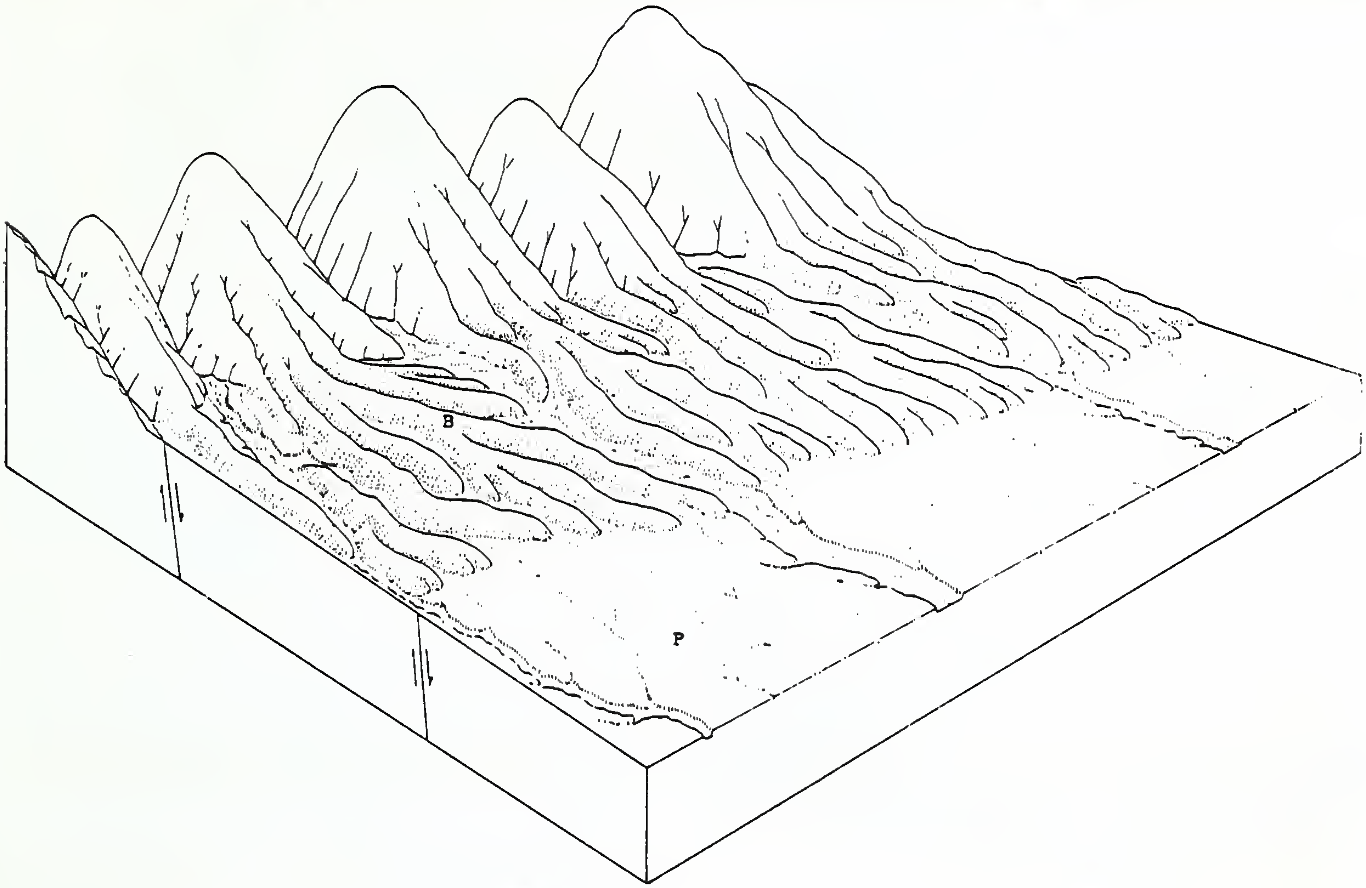

Figure B-4—A zone of semiparalleled *ballenas* (B) along a mountain front. A somewhat dissected *fan piedmont* (P) is downslope from the ballenas (adapted from Peterson 1981).

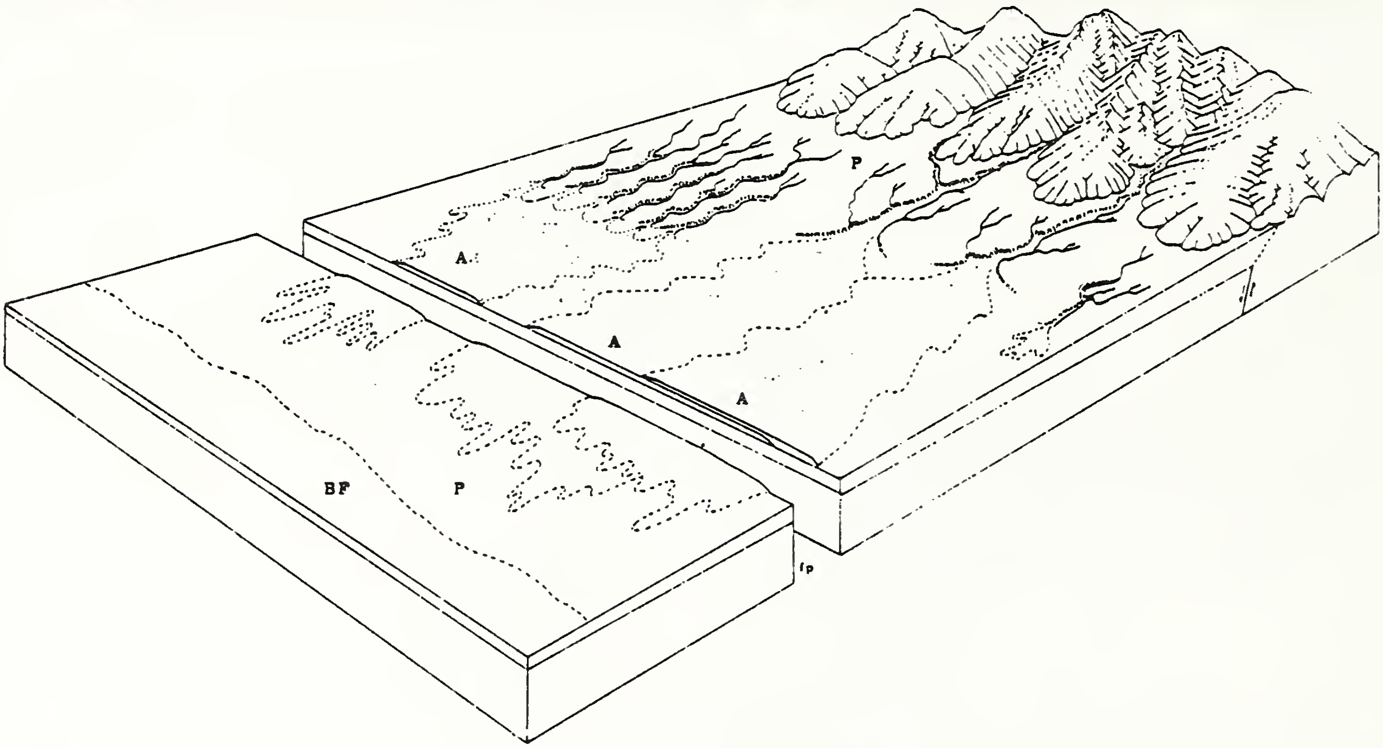

Figure B-5—*Fan aprons* (A) or *fan piedmont* (P), upslope from the *basin floor* (BF) (adapted from Peterson 1981).

Figure B-6—Diagram including a *circue* (C) (adapted from Land System Inventory Handbook, USDA Forest Service, R10. 1982).

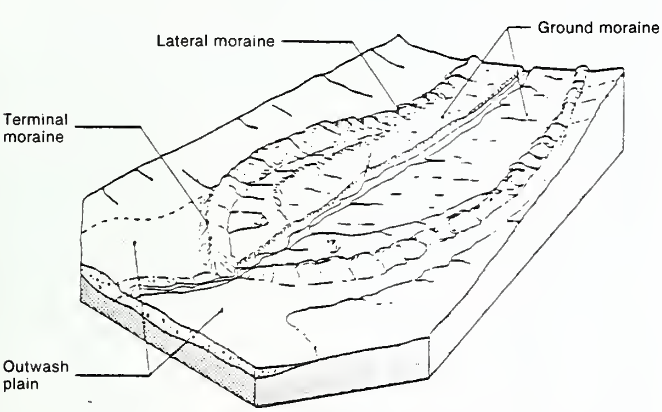

Figure B-7—Schematic block diagram showing some glacial features (from: Landform Units; common to the Bitterroot, Clearwater, Lolo, and Nez Perce National Forests as used in Land Type Mapping; U.S. Forest Service; Region 1).

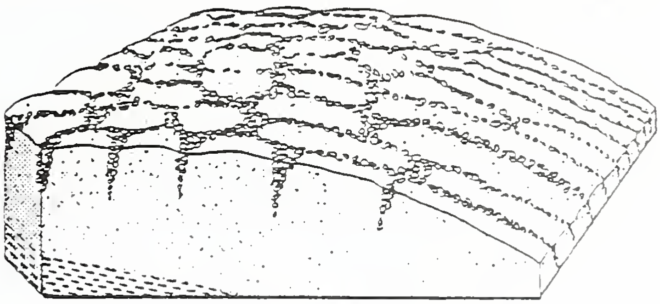

Figure B-8—Schematic block diagram of patterned ground (from: Landform Units; common to the Bitterroot, Clearwater, Lolo, and Nez Perce National Forests as used in Land Type Mapping; USDA Forest Service; Region 1).

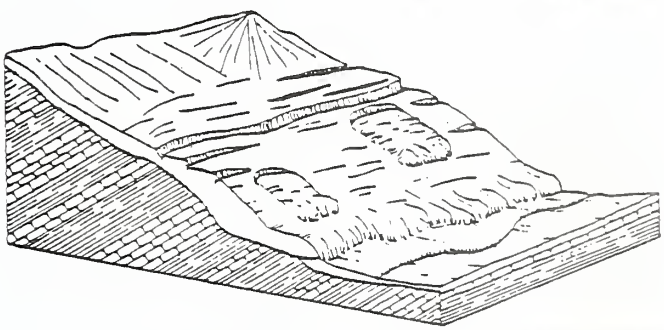

Figure B-9—Schematic block diagram of solifluction landform (from: Landform Units; common to the Bitterroot, Clearwater, Lolo, and Nez Perce National Forests as used in Land Type Mapping; USDA Forest Service; Region 1).

Listing of Landform Terms

Terms in these lists are in groups that deal with the shape-form-position, materials, or genesis-process of landforms. Some terms for materials, for example, alluvium and till, also imply a process or genesis but are only included in the list of materials. A few terms are in two lists because of the way they are defined.

Shape-Form-Position Terms

Active slope
Alluvial cone
Alluvial fan
Alluvial flat
Alluvial plain
Alluvial terrace
Alpine
Anticline
Arête
Arroyo
Avalanche chute
Avalanche track
Backslope
Backswamp
Badlands
Bajada
Ballena
Bar
Bar and channel
Barrier beach
Barrier flat
Barrier island
Base level
Basin
Basin floor
Basin-floor remnant
Beach
Beach plain
Beach ridge
Beach terrace
Bench
Berm
Bluff
Bog
Bolson
Braided channel or stream
Break
Breaks
Butte
Caldera
Canyon
Carolina bay
Catsteps
Channel
Cirque
Cliff
Coalesced fan piedmont
Coastal plain
Col
Crest
Cuesta
Delta
Dipslope
Divide
Dome
Draw
Drumlin
Dune
Dune (Barchan)
Dune (Parma)
Dune (Seif)
Ephemeral stream
Escarpment
Esker
Estuary
Fall line
Fan apron
Fan piedmont
Fan terrace
Fault
Fen
Flood plain
Flood-plain landforms
Flood-plain playa
Flood-plain splay
Floor
Fold
Foothills
Footslope
Foredune
Geomorphic surface
Gilgai
Gorge
Gulch
Gully
Hanging Valley
Headland (coast)
Headwall
Hill
Hillslope
Hogback
Homoclinal
Hummock
Interfluve
Intermittent stream
Intermontane basin
Joint (Geology)
Kame
Kame terrace
Karst
Kettle
Knickpoint
Knob
Knoll
Lagoon
Lake plain
Landform
Landform element
Landscape
Land-surface form
Ledge
Levee
Meander, meandering channel
Meander belt
Meander scroll
Mesa
Metastable slope
Mima mound
Monocline
Moraine (glacial geology)
Moraine (end)
Moraine (ground)
Moraine (lateral)
Moraine (recessional)
Moraine (terminal)
Mound
Mountain
Natural levee
Nunatak
Outwash plain
Overthrust
Oxbow
Oxbow lake
Patterned ground
Peak
Pediment
Peneplain
Piedmont
Piedmont slope
Pingo
Plain
Plateau
Playa
Pocosin
Point bar
Pothole
Ravine
Reef
Relief
Ridge
Saddle
Salt marsh
Scarp
Scour
Semi-bolson
Shoal
Shoulder
Sinkhole
Spit
Spur
Steptoe
Strath terrace
Stream terrace
Structural bench (or bench)
Summit
Swale
Swamp
Swash zone
Swell-and-swale topography
Syncline
Tableland
Terrace
Terracettes
Thermokarst
Tidal flat
Till plain
Toeslope
Topography
Trough (geomorph)

Trough end
Trough valley
Trough wall
Upland (geomorphology)
Uplift
Upthrust
Valley
Valley-border surfaces
Valley flat (flood-plain landform)
Valley floor
Valley side (valley wall)
Valley train
Wash (dry wash)
Wave-built terrace
Wave-cut platform
Wave-cut terrace
Wind gap

Materials Terms

Ablation till
Alluvium
Ash
Basal till
Bedrock
Block field
Breccia
Caliche
Clast
Clastic
Colluvium
Conglomerate
Debris
Desert pavement
Detritus
Drift (glacial geology)
Eolian
Epiclastic
Erosion pavement
Facies (stratigraphy)
Felsenmeer
Formation (stratigraphy)
Glacial marine
Glaciomarine
Glacial drift
Glacial outwash
Glacial till
Glaciofluvial deposits
Glaciolacustrine deposits
Igneous rock
Intrusive
Lacustrine deposit
Lahar
Lamination (lamina)
Limestone
Lithologic
Lodgement till
Loess
Marl
Metamorphic rock
Muck
Mudstone
Outcrop
Paleosol
Peat
Pedisediment
Permafrost
Plutonic
Pyroclastic
Regolith
Residuum
Rubble
Sandstone
Saprolite
Scoria
Scree
Sediment
Sedimentary Rock
Shale
Siltstone
Slope alluvium
Sloughed till
Stone line
Talus
Tephra
Till (glacial)
Tuff
Valley fill
Valley side alluvium
Varve
Volcaniclastic

Genesis-Process Terms

Buried
Bypassed
Colluvial
Constructional (geomorph.)
Creep
Cryoplanation
Debris flow (mudflow)
Deposition
Erosion
Erosional (geomorph.)
Exhumed
Extrusive
Flow (mass move)
Fluvial
Frost churning
Frost riving
Frost shattering
Glacial
Glaciation
Holocene
Landslide
Lithification
Mass wasting (mass movement)
Nivation
Periglacial
Pleistocene
Pliocene
Pluvial lake
Quarternary
Relict
Scour
Slump
Solifluction
Stratified
Tertiary
Volcanic
Weathering

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