USDA

United States
Department of
Agriculture

Forest Service

Gen. Tech.
Report W0-68

September 2005

Terrestrial Ecological Unit Inventory Technical Guide: Landscape and Land Unit Scales

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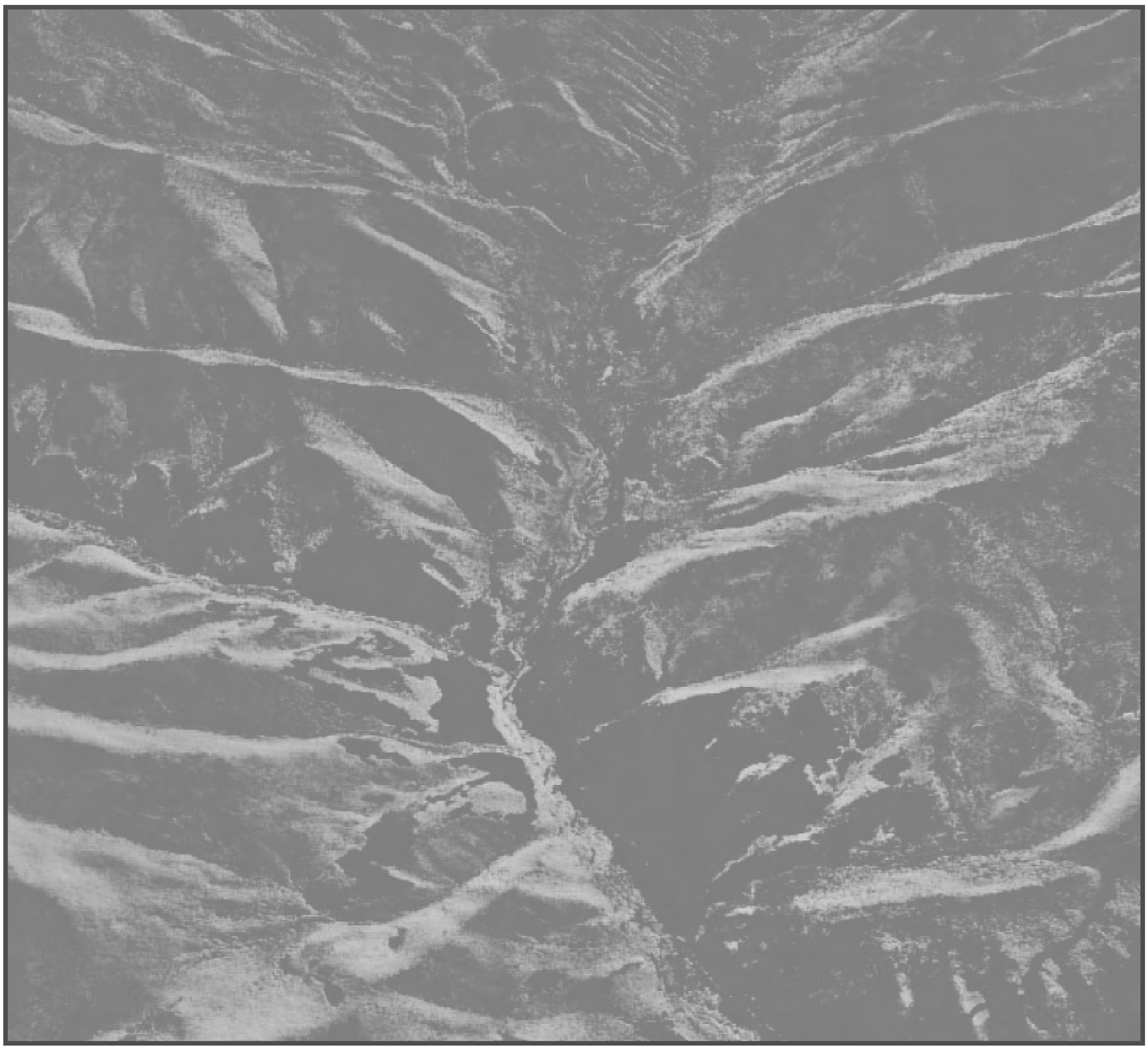

Acknowledgments

Special thanks and recognition are extended to the following persons who contributed extensively to the content and preparation of the document:

- The Terrestrial Ecological Unit Inventory Update Team for many hours of hard work.
- Regional program managers for providing comments.
- Jim Keys, National Coordinator for Integrated Resource Inventories, for his sponsorship.

The following is the proper citation for this document:

Winthers, E.[1]; Fallon, D.[2]; Haglund, J.[3]; DeMeo, T.[4]; Nowacki, G.[5]; Tart, D.[6]; Ferwerda, M.[7]; Robertson, G.[8]; Gallegos, A.[9]; Rorick, A.[10]; Cleland, D. T.[11]; Robbie, W.[12] 2005. Terrestrial Ecological Unit Inventory technical guide. Washington, DC: U.S. Department of Agriculture, Forest Service, Washington Office, Ecosystem Management Coordination Staff. 245 p.

Cover Photo: Landsat Thematic Mapper imagery (30 m) and digital orthophoto quadrangles were fused together to produce this high-resolution image of the Beartooth Mountains on the Custer National Forest near Red Lodge, Montana. Rock Creek drainage is in the center and Red Lodge Ski Area to the right. This perspective view was generated by draping the merged imagery over a digital elevation model (10 m).

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Foreword

This technical guide provides instruction and information on the development of the Terrestrial Ecological Unit Inventory (TEUI) for lands administered by the U.S. Department of Agriculture Forest Service. It provides a set of national standards, suggested methodologies, and a list of criteria for defining, describing, and classifying terrestrial ecological units and types.

The *TEUI Technical Guide* provides the standard for development of terrestrial ecological units at the landtype association, landtype, and landtype phase levels of the National Hierarchy Framework of Ecological Units (Cleland et al. 1997).

The *TEUI Technical Guide* is not intended to replace the correlation process of the National Cooperative Soil Survey (NCSS). It relies on the NCSS process to ensure quality control of all TEUI products, particularly soils data.

The following references may be useful in development of the TEUI and supplement the direction contained in this technical guide:

- Draft Forest Service Manual 1940, *Resource Inventories and Monitoring and Ecosystem Assessments (in press)*.
- Draft Forest Service Handbook 1909.xx, *Resource Inventories and Monitoring and Ecosystem Assessments (in press).*
- *National Soil Survey Handbook* (USDA NRCS 2003b).
- *Soil Survey Manual* (USDA NRCS Revised 1993).
- *Keys to Soil Taxonomy* (USDA NRCS 2003a).
- *National Forestry Handbook* (USDA NRCS 2004).
- *National Forestry Manual* (USDA NRCS 2000).
- *Field Book for Describing and Sampling Soils*, Ver. 2.0 (Schoeneberger et al. 2002).

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1.1 Overview and Purpose

The purpose of this technical guide is to provide specific direction and guidance for conducting Terrestrial Ecological Unit Inventory (TEUI) at the landscape and land-unit scales. TEUI seeks to classify ecological types and map terrestrial ecological units (TEUs) to a consistent standard throughout National Forest System lands. The objectives, policies, and responsibilities for TEUI are contained in Forest Service Manual (FSM) 1940. U.S. Department of Agriculture (USDA) Forest Service policy dictates that ecological units be used in natural resource inventory, monitoring, and evaluation; in land management planning; and in making predictions and interpretations for management of National Forest System lands.

This guide is one among several recently established by the new FSM 1940 and Forest Service Handbook (FSH) 1900 series direction. This direction consolidates many outdated and redundant handbooks scattered throughout the directive system for all program areas responsible for conducting inventory and monitoring activities.

The new chapter in FSM 1940, "*Resource Inventories and Monitoring,*" establishes the management framework for all integrated inventories. It codifies the broad authorities, management objectives (results), policies, responsibilities (duties and delegations), and standards that govern how the agency designs, develops, tests, conducts, reports, uses, and evaluates resource inventory systems and data. The chapter requires field units to use the various technical guides intended to provide detailed instructions for conducting inventory and monitoring work (Connolly 2001).

The new FSH 1900 series, "*Resource Inventories and Monitoring,*" covers the data standards, procedures, practices, and other protocols that govern all our resource inventory and monitoring efforts. The handbook consolidates relevant inventory and monitoring direction from existing handbooks. It does not contain detailed instructions, templates, or other information contained in technical guides (Connolly 2001).

Figure 1.1 provides a graphical sketch of the relationship of manual and handbook direction to technical guides. The technical guides contain the detailed instructions and procedures on how to conduct specific inventory and monitoring activities. They are designed to be flexible so that updates and improvements can be made annually, or as needed based on best available science. All technical guides share the same overall format and outline as identified in the FSH 1900 series.

This guide contains three chapters and several appendixes on the following subjects:

- Chapter 1 provides an overview of TEUI concepts including background information, key concepts, and roles and responsibilities.
- Chapter 2 provides detailed information on conducting TEUI at the landtype association (LTA) level.
- Chapter 3 provides detailed instruction on conducting TEUI at the landtype (LT) and landtype phase (LTP) levels.
- Appendixes contain various field forms and detailed descriptions of data elements used in the protocols. Also included are a list of citations, a glossary, and other pertinent information.

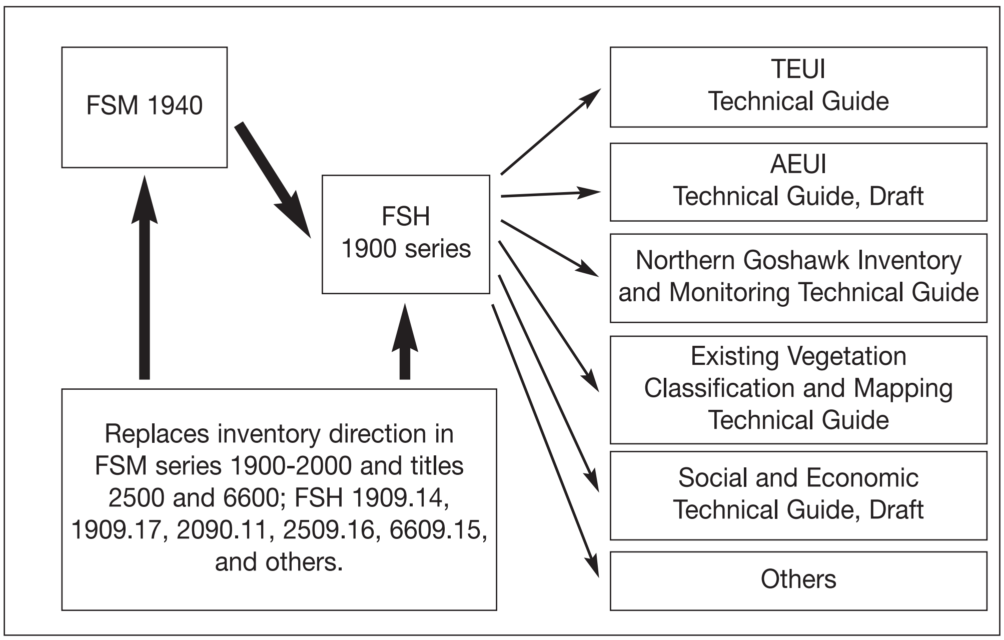

Figure 1.1. *Relationship of Forest Service manual and handbook direction to technical guides.*

1.2 Background and Business Needs

1.2.1 Background

Ecological classification and mapping systems are designed to stratify landscapes at multiple scales so we can understand the arrangement, pattern, and capabilities of ecosystems. With this knowledge, we strive to make informed decisions about the management of public lands throughout the United States. Wertz and Arnold (1972) developed one of the first such systems in the Northern Rocky Mountain region in 1968. Their Land Systems Inventory (LSI) provided a method by which land with similar hazards and capabilities could be inventoried or categorized into repeating map units. A system such as LSI was especially necessary after the National Environmental Policy Act of 1970 required an inventory of all forest lands related to the identified roadless areas. The Cascade Ranger District of the Boise National Forest was the first to implement LSI in 1968; by 1980, many LSIs had been completed throughout the region. In their 1972 publication *Land Systems Inventory*, Wertz and Arnold also introduced a hierarchy of ecological units including sections, subsections, LTAs, and LTs.

This hierarchy was later refined by Cleland et al. (1997) to become known as "The National Hierarchy of Ecological Units." The Province of British Columbia (2001) developed a similar hierarchy land classification system in 1985 called the Ecoregion Classification System. At the detailed ecosystem level, ecosystem units are mapped using the Terrestrial Ecosystem Mapping (TEM) methodology. The TEM methodology stratifies the landscape into map units according to a combination of ecological features, primarily climate, physiography, surficial material, bedrock geology, soil, and vegetation (Province of British Columbia 1998). These concepts and methods of ecological mapping form the basis for the TEUI at the land unit and landscape scales. This technical guide borrows from these original principles and concepts, refining them yet again to meet more specific guidelines and data standards.

1.2.2 Business Needs

TEUI, in combination with other standard resource layers, provides the basis for selecting suitable areas for major kinds of land-use activities, identifying areas that need more intensive investigation, evaluating various land management alternatives, and predicting the effects of a given activity on resource health or condition. TEUI maps, data, descriptions, and management interpretations provide basic land capability information necessary for ecological assessments; project planning; watershed and landscape analysis; forest plan revisions; and implementation and monitoring of forest plans. The information provided can be used for activities such as assessing resource conditions, conducting environmental analyses, defining and establishing desired conditions, and managing and monitoring natural resources.

1.3 Key Concepts

To implement ecosystem management, we need basic information about the nature and distribution of ecosystems (Cleland et al. 1997). An ecosystem consists of a community of organisms and their physical environment, which together form an interacting system or unit, and occupy an identifiable space (Lincoln et al. 1998, SRM 1998). TEUI includes classification and mapping of ecosystems. Ecological classification provides basic information about the nature of ecosystems and mapping depicts the distribution of ecosystems.

TEUI endeavors to classify and map ecosystems based on biotic and abiotic factors that comprise the physical environment. These factors are referred to as landscape elements and are illustrated in figure 1.2, which diagrams the influence of landscape elements on each other. The diagram is arranged in four levels. The elements at the top (bedrock geology, regional climate, and geomorphic processes) are largely independent variables (Daubenmire 1978). The elements in each level of the diagram are influenced by the elements in the levels above; the farther apart the levels, the less direct the influence.

If a close relationship is established between independent and dependent variables, then the independent variables may be useful predictors of the dependent variables (Webster and Oliver 1990). In figure 1.2, the variables of bedrock, geomorphic process, and regional climate do not typically have a close enough relationship with soil and PNV to be useful predictors (as illustrated in figure 1.2 by their distance from the soil and PNV elements). Landform, surficial geology, local climate, and morphometry more directly influence soil and PNV development, and thus are typically better proxy indicators of soil and vegetation, and consequently ecological types. The relative importance of these factors varies across ecoregions and may vary within an inventory area. TEUI requires determining and documenting the importance and relationship of these factors.

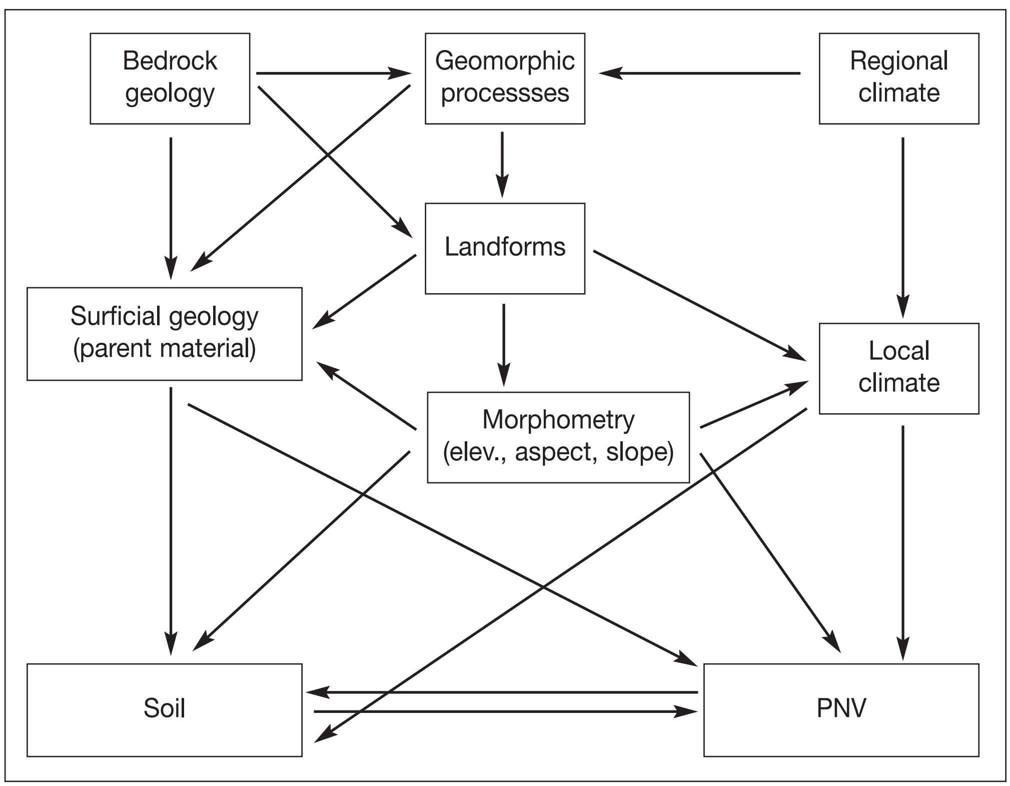

Figure 1.2. *General relationships of landscape elements.*

1.3.1 The National Hierarchy Framework of Ecological Units

The National Hierarchy Framework of Ecological Units (hereafter referred to as the National Hierarchy) is a land classification hierarchy that provides a framework for developing TEUs at continental to local scales. Since this is a nested hierarchy, finer-level classes are descendants of higher-level classes and have their characteristics. The hierarchy framework is organized into four "planning and analysis" scales, which are described by eight levels of ecological units. The levels in the National Hierarchy at each planning scale are described below (Cleland et al. 1997) and represented in table 1.1. This technical guide, however, only focuses on the landscape and land-unit scales. Hence, we will not discuss standards and methods for ecoregion and subregion ecological inventories.

Ecoregion

The ecoregion scale comprises three levels of ecological units (domain, division, and province), which are recognized by differences in global, continental, and national climatic regimes and gross physiography.

Subregion

The subregion scale comprises two levels of ecological units (section and subsection) characterized by combinations of regional climate, geomorphic process, topography, and stratigraphy.

Landscape

The landscape scale contains the LTA level. The LTA depicts broad patterns of soil families or subgroups, potential natural vegetation (PNV) series, and, on occasion, show successional dynamics. Top-down delineation uses other abiotic factors in addition to, or in lieu of, soils and PNV. These factors may include dominant geomorphic process, landforms, surficial and near-surface geologic formations, and local climatic effects. The relative utility of these elements for delineating the LTA varies with ecological province. The LTA can also be designed and delineated bottom-up by aggregating the LT based on the above factors.

Land Unit

The land-unit scale comprises two levels of ecological units (LT and LTP) characterized by repeating patterns of one or more ecological types. LTs and LTPs represent the largest scale (land unit) and most detailed levels of the National Hierarchy.

LTs are subdivisions of LTAs. They can be used to refine top-down LTAs in which they occur based on comparison of their component ecological types and incorporation of their finer scale delineations. Composition of LTs can be summarized to describe the composition of LTAs.

Table 1.1. *Suggested level of detail used for classification and mapping at the landscape and land-unit levels of the National Hierarchy (modified from Cleland et al. 1997).*

Planning and analysis scale	Ecological unit levels	Geology	Geomorphology	Soil	Potential natural vegetation
Landscape	Landtype association (LTA)	Primary lithology or groups of secondary lithology	Geomorphic process and subprocess types	Great group and subgroup	Series and subseries
Land unit	Landtype (LT)	Secondary lithology	Landforms, element landforms, and morphometry	Subgroups, families, and series	Subseries and plant associations
	Landtype phase (LTP)	Secondary lithology	Landforms, element landforms, and morphometry	Series and phases of series	Plant associations and plant association phases

1.3.2 Classification, Map Unit Design, and Map Unit Delineation

The purpose of TEUI is to classify ecosystem types and map land areas with similar capabilities and potentials for management (Cleland et al. 1997). Because of their management significance, soils and vegetation, including historic and potential, form the primary criteria for classifying ecosystems and designing ecological map units at finer scales. Other landscape elements are driving factors in the development of soils and vegetation and are used primarily as delineators of ecological units at these scales. In areas where geologic hazards limit management options, bedrock and/or surficial geology may become classification and design criteria.

Relationship of Classification and Mapping

Soil scientists and vegetation ecologists have long sought to have their respective products serve as the basis of fine-level units (Nowacki 2003).

Soil science has emphasized soil classification and mappings of soil components on the landscape, while vegetation ecology has focused on classification using multivariate methods. TEUI is an attempt to combine the strengths of these two disciplines and more fully integrate climatic and geologic factors to more effectively classify and map ecosystems.

Multivariate analysis is also helpful in developing ecological classifications when relationships between PNV, existing vegetation, soils, and other landscape elements are obscured by other ecological or biological phenomena. These may include climate change and vegetation inertia (Collinson 1988, Pielou 1991), changes in a species indicator value because of genetic variation and geographic changes in associated species (Mueller-Dombois and Ellenberg 1974), and differing rates of soil and vegetation development following large geologic or geomorphic events (Pielou 1991). Multivariate analysis can also focus on specific soil properties instead of soil taxonomy, which still has many inherent agricultural biases (USDA Soil Conservation Service 1994).

The above issues make multivariate analysis essential for ecological classification at the LT and LTP levels. It can also be useful in developing ecological classifications for bottom-up LTAs.

Cleland et al. (1997) indicate that at coarse scales ecosystem landscape elements can be analyzed and mapped separately, and then combined using the Geographic Information System (GIS) to produce ecological unit maps. At fine scales, landscape elements are evaluated simultaneously to classify ecological types, which are then used to design ecological map units. This process is used because of the importance of biotic factors, the level of discernible detail, the number of landscape elements, and the number of variables used to characterize elements progressively increase at finer scales (Cleland et al. 1997).

Map Unit Delineation

PNV and soils share an important property in relation to mapping. Neither can generally be seen on aerial photos, satellite imagery, or digital elevation maps. Soil cannot be seen because it is underground. PNV often cannot be seen because existing vegetation is usually not at potential because of natural or human disturbances. Moreover, it can be difficult to identify plant species other than trees on photos or imagery.

Because soils and PNV cannot be delineated directly, we rely on other landscape elements, as surrogates, such as landform, morphometry, and surficial geology in combination with existing vegetation to map them. Those elements serve as map unit delineation criteria, but not necessarily as map unit design criteria. Map unit design involves deciding which elements we want to depict spatially and how detailed, both thematically and spatially, that depiction will be. Map unit delineation criteria are selected to implement the map unit design.

Ecological Classification

An ecological type is a category of land with a distinctive combination of landscape elements, differing from other types in the kind and amount of vegetation it can produce and in its ability to respond to management actions and natural disturbances. The ecological classification process is used to define, quantify, and document relationships among abiotic landscape elements, existing vegetation types, and PNV types. These relationships are used to develop a classification of ecological types. Different combinations of landscape elements that do not differ in PNV, successional dynamics, or management capabilities do not always constitute separate ecological types.

Traditionally, landscape elements have been classified separately. Some classifications deal with qualitative attributes, while others emphasize quantitative attributes. Classification of ecological types requires integration of numerous qualitative and quantitative attributes. The methods of multivariate analysis are best suited for this task. However, use of an interdisciplinary team to select analysis variables is required to ensure the process is objective.

Gauch (1982) states that, "multivariate analysis is the branch of mathematics that deals with the examination of numerous variables simultaneously. The need for multivariate analysis arises whenever more than one characteristic is measured on a number of individuals, and relationships among the characteristics make it necessary for them to be studied simultaneously. The purpose of multivariate analysis is to treat multivariate data as a whole, summarizing the data and revealing their structure." Put another way, multivariate analysis is used "to make large, unwieldy masses of multivariate field data comprehensible and interpretable" (Pielou 1984).

In summary, classification of ecological types organizes knowledge about relationships between ecosystem elements and the significance of those elements and relationships for land management. This knowledge can be used to design ecological map units that "identify land . . . areas at different levels of resolution that have similar capabilities and potentials for management" (Cleland et al. 1997). Ecological classification can help determine both the thematic and spatial resolution needed to address management issues. Once the detail level of the map units has been determined, the relationships documented in the ecological classification can be used to select delineation criteria for those map units. Thus, classification of ecological types can greatly improve both map unit design and map unit delineation.

1.3.3 Geology

Geology is an important element of TEUI because it is one of the abiotic elements and the foundation for the biotic elements. Geology greatly influences soil formation, provides nutrients for plant uptake, and often affects water transport and availability. Geologic information is essential for predicting the occurrences and distributions of ecological types. The geology element of TEUI should be documented during the mapping and classification procedures. Initial data should be collected as part of the literature search step during the initial steps of TEUI.

The primary sources for existing geologic data and maps are the U.S. Geological Survey (USGS) and State geological surveys. Local university geology departments may also have an archive of unpublished mapping for the inventory area.

Bedrock and Surficial Geology Classification and Description

Both bedrock and surficial geology are described for each ecological type. Bedrock data collection will conform to the standards described in *Geology in the Field* (Compton 1985), sections 1-4, 3-1, 3-2, 3-5, 3-6, 5-1, 5-2, and 5-3 with additional guidance from chapters 6 and 7. Surficial materials data collection will conform to the *Soil Survey Manual* (1993, 73–80).

Describe and classify bedrock geology by lithology (i.e., rock class or name) using *Classification of Rocks* (Travis 1955). In addition, if the bedrock's stratigraphy (i.e., formation or member, and geologic age) is known or suspected to correlate with ecosystem character and function, it must also be determined.

Lithology and Surficial Materials

TEUI uses primary and secondary lithology as defining elements. Primary lithology is the class to which a rock belongs: igneous extrusive, igneous intrusive, sedimentary, or metamorphic. Secondary lithology is the specific rock type (e.g., basalt, granite, sandstone, gneiss); each implies one and only one primary lithology. If TEUI is composed of many rock types (e.g., a mix of basalt, andesite, and tuff), it may be best to classify at the primary lithology level (e.g., igneous extrusive).

Bedrock characteristics (i.e., texture, weathering, chemistry, fracture interval, competence, structure type, azimuth, and inclination) will be described for those integrated plots where bedrock is encountered and for "stops" on geologic traverses. See appendix D, Geology and Geomorphology Form.

Surficial materials are in the "unconsolidated" primary lithology class. They are defined as nonlithified deposits lying on bedrock or occurring on or near the Earth's surface. Surficial materials are characterized by their depositional environment ("kind") and the rock type (secondary lithology) from which they came ("origin"). Some examples: glacial till from granite, alluvium from sedimentary rocks, landslide deposit from limestone, and volcanic ash of basalt composition. Another important factor in characterization is the material's texture (e.g., bouldery, sandy, clayey). Texture terms are applied during the integrated-plot description. Multiple surficial materials, if present, should be noted (e.g., loess, over colluvium, over residuum). See appendix D.

Stratigraphy

According to Salvador (1994), "Stratigraphy is the description of all rock bodies forming the Earth's crust, and their organization into distinctive, useful, mappable units based on their inherent properties or attributes. It includes the classification, naming, and correlation of these units to establish their relationship in space and succession in time." At the land unit scale, this description usually consists of a geologic age and a stratigraphic-unit name followed by a specific rock type, or by the term "formation" if the unit contains more than one rock type. Formations may be divided into "members" or aggregated into a "group."

When a formal stratigraphic map unit exists, it may be used to help describe a TEU. The primary sources for stratigraphy are published geologic maps that conform to the USGS Code of Stratigraphic Nomenclature. Refer to the legend and geologic map unit descriptions to identify the geologic time units and formations in an area.

Stratigraphic names, descriptions, ages, and references should be included in the TEUI manuscript, and incorporated in regional code tables of the corporate database. It is important to note that variations in lithology and thicknesses of specific stratigraphic units may exist within a survey area, or in regional settings. Therefore, one description of a particular lithology may not represent those strata across a survey area.

1.3.4 Geomorphology

The primary reference and data standards for the geomorphology components used in the development of TEUI are contained in the USDA Forest Service publication *A Geomorphic Classification System, version 1.4* (Haskins et al. 1998).

Geomorphology, as described in the above publication, includes three primary components:

1. **Geomorphic Process.** The dominant internal or external geologic force that has interacted with the existing geologic structural framework to shape the Earth's surface.

2. **Landform.** "Any physical feature of the Earth's surface, having a characteristic, recognizable shape and produced by natural causes" (Bates and Jackson 1980, 1987).

3. **Morphometry.** "The measurement and mathematical analysis of the configuration of the Earth's surface and of the shape and dimensions of landforms" (Bates and Jackson 1980, 1987).

Landform, in this classification hierarchy, is directly linked to geomorphic process. Process is implied by selection of a particular landform. A landform choice, therefore, carries with it the process that was responsible for its development (reflected in the list of valid values found in appendix D).

Morphometry is used to quantify the land surface and describe further the variability in landforms. It can be used to predict changes in slope hydrology, soils, and plant communities. The following measurements or characterizations are elements of morphometry: relief, elevation, aspect, slope gradient, slope position, slope shape, slope complexity, landform width, dissection frequency, dissection depth, drainage pattern, and drainage density. Not all parameters are applicable at all levels. In addition, these parameters can be expressed as ranges of values, averages, or means. See appendix D for definitions.

Geomorphic Process

The appearance of a landscape is a result of the geomorphic processes that have shaped it in the past, and that continue to shape it today. The history of a landscape may be complex, with many geomorphic processes overprinting one another. This overprinting occurs when two or more dissimilar geomorphic processes have operated on an area at different times because of the influences of climatic change and/or tectonics. Such complexity is documented using geomorphic generation, which identifies the status of all the processes that operated on any given location.

The Great Sand Dunes National Monument in southern Colorado represents an easily understood example of landscape (and landform) correlation with generations of geomorphic processes. The sand dunes occupy a portion of the still-active Rio Grande rift along the margin of the San Luis Valley, which was formed by tectonic and fluvial geomorphic processes. The present day landscape, however, is dominated by eolian (dune-forming) processes.

Landforms may be characteristic of a combination of geomorphic processes; for example, talus forms by weathering, erosion, and downslope movement. Landforms also may be characteristic of more than one geomorphic process. Canyons form through fluvial processes but also are typically characterized by mass wasting (landslides and rock falls).

Determination of the geomorphic generation of each landform will identify the relationship between the landforms and the status of the process, which formed or continues to form the landforms. The appropriate terms used to identify geomorphic generation are active, dormant, and relict.

Appendix D lists the valid values to be used in TEUI classification and characterization.

Use in Mapping

The *National Soil Survey Handbook* (NSSH), part 627.02, (USDA NRCS 2003b) describes the delineation of major landform units and landform components as a preliminary procedure in field mapping. The next step is the identification, description, and classification of the kinds of soils associated with the landform components. The *NSSH* (USDA NRCS 2003b) states that because "soil patterns commonly coincide with major landforms and individual soils with individual landform components, the objective of identifying and understanding the relationship between landforms and soils is to enable a soil scientist to predict the kind of soil on the landform."

The relatively larger scale of the landform component is often useful for stratifying the landscape into segments having similar climate, physiography, geomorphology, and parent materials from which further predictable delineations of geology, soils, and PNV can be made.

Application

In complex landscapes, the landform often serves as the primary delineation criterion for identifying TEUs. Landforms and morphometry are important in defining the way water and materials translocate over and through watersheds. Landforms and morphometry are important for influencing watershed storm precipitation response, sediment routing, erosion rates and volumes, groundwater and materials storage and recharge, and duration and intensity of solar radiation.

Landforms and their associated geology also enable us uniformly and consistently to predict and interpret properties such as hydrologic behavior, slope stability, and sediment storage, for assessing land-use potential, capabilities, limitations, and hazards.

Geomorphology often changes where natural patterns of the landscape change. Consideration of whether a change is significant and should be delineated separately from surrounding landforms depends on many factors. For example, changes in morphometry may signal a significant coincidental change in geomorphology.

An understanding of geomorphic processes and their resultant landforms provides the mapper the ability to predict and extrapolate TEUI element distributions.

1.3.5 Soil

The soil element of an ecological type must be described, classified, and characterized according to the standards defined in the *Soil Survey Manual* (USDA NRCS 1993) and the *NSSH* (USDA NRCS 2003b).

Characterization

Document soil properties (both chemical and physical) that are the basis for classification. Include soil properties that significantly influence ecosystem character and function. Describe and establish the range of significant soil properties. It may be desirable to phase those soil properties that influence the character or interpretation of each component.

Characterization should be based on observed ranges from all samples collected for that ecological type. Characteristics not observed but estimated or derived (such as available waterholding capacity) should be designated as such and methods documented.

Soil Classification

A national soil classification system provides the definitions and nomenclature necessary for classifying soil. The official soil series descriptions provide definitions, procedures, and nomenclature for establishing soil series. See the *NSSH* (USDA NRCS 2003b), Part 614. Classify the soils according to the most recent edition of *Keys to Soil Taxonomy* (USDA NRCS 2003a). Classify soils at the soil series or family level of soil taxonomy. For highly variable areas, such as riparian areas, disturbed areas, or steep slopes, classify soils at a higher level of soil taxonomy.

Soil classification is used to provide the following elements:

- A connotative naming system that enables those users familiar with the nomenclature to recognize selected properties of soils.
- A means for understanding the relationships among soils in a given area and among different areas.
- A means of communicating concepts of soil and soil properties.
- A means of projecting experience with soils from one area to another.
- Names that can be used as reference terms to identify map unit components.

Application

The information assembled about soils in the TEUI map unit descriptions and associated data tables are used to predict or estimate the potentials and limitations of soils for many specific uses. The predictions serve as a basis for judgment about land use and management for areas ranging from small tracts to regions of several million acres. These estimations must be evaluated along with economic, social, and environmental considerations before recommendations for land use and management become valid. Many standard and locally defined interpretations are available from the TEUI (see chapter 3, tables 3.6 and 3.7).

1.3.6 Vegetation

The vegetation element of an ecological type must be described, classified, and characterized. Historic vegetation, disturbance regimes, exisiting vegetation, PNV, and state and transition models are typically documented for each ecological type. Guidelines for classifying and mapping ExistingVegetation are described the *Existing Vegetation Classification and Mapping Technical Guide* (Brohman and Bryant 2005).

Use in Mapping

Existing vegetation is often used to delineate ecological map units, however, care must be taken, as exisiting vegetation does not always reflect historic or potential vegetation. Historic vegetation, disturbance regimes, and potential vegetation are typically not mapped because it cannot be readily identified on aerial photography. Rather, the relationship between existing vegetation and association of landscape elements are used to predict these important vegetation characteristics. The text that follows gives guidelines for determining historic vegetation, disturbance regimes, PNV, and developing state and transition models.

Historic Vegetation and Disturbance Regimes

As primary producers of living tissue (biomass), vegetation is a fundamental component of ecosystems. Human and animal existence and welfare are ultimately derived from vegetation. Humans have manipulated vegetation over the course of thousands of years for food and fiber production, and continue to do so. Since resource management largely involves vegetation alteration in one-way or another, successful land stewardship is predicated on understanding various aspects of vegetation: its composition, structure, dynamics (successional changes), and potential.

The Earth's vegetation is a complex patchwork, reflecting an amalgamation of abiotic and biotic interrelations across time and space. Vegetation communities are a result of interaction within and among (1) biota (species evolution, adaptation, gene flow, physiological traits, competitive abilities, and resiliency; herbivory), (2) physical environments (e.g., climate, topography, geology, soils), and (3) disturbances (wind, fire, insects, disease, etc.) including human activities. The inherent complexities of vegetation dynamics (e.g., how vegetation originated in an area and how it might change in the future) require several lines of inquiry for adequate understanding. These core components include historic vegetation, disturbance regimes, existing (current) vegetation, and PNV. All are important for understanding vegetation patterns and processes at various spatial and temporal scales and are essential for vegetation management, particularly for preparing desired future conditions, silvicultural prescriptions, and ecological restoration plans.

Historic Vegetation

Vegetation communities are as much a product of past events as they are contemporary processes; thus, ecologists who overlook the past are likely to misinterpret the present (Whitney 1994, 4). Indeed, "stepping back to look forward" is a rationale way of understanding the historical milieu that has led to current vegetative conditions (Foster 1998). Not only do stand histories help explain the origin of current forest conditions (Carvell 1986), but knowledge of past or historic vegetation (compositions, structures, dynamics) proves crucial in the restoration of ecological systems that have been negatively altered by human or natural disturbances. Recent compilations by Fulé et al. (1997), Balee (1998), Swetnam et al. (1999), and Egan and Howell (2001) provide overarching principals of historical ecology and its relevance to resource management and ecosystem restoration.

Trends in historic vegetation can be displayed over long time periods spanning thousands of years. The relevance of ecological data diminishes the further back in time one goes due to increasing differences in ecological conditions (e.g., climate, disturbance regimes, species distributions). Thus, a more narrow, ecologically relevant time period is sought in order to capture past vegetation conditions for land management objectives (e.g., document native communities, assess historic vegetation changes; set ecological restoration goals). A 500-year period immediately preceding European settlement is a reasonable time period for reference conditions. By focusing on vegetation characteristics (composition, structure, and dynamics) of this time period, we document those conditions immediately prior to major landscape changes wrought by European settlement (Whitney 1994). Historic vegetation can be reconstructed using a variety of approaches, either singly or, more robustly, in combination (Noss 1985; Whitney 1994, chapter 2).

1. **Historical Accounts and Notes.** Written observations (chronicles, journals, diaries, newspapers, etc.) from early explorers, surveyors, and settlers serve as fundamental descriptions of past vegetation. Examples of early descriptive accounts for interpreting original forests include Bromley (1935, southern New England) and Nelson (1957, Georgia).

2. **Early Land Surveys.** This probably represents the best and most frequently used information source for reconstructing pre-European vegetation, especially in forested areas. There are two principal types of land surveys conducted in the United States.

   a. The metes and bounds system was the primary land survey method in Colonial America. This system led to indiscriminate and irregular divisions of the land, often shaped in deference to the owner desires, using trees, rock outcrops, post and stone monuments, river and stream courses, and ridgelines as boundary markers (Ernst 1979, Abrams and Ruffner 1995, Black and Abrams 2001a). Representative excerpts from early land surveys can be found in Spurr (1951). Because it was an unintentional vegetation survey, a number of biases and errors may occur in the tree data (Whitney 1994, Black and Abrams 2001a). Witness-tree data should be used cautiously because of known biases of corner tree selection, including economic value, ease of inscription, size, vigor, longevity, and age. Where it exists, other ancillary data, such as trees marked for road surveys, can be used to assess for bias (Whitney 1994, Burgi and Russell 2000). Often pre-European forest composition is reconstructed using simple tallies of corner trees. These data, in turn, can be compared to contemporary vegetation surveys to depict historic vegetation changes (Nowacki and Abrams 1992, Abrams and Ruffner 1995) or correlated with soil-site factors to document species-environmental relations (Black and Abrams 2001a). The tree data are not as conductive to statistical analysis as later systematic (rectangular) land surveys and thus are less reliable in quantifying pre-European settlement forest conditions.

   b. Through the Land Ordinance of 1785, Congress established the rectangular system for surveying public lands (Stewart 1935, Ernst 1979, White 1991). Designated the General Land Office (GLO) Survey, the majority of the United States was surveyed via this system, except for the original 13 States, Kentucky, Tennessee, Vermont, and Texas (Ernst 1979). This land survey method consists of a nested grid consisting of townships (6-mile squares), sections (1-mile squares; 640 acres), and quarter sections (0.5-mile squares; 160 acres). Surveyors were instructed to blaze and inscribe two to four "bearing" or "witness" trees (one per compass quadrant) at quarter-section corners. "Line" trees encountered between corners along survey lines were also marked. Pertinent ecological data recorded from these trees, known collectively as "witness trees," include species, diameter, and distance to the survey corner.

The systematic collection of witness-tree data fosters the use of statistical analyses for forest reconstruction and the detection of possible surveyor biases. The proper use and limitations of witness-tree data are thoroughly summarized by Hutchinson (1988), Schulte and Mladenoff (2001), and Whitney and DeCant (2001). Statistical procedures used to assess for surveyor bias and variability have been proposed by Bourdo (1956), Delcourt and Delcourt (1974), and Manies et al. (2001). Due to landscape heterogeneity and data-point-density limitations, caution needs to be employed when using GLO survey data to recreate pre-European settlement vegetation at fine scales (i.e., less than several townships or areas less than 10^4 ha) (Manies and Mladenoff 2000). GLO survey data are best compiled to form vegetation units of a quarter mile (160 acres) to 1 mi^2 (640 acres) (Delcourt and Decourt 1996). This unit-size is reasonable for assessing post-European settlement changes at the landscape scale.

GLO survey data often have been extrapolated spatially onto the landscape by coupling it to soil surveys forming discrete forest type maps (see Shanks 1953, Lindsey et al. 1965, Crankshaw et al. 1965, Siccama 1971). Substantial improvements in spatially projecting GLO survey data have been made by employing fuzzy logic to produce superior forest type classifications and maps (Brown 1998). Qualitative GLO survey data provided by written descriptions of vegetation (and disturbance patches) along transects between corners can be used to collaborate quantitative results from bearing-tree data (Nowacki et al. 1990, table 7).

GLO Survey provides forest structure data to reconstruct the spatial arrangement and size-class distribution of trees, although again some sampling bias may exist (Bourdo 1956). Statewide maps of pre-European settlement vegetation composition exist for Indiana (Lindsey et al. 1965), Michigan (Veatch 1959), Minnesota (Marschner 1974), Ohio (Sears 1925, Gordon 1969), and Wisconsin (Finley 1976). Digital pre-European settlement maps for the Upper Great Lakes States are available on the Internet (http://www.ncrs.fs.fed.us/gla/). By integrating past survey data with land-use histories and current inventories, important shifts in vegetation composition and structure can be documented and explained (Whitney 1990, White and Mladenoff 1994, Abrams and Ruffner 1995). Silbernagel, Chen, et al. (1997) and Silbernagel, Martin, et al. (1997) have done a particularly superb job of integrating pre- and post-European settlement vegetation and land-use data with a spatial hierarchy to describe historic vegetation changes within a landscape context.

3. **Photography.** Nothing is more self-evident than providing visible portrayals of the past. As the old adage goes: “A picture is worth a thousand words.” Through repeat photography, vegetation changes over time can be sequentially documented and catalogued (Progulske 1974, Gruell 1983, Gary and Currie 1977, Reid et al. 1980, Strickler and Hall 1980, Skovlin and Thomas 1995).

4. **Statistical Series.**

    a. Land-use data (Marks 1942, Brender and Merrick 1950, Moore and Witham 1996, McWilliams et al. 1997).

    b. Timber, agricultural, and fuel accounting books (Reynolds and Pierson 1942, Dinsdale 1965, Gates 1976, Johnson and Gerland 1996, Simard and Bouchard 1996).

5. **Studies of Primary, Original, or Old-Growth Forests.** In certain areas where disturbance regimes are equivalent to that of the past, present-day vegetation compositions and structures may closely resemble pre-European settlement conditions. Examples of this direct method include boreal forests of Minnesota (Heinselman 1973), conifer-northern hardwoods of Upper Michigan (Frelich and Lorimer 1991), and spruce-hemlock forests of southeast Alaska (Nowacki and Kramer 1998). See Nowacki and Trianosky (1993) for a listing of published old-growth manuscripts covering the Eastern United States.

6. **Archaeological Evidence.** Archaeological sites can provide an ethnobotanical record of surrounding local vegetation (Delcourt et al. 1998). There are known restrictions since materials reflect human collections of plants used for food and medicinal purposes. Tankersley et al. (1996) provides a good example of using archaeological information to determine a segment of prehistoric vegetation.

7. **Paleoecological Data.** This data provides long-term vegetation trends, sometimes spanning tens of thousands of years, and includes pollen, macrofossil, and charcoal/sediment analyses (Wright 1974, Clark 1990, Foster and Zebrek 1993, Motzkin et al. 1993, Russell et al. 1993, Rhodes and Davis 1995, Baker et al. 1996, Clark and Royall 1996, Kearsley and Jackson 1997, Delcourt et al. 1998, and Pitkanen 2000) and physical evidence of trees buried *in situ* (Pregitzer et al. 2000).

8. **Soil Phytoliths.** Phytoliths are "jewels of the plants world," representing hydrated silica imprints of plant cells (Fredlund 2001). These microscopic fossils can be used as a means to reconstruct past vegetation (Birkeland 1974). Due to differences in silica content (grasses are high in silica content whereas most tree leaves are low), some plants may be over represented while others under represented (Fredlund 2001). Due to their enhanced ability of silica production, grasslands are the best biomes for using this line of evidence.

9. **Traditional Ecological Knowledge/Native Oral Histories.** Although downplayed or overlooked in the past, the application of traditional ecological knowledge for understanding past conditions is rapidly gaining momentum (Kimmerer 2000). A full issue of *Ecological Applications* (October 2000) is dedicated to this line of research (Ford and Martinez 2000).

Disturbance Regimes

The role of natural disturbance in shaping forest composition, structure and function is recognized globally (Pickett and White 1985, Attiwill 1994, Reice 2001). Many forest characteristics are better understood as responses to different kinds of disturbances rather than the result of successional change towards equilibrium (Brubaker 1987). As such, disturbance ecology is extremely relevant to resource management, providing an important conceptual framework for understanding our environment (Engstrom et al. 1999). Natural disturbance alter ecosystem characteristics that matter to managers, including species composition and structure, biodiversity, resource productivity, and incidence of disease. Managers themselves respond to and introduce disturbances all the time. Since disturbances have so profoundly influenced the biotic portion of ecosystems (e.g., species evolution and adaptations; vegetation compositions and structures), it stands to reason that disturbance regimes can be used as a template to design our management activities upon – that is, emulating those processes that have led to native biodiversity and other ecological attributes (Attiwill 1994, Swetnam et al. 1999). Silviculture stands to benefit substantially through emulating natural disturbance regimes (Kimball et al. 1995, Walker et al. 1996, Nowacki and Kramer 1998, Cissel et al. 1999, Bergeron et al. 2002, Seymour et al. 2002), although there are caveats to consider (Patch 1998, Lorimer 2001). This topic is thoroughly explored in a special issue of *Forest Ecology Management* (Mitchell et al. 2002). Disturbance ecology includes human effects (land-use histories) that have influenced today's vegetation characteristics (Brender 1974, Whitney and Somerlot 1985, Christensen 1989, Glitzenstein et al. 1990, Orwig and Abrams 1994). Lorimer (1985; list modified below) itemizes a variety of quantitative methods for ascertaining forest disturbance history.

1. **External Physical Evidence**

    a. Fire scars. Exposure to recurrent fire causes the scarring of tree boles, thus forming a record of past disturbance events in pyrogenic systems (Buell et al. 1954, Johnson 1979, Dieterich 1980, Guyette and McGinnes 1982, McBride 1983, Swetnam 1993, Gutsell and Johnson 1996, Loope and Anderson 1998). Fire periodicity and extent can be reconstructed using fire-scar data.

b. Forest floor. Physical evidence can be used to trace developmental histories of forest stands (Henry and Swan 1974, Oliver and Stephens 1977).

c. Paleoecological data. Pollen, macrofossil, and charcoal assemblages in bog and lake sediments can be used to reconstruct past disturbance regimes (Clark 1990, Larsen and MacDonald 1998). Armed with pollen, charcoal, and ethnobotanical data, Delcourt et al. (1998) established strong linkages among prehistoric human occupation, plant domestication, and increases in local fire.

2. **Demographic Evidence**

a. Tree-age and size distributions and time-since-disturbance maps. See Heinselman (1973), Johnson and Larsen (1991), and Reed et al. (1998) for examples.

3. **Physiological Evidence**

a. Radial growth patterns. Tree rings are a natural data storage system containing valuable ecological and historical information (Creber 1977, Banks 1991). In dense temperate forests, tree-ring growth is often linked to competition for growing space/resources rather than climatic factors (Phipps 1982, Blasing et al. 1983, Cook and Kairiukstis 1990, chapter 3). In these situations, radial growth patterns have been successfully used to detect and quantify disturbance events (Lorimer and Frelich 1989, Payette el al. 1990, Nowacki and Abrams 1997, St. George and Nielsen 2000, Rentch et al. 2002).

4. **Structural Evidence**

a. Canopy structure.

b. Diameter distributions. See Heinselman (1973) for landscape-level reconstructions of disturbance events.

Additional information can be obtained through:

5. **Historical Accounts.** Journals, chronicles, diaries, etc., from early explorers, surveyors, settlers, and early newspaper reports can be used to document pre- and post-European disturbance regimes (Day 1953). Historical maps (Van Wagner 1988, Payette et al. 1989).

6. **Early Land Surveys.** Pre-European settlement disturbance regimes (disturance types, sizes, intensities, frequencies) have been successfully chronicled by GLO Survey (Grimm 1984) or equivalent survey data (Seischab and Orwig 1991).

Disturbance regimes have been described for conifer-northern hardwoods (Lorimer 1977; Dunn et al. 1983; Canham and Loucks 1984; Whitney 1986, 1987), pine forests (Whitney 1986, 1987), swamp conifer forests (Whitney 1986, 1987), and boreal forests (Lorimer 1977). Early government land surveys can be used to estimate pre-European settlement fire frequency in pyrogenic landscapes (Lorimer 1980). The effects of Native American disturbance on pre-European forests have been traced through catchment analysis of witness-tree data (Black and Abrams 2001b).

Existing Vegetation

While *existing* vegetation information is also critical for sound forest planning, it serves a different purpose than TEUI. Whereas TEUI seeks to identify differences in the inherent potential of land units to generate ecosystem diversity and maintain its functions, existing vegetation maps reflect the current state of ecosystem structure and floristic composition. Potential and existing vegetation maps therefore provide different— but related and equally important— sets of information for forest planning. Protocols for classifying and mapping existing vegetation are described in the draft *Existing Vegetation Classification and Mapping Technical Guide* (Brohman et al. 2005).

Potential Natural Vegetation

PNV is *the vegetation that would become established if all successional sequences were completed without human interference under present climatic and edaphic conditions* [adapted from Tüxen (1956) as translated by Mueller-Dombois and Ellenberg (1974)].

Environmental conditions include climate, geology, geomorphology, and soil characteristics. Although it is important in classifying PNV to separate potential vegetation from these and other environmental variables, environment of course strongly influences development of PNV. “Present climatic and edaphic conditions” includes conditions created by past human activities (Tüxen 1956 as cited by Mueller-Dombois and Ellenberg 1974), such as soil loss. PNV may include naturalized, non-native species. Introduced species capable of displacing native species represent a change in floristic conditions that changes the PNV of a site. These new species may have been introduced by natural migration or by human actions.

Utility of Potential Natural Vegetation

Historically, the completion of the successional sequence (the sere) in the above definition was seen as progressing toward a stable, climax state limited only by climatic constraints. In recent years, this concept of climax as a single stable state has been shown to be overly simplistic (Cook 1996). Following disturbance, vegetation on similar sites can proceed toward multiple possible future conditions. Our objective in classifying and using PNV, however, is not to promote the climax concept as a certain, rigid endpoint to succession. Rather, our goal is to capture the land's capability to support certain vegetative ecosystems by using potential vegetation as a concise, easily communicated and validated "shorthand" to describe this capability. PNV, then, is best thought of as the vegetation expressing its potential on the land, and can occur at all scales from site to region.

PNV should always be seen in the context of existing and historic vegetation. Our understanding of landscapes is likely to be incomplete without a full understanding of how existing, potential, and historic vegetation relate to each other. Existing and historic vegetation have been described previously in this document.

The objective of PNV classification is to concisely describe the capability of land to produce vegetation and support other ecosystem processes and functions through a well-defined vegetation description. Although this approach is only approximate, or may be overly simplified in some cases, this does not mean that PNV is not useful. Indeed, there may be value in this simplification, provided we are fully aware of its weaknesses, because information that is too detailed or complicated quickly loses currency with land managers. PNV is one of the most useful integrated expressions of environment we have that is related directly to vegetation. It has been widely and successfully used for planning at project, national forest, and river basin scales.

PNV is a more permanent feature of the landscape than is existing vegetation and sets the context in which a variety of structural and compositional stages of vegetation may occur. Consider an acre of PNV forest on deep soils adjacent to an acre of PNV grassland on shallow soils. Vegetation structure and composition of each acre can vary within the environmental constraints of each site. The PNV grassland acre of shallow soils is incapable of supporting a forest, but the PNV forest acre may support a variety of grassland, shrubland, and forested communities. The acre of PNV grassland will only support a limited variety of grass and forb communities. The PNV classification of the 2 acres would always be different, but they may at times support the same existing vegetation.

When PNV is coupled with other key landscape elements (soil, landform, climate, and geology) to identify an ecological type classification, PNV becomes more useful. For example, the geographically widespread subalpine fir/grouse whortleberry (ABLA/VASC) plant association occurs on a variety of sites. When soils and landform are used along with this plant association to classify ecological types, more precise descriptions of site potentials emerge.

In summary, PNV classification is a pragmatic shorthand means of understanding and communicating vegetative site differences. It is used along with landscape elements to classify ecological types. See 1.3.2 Ecological Classification for further details.

Potential Natural Vegetation Classification Criteria

The plant association is the fundamental unit of vegetation taxonomy for both potential and existing vegetation. Other levels of vegetation classification are derived from the association. The FGDC (1997) *Vegetation Classification Standard* specifies that the term "association refers to existing vegetation, not a potential vegetation type." In other words, the term association does not necessarily refer to a climax plant community. This usage predominates in vegetation ecology (Krebs 1972, Mueller-Dombois and Ellenberg 1974, Barbour et al. 1980, Collinson 1988). In contrast, the USDA Forest Service (1991b) and USDA Natural Resources Conservation Service (NRCS) (1997) have used the term 'plant association' to refer to a climax or potential natural plant community, following Daubenmire (1968). The FGDC standard mandates that term 'association' or 'plant association' not be used to imply a climax plant community. However, it is acceptable to classify PNV at the association level of vegetation taxonomy.

Community composition is the "kinds, absolute amounts, or relative proportions of plant species present in a given area or stand" (Brohman and Bryant 2005). In practice, we recommend use of absolute areal percent cover as the best method to capture the amount of a species present. Areal percent cover is the fraction of a sample plot covered by the species of interest. This has the advantages of both simple data collection and good correlation to changes in site characteristics.

A vegetation classification in itself does not include abiotic factors. (The direct combination of a vegetation classification taxon and its abiotic counterparts defines an ecological type.) In developing a PNV classification, however, both plant abundance and environmental data are critical, since relating the amount of a species to site characteristics—soil moisture and nutrient status, aspect, elevation, etc.—defines the threshold separating one community from another. For example, 3-percent areal cover of shield fern is used in southeastern Alaskan western hemlock forests to characterize an ecosystem with well-aerated, nutrient-rich soils. Sites with less than 3-percent cover of shield fern have typically not reached this threshold of soil nutrient availability, and are classified as a different association. Such a classification would not be possible without correlating the vegetation data to soils data. This is a core principle of classifying potential vegetation: characterizing vegetation by changes in environmental thresholds rather than the simple abundance of each species. These changes reflect a species' change in abundance along environmental gradients (species amplitude). This is also why the modern concept of PNV centers on capturing the diagnostic structure, function, and composition of an ecosystem—its potential—rather than identifying a climax plant community state.

Diagnostic species are "*any species, or group of species, whose relative constancy or abundance clearly differentiates one* [*vegetation*] *type from another*" (Jennings et al. 2004). This definition implies that diagnostic species must be determined empirically through analysis of plot data (Mueller-Dombois and Ellenberg 1974). Identifying diagnostic species is an inherent part of classifying associations and alliances. Diagnostic species include dominant, differential, character, and indicator species. These are defined as follows:

> **Dominant species**—"*the species with the highest percentage of cover, usually in the uppermost … layer"* (Kimmins 1997 as cited in Jennings et al. 2004). Dominant species represent a quantitative difference in composition between vegetation types. Two stands or types may have identical floristics (plant species present) but differ in dominant species.
>
> **Differential species**—"a plant species that, because of its greater fidelity in one kind of community than others, can be used to distinguish vegetation units" (Gabriel and Talbot 1984 as cited in Jennings et al. 2004). A differential species is usually present in one vegetation type but absent in other types. They constitute a floristic or qualitative distinction between vegetation types.
>
> **Character species**—"*a species that shows a distinct maximum concentration (quantitatively and by presence) in a well-definable vegetation type"* (Mueller-Dombois and Ellenberg 1974). Character species constitute a quantitative difference in composition between vegetation types.
>
> **Indicator species**—"*a species whose presence, abundance, or vigor is considered to indicate certain environmental conditions"* (Gabriel and Talbot 1984 as cited in Jennings et al. 2004). Indicator species may represent either a qualitative or quantitative distinction between community types.

Dominant species are generally self-evident. Other diagnostic species are typically determined empirically through analysis of species abundances and environmental data. Plots are grouped on or by species composition. This is often done with an algorithm to objectively search for groups of species that occur together repeatedly across the landscape. The diagnostic value of a species may change from one part of its geographic range to another because of genetic variation, compensating environmental factors, or changes in associated species.

Potential Natural Vegetation Hierarchy

PNV can be classified at four hierarchy levels: series, subseries, plant association, and plant association phase. The four taxonomic levels are defined as follows:

- A ***series*** is a taxonomic unit of PNV classification that aggregates plant associations that share the same climax species in the dominant layer. In forested vegetation this is typically the most shade tolerant tree species capable of occupying a site. The term series traditionally has been applied only to climax vegetation. Analogous terms for existing vegetation include *dominance type* and *alliance* (Jennings et al. 2004).

- A ***subseries*** is a taxonomic subdivision of a series that groups plant associations that share diagnostic species which show similar relationships to major environmental gradients (Mueller-Dombois and Ellenberg 1974). Regional terminology equivalent to the subseries concept may include *Plant Association Groups* and *Habitat Type Groups*, although in practice these groups sometimes contain members from different series. Analogous terms for existing vegetation include *alliance* and *suballiance.*

- A ***plant association*** (or association) is "a recurring plant community with a characteristic range in species composition, specific diagnostic species, and a defined range in habitat conditions and physiognomy or structure" (Jennings et al. 2004). Although the FGDC (1997) Vegetation Classification Standard specifies that the term "plant association" does not imply a climax plant community, it is acceptable to classify PNV at the association level of vegetation taxonomy. Plant associations are named after diagnostic tree, shrub, and herb species. *Habitat Type* serves as a loosely equivalent term to plant association in some regions.

- A ***plant association phase*** is a taxonomic subdivision of a plant association based on one or more diagnostic species. Habitat Type Phase serves as equivalent terminology to the plant association phase concept used by some regions.

The hierarchy is applied as illustrated in table 1.2, which shows examples of three levels in the PNV hierarchy. Any PNV identification within the hierarchy infers all PNV in levels above, but not the reverse. For example, the Big Sagebrush/Bluebunch Wheatgrass p.a. is a shrubland in the Big Sagebrush Series by definition. Conversely, the Big Sagebrush Series does not necessarily imply the Big Sagebrush/Bluebunch Wheatgrass p.a. as there are other plant associations within the Big Sagebrush Series. Coding for individual species is taken from the NRCS PLANTS database.

Table 1.2. *Potential natural vegetation hierarchy examples.**

Series	Subseries	Plant association	Plant association phase
White fir (ABCO)	Reserved	White fir—Douglas-fir/Rocky Mountain maple (ABCO-PSME/ACGL)	Creeping barberry phase (ABCO-PSME/ACGL, MARE11)
Quaking aspen (POTR5)	Reserved	Quaking aspen/Beaked hazelnut (POTR5/COCO6)	Western Brackenfern phase (POTR5/COCO6, PTAQ)
Twoneedle pinyon—Utah juniper (PIED-JUOS)	Reserved	Twoneedle pinyon—Utah juniper/Utah serviceberry—alderleaf mountain mahogany (PIED-JUOS/AMUT-CEMO2)	Greenleaf manzanita phase (PIED-JUOS/AMUT-CEMO2, ARPA6)
Sagebrush (ARTR2)	Reserved	Big Sagebrush/Idaho fescue (ARTR2/FEID)	Sticky purple geranium phase (ARTR2/FEID, GEVI2)
Tufted hairgrass (DECE)	Reserved	Tufted hairgrass—Slender wheatgrass (DECE-ELTR7)	N/A
Porter's wild lovage (LIPO)	Reserved	Porter's licorice-root—lodgepole lupine (LIPO-LUPA8)	N/A

**Examples are adapted from Johnston (1989). Symbols for species are from PLANTS (USDA NRCS 2004).*

Types of Potential Natural Vegetation

Different combinations of macroclimate, topography, and soils can result in similar growing conditions and support the same PNV. However, the same PNV may reflect a different limiting factor in each case. Differences in limiting factor can result in different responses to vegetation management, even though the PNV is the same. It is, therefore, useful, to identify the environmental factors influencing vegetation development.

Based on Tansley's (1935) "polyclimax" theory, Daubenmire (1968) describes categories of climax vegetation based on which environmental factor most directly influences vegetation composition and structure. Similar categories are useful for describing the environmental factor most strongly influencing PNV on each ecological type. Although Daubenmire underestimated the role of natural disturbances (Cook 1996), the categories are useful for describing the effects of a given disturbance. The following discussion and terms are based on Daubenmire's (1968) treatment.

PNV types that reflect climatic, edaphic, and/or topographic conditions have been referred to as *primary PNV types.* PNV types that depend for their maintenance on periodic natural disturbance are called *secondary PNV types*. Primary PNV reflects the effects of inherent physical ecosystem attributes (or landscape elements) such as climate, geology, geomorphology, and soil properties. Secondary PNV is maintained by a specific type of ecosystem process (i.e., natural disturbances such as wildfire). By definition, vegetation maintained by periodic human activity is not PNV.

Categories of primary PNV include the following:

> ***Climatic PNV***—Any PNV type that reflects macroclimatic conditions and shows no dependency for its maintenance on periodic natural disturbance. Seasonal air temperatures, the amount and distribution of precipitation, and light intensity are the predominant elements of macroclimate.
>
> **Edaphic PNV**—Any PNV type that differs significantly from the climatic PNV of an area due to soil properties not related to slope or topographic position. Examples of soil properties that may override the influence of macroclimate include depth, stoniness, texture, pH, and nutrient status. Many of these properties are affected by geologic parent material and geomorphic process.
>
> **Topographic PNV**—Any PNV type that differs significantly from the climatic PNV of an area due to microclimatic conditions created by topographic characteristics. These can include steep slopes, north or south aspects, and areas of snow accumulation or loss.
>
> **Topo-edaphic PNV**—Any PNV type that differs significantly from the climatic PNV of an area due to a combination of microclimatic and soil conditions created by topographic characteristics. An example is an aspen grove growing in a kettle where fine sediments accumulate, creating finer-textured soils. Drifting snow accumulates in the kettle, creating a wetter microclimate.

Categories of secondary PNV include the following:

> **Pyric PNV** (or fire PNV)—Any PNV type that differs significantly from the primary PNV of an area due to periodic wildfire. A pyric PNV maintains its composition and structure only as a consequence of periodic natural burning, which eliminates fire-sensitive species and maintains fire-tolerant or fire-dependent species.
>
> **Zootic PNV**—Any PNV type that differs significantly from the primary PNV of an area due to repeated native animal activity (such as grazing, trampling, burrowing, etc.) or periodic infestations of native insects or diseases.

A particular site may be described in terms of both a primary PNV and a secondary PNV type. For example, many areas in the Great Basin were dominated by big sagebrush with a 20- to 40-year fire return cycle prior to settlement. Since settlement, fire suppression has greatly lengthened the fire return interval, which has allowed juniper to dominate these areas. On such sites juniper is the climatic PNV and big sagebrush is the pyric PNV.

In another widespread example, cheatgrass has become the pyric PNV on many areas where big sagebrush is the climatic or edaphic PNV. The presence of highly flammable cheatgrass has shortened the fire return interval from 20 to 40 years to less than 10 years, which effectively prevents the reestablishment of sagebrush.

State and Transition Models

Understanding vegetation dynamics as influenced by soil, climate, topography, and time is essential for accurately classifying, mapping, and interpreting ecological types. As soil and plant community develop on a site, succession occurs. The state and transition model is one successional model that describes how different disturbances (fire, flooding, grazing, mechanical, air pollution, insects) and stresses (drought, increased precipitation, climate change and variability, exotic species) affect changes in the plant community. This model assists in developing successional pathways (transitions) and plant communities (states) that evolve under various climates and management practices. State and transition models are conceptual and based upon nonequilibrium ecology and depicted through box-and-arrow diagrams in which boxes represent observed or theoretical ecosystem states and arrows represent the observed or theoretical transitions among these states (figure 1.3). They are essentially a means of mapping system behavior in the absence of adequate predictive models (Westoby et al. 1989). Traditional theories of plant succession leading to a single climax community have been found to be inadequate

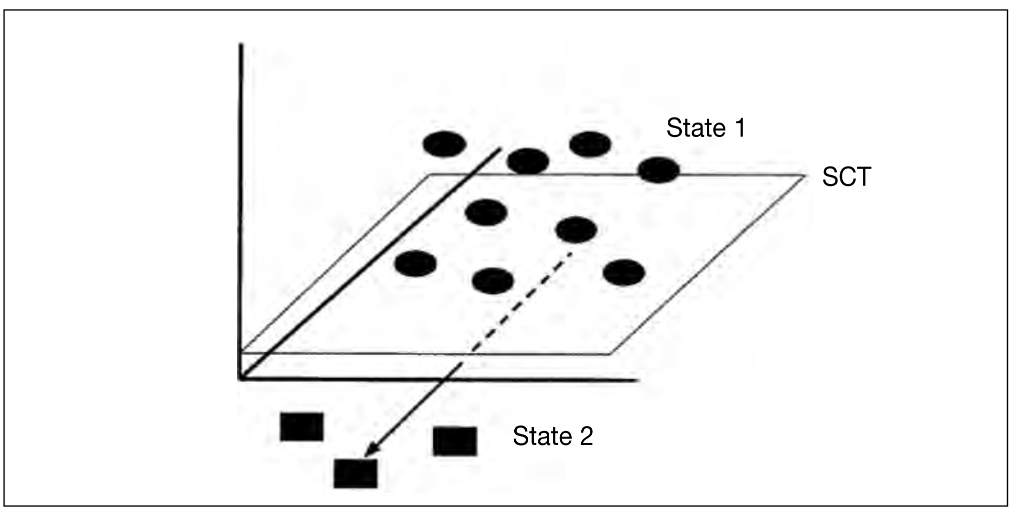

Figure 1.3. *Broad application of the state and transition concepts. Derived from the Society for Range Management (SRM) Task Group on Unity in Concepts and Terminology (1995). The plane labeled SCT (site conservation threshold) represents a change from one ecological site to another and may also be considered a threshold between two states. The individual boxes or ovals represent plant communities or seral stages that exist within one state (Stringham et al. 2001).*

for understanding the complex successional pathways of semiarid and arid ecosystems. Plant succession as influenced by arid and semiarid environments change at different temporal and spatial scales than communities growing within moister more humid and colder environments. These communities often exhibit nonlinear dynamics and are beyond the basic description using linear Clementsian climax theory.

A state is the general description of the known ecological type characteristics and properties. It is a recognizable, resistant, and resilient complex of two components: the soil base and the vegetation structure. The vegetation and soil components are necessarily connected through integrated ecological processes that interact to produce a sustained equilibrium, or stability, that is expressed by a specific suite of vegetative communities and is not simply reversible in the linear successional framework. Stability refers to the capability of the state to return to its original vegetative structure when stresses or disturbances are removed.

As the characteristics and properties or function significantly change there is a transition to a new state. A transition is a trajectory of the system change triggered by natural events, management actions, or both that will not come to rest until a new equilibrium is established. The processes that cause a shift from one state to another are called transition pathways. Transitions can be transient or persisting depending upon the frequency, magnitude, and extent of the disturbance. Regardless of the rate of change the system does not stabilize until the transition is complete.

Through inventory and analysis it is important to differentiate between processes that influence variation within states and those processes that result in crossing thresholds between states. Thresholds are boundaries in space and time between any and all states, or along irreversible transitions, such that one or more of the primary ecological processes has been irreversibly changed and must be actively restored before return to a previous state if possible (Stringham et al. 2001). This change is not reversible on a practical time scale without substantial inputs of energy. These processes need to be assessed and documented.

Characterization and Classification

The characterization and classification of plant communities for state and transition model development will follow standard sampling and description protocols as outlined in this guide. Document local agreement for development of this information in a memorandum of understanding (MOU) and/or work plans. The first vegetation state to describe using this model is the historic climax plant community. From this state, other states known to occur on the site and the transitions that lead to and from each state are developed. Vegetation composition, canopy cover, and structure are essential data elements for characterizing plant communities that can lead to classification of an ecological state. Documentation of these conditions is critical for establishing a framework for describing, understanding, and predicting ecosystem dynamics. Abiotic and flora characteristics and properties are fundamental in categorizing or classifying the ecological type as related to state and transition modeling.

Use in Mapping

Incorporating state and transition modeling into the TEUI mapping process requires considerable thought and planning to ensure scale and cartographic integrity are consistent with objectives of the inventory. Use the MOU and/or work plan to address the requirements of the TEUI mapping process. States of plant communities should be readily observable and documented. These states should be delineable at an appropriate scale and repeat to the extent that there is more than one area where the vegetative state can be located and observed. Similar vegetative states that are similar in composition, cover, and structure and separated by geographic features are mapped as the same repeating ecological type and ecological unit.

Application

Within the state and transition model, states can approximate seral stages or phases of vegetation development. Both narrow and broad interpretations of states can be made depending upon the establishment of thresholds.

Broadly applied, states are climate/soil/vegetation domains that encompass a large amount of variation in species composition. For example a grassland state would include many seral stages of the overall grassland community. These seral stages are within the amplitude of natural variability characteristic of the state and represent responses to a disturbance that do not force a breach of the threshold (Stringham et al. 2001). It is assumed that the domination of successional processes determines the boundary of the grassland state. In the broad definition of state, the range of natural variability characteristic of the plant communities within a site is the result of, and contributes to, the current functional integrity of the site's primary ecological processes.

The narrower interpretation of states allows for far less variation in plant community composition (figure 1.4). States are typically depicted as seral stages or vegetation development. A state change does not necessarily represent a movement across a threshold.

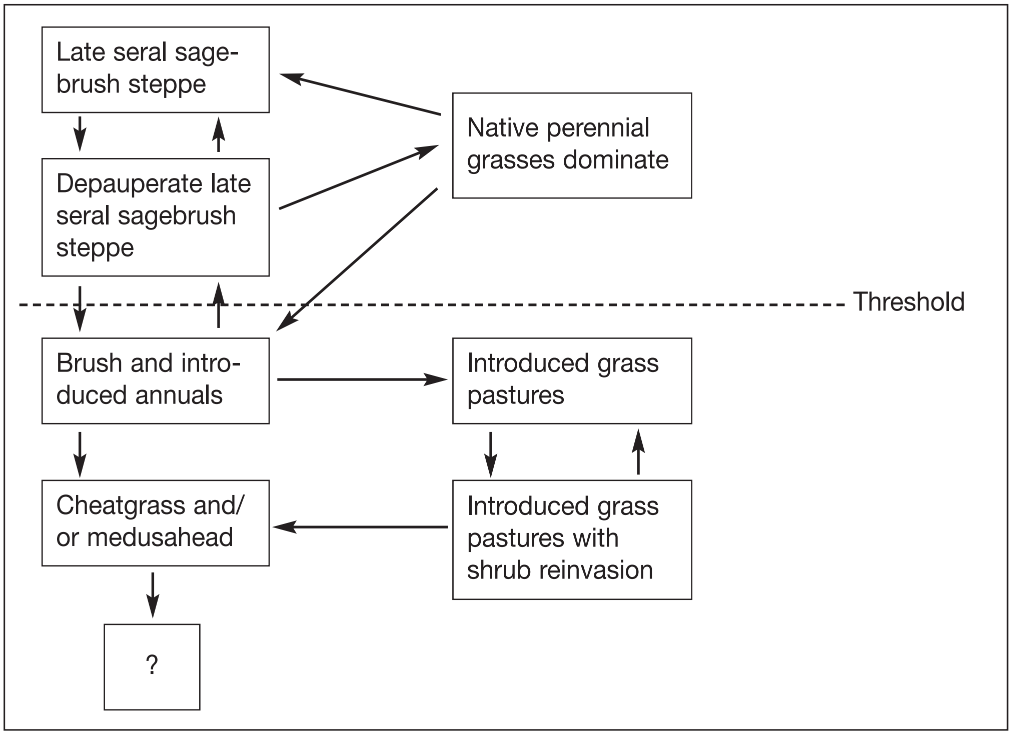

Figure 1.4. *Specific, or narrow, application of states with each state (box) representing one phase or seral stage of vegetation development. Transitions between states are indicated by arrows, and the dashed lines represents a threshold. The dashed transitional line signifies the requirement of substantial energy input to move the state back across the threshold (Stringham et al. 2001).*

The management and natural mechanisms responsible for community phase shifts and transition initiation must be included in the model description as applied in the TEUI process. The description of these mechanisms should contain information on their impact on primary ecological processes and the resulting change in the biotic community and system function. Typically, the change in the biotic community is documented, not the causal mechanism. Causes of vegetation change should be determined and the effects of this activity described. It is likely a combination of factors is responsible for these dramatic shifts.

1.4 Roles and Responsibilities

1.4.1 National Responsibilities

- Developing the TEUI program and implementing it as part of the agency's Inventory and Monitoring Framework.
- Developing classification and characterization standards for ecological types and ecological units and ensuring compatibility of any USDA Forest Service-generated descriptions across regional lines.

- Providing direction for the classification, inventory, and evaluation of ecosystem capability.

- Ensuring consistency for national application and interpretation of ecological units.

- Ensuring regions are completing the soils portion of TEUI to NCSS standards.

- Ensuring regions are accountable for completion of TEUI to national standards and protocols and as scheduled in inventory and monitoring program plans.

- Ensuring the incorporation of servicewide GIS data standards in the TEUI program.

- Ensuring regions are collecting data that is compatible with corporate databases.

1.4.2 Regional Responsibilities

- Implementing the TEUI program to national standards and protocols.

- Developing TEUI information in advance of assessments, forest plan revisions, and monitoring as scheduled in the regions' inventory and monitoring program plan.

- Providing development of regional and local interpretations of ecosystem relationships, responses, diversity, productivity, and sustainability.

- Ensuring ecological type and map unit information is developed consistently across administrative units and major land resource areas. Coordinating with other agencies for correlation of ecological type descriptions and map units.

- Providing standards for application and interpretation of ecological types and map units, and ensuring consistency of standards and interpretations between regions and field units.

- Performing quality control so that performance measures and outcomes are accomplished for TEUI through instituting field review of TEUI products to assure consistency and quality.

1.4.3 Forest Responsibilities

- Implementing the TEUI program to national standards and protocols.

- Ensuring that TEUI is accomplished according to schedule.

- Collecting information to characterize ecological types and map units.

- Providing day-to-day quality control of mapping and data collection process.
- Ensuring that ecological information is used in forest planning and assessments, and in project implementation on National Forest System lands.

1.5 Relationship to Other Federal Inventory and Monitoring Programs

1.5.1 Natural Resources Conservation Service

Soil Survey Program

The soil survey program of the United States is conducted under several statutory authorities. Public Law 89-560 directs the Secretary of Agriculture to (1) make an inventory of soil resources of the United States, (2) keep the inventory current, (3) make the information available in a useful form by preparing reports and interpretations, and (4) provide technical assistance and consulting services to promote the use and application of soils information. NRCS has lead responsiblity for this effort (USDA NRCS 2003b).

The soil data collected through implementation of the *TEUI Technical Guide* will meet the following NCSS standards:

- Classification as found in *Keys to Soil Taxonomy* (USDA NRCS 2003a);
- Description, as found in *The Field Book for Describing and Sampling Soils* (Schoeneberger et al. 2002); and
- Documentation described in the *NSSH*, Part 627.08 (USDA NRCS 2003b) with exception of a TEUI map instead of a soil map.

The soil component of TEUs is verified in the field, and the soil correlation process in TEUI provides for consistent soil classification, naming, and interpretation. MOU and/or work plans serve as a cooperative agreement with NCSS partners and govern the management and administration of the soils portion of the TEUI and address how NCSS standards will be achieved.

National Soil Information System

The National Soil Information System (NASIS) is a corporate database that stores soil survey data. Many of the data elements and attributes for soils identified in this technical guide are identical with those in NASIS. Methods of sharing these data between agencies can be accomplished through data cross walks and migration routines.

Ecological Site Information System

The Ecological Site Information System (ESIS) is the NRCS repository for data associated with the collection of forest land and rangeland plot data (vegetation) and the development of ecological site descriptions (ESD). While the data elements collected for TEUI and NRCS ecological sites are similar, they differ in that the ESIS data are not integrated, collected, or mapped as part of the soil survey program. ESIS is organized into two applications and their associated databases described below.

Ecological Site Description

The ESD application provides the capability to produce automated ESDs from the data stored in its database. The ESD application is the official repository for all data associated with the development of forest land and rangeland ESDs by the NRCS.

Ecological Site Inventory

The Ecological Site Inventory application provides the capability to enter, edit, and retrieve range, forestry, and agro-forestry plot data.

1.6 Quality Control and Assurance

Quality control and assurance are addressed for each protocol in chapters 2 and 3.

1.7 Change Management

1.7.1 Update Schedule

The *TEUI Technical Guide* will be updated as needed or as directed by Washington Office staff with the concurrence of the national and regional TEUI program leaders.

1.7.2 Process

The updated *TEUI Technical Guide* will be released for a 3-month review period. Regional TEUI program leaders will compile and consolidate reviews from their respective regions and submit edits to the national TEUI program leaders for consideration.

Peer Review

The *TEUI Technical Guide* will be reviewed by all involved in TEUI, including soil scientists, geologists, and ecologists throughout Government agencies and universities. A current list of reviewers is available in appendix G.

Regional Supplements

Regions may supplement the information in this technical guide with methods or guidance required for meeting specific issues or needs of the region.

Chapter 2. Landtype Associations Protocol

2.1 Objective

The objective of this protocol is to provide consistent standards for the mapping and documentation of landtype associations (LTAs).

The development of standard ways of delineating, classifying, and describing LTAs across broad geographic regions will increase the reliability and interpretation of these units for broad-scale analysis. In lieu of standards, LTAs become less defensible scientifically because of lack of peer review, and less defensible legally because adjacent entities, such as national forests, will be inconsistent in addressing the same or similar resource management issues (DeMeo et al. 2002).

2.1.1 Business Requirements

LTA maps and descriptions are primarily used in the land management planning process as analysis units to organize broad areas by suitability, identify restoration priorities, and serve as a coarse filter for protecting biodiversity (Almendinger et al. 2000). Because LTAs describe both the abiotic and biotic elements of ecosystems, they provide an excellent analysis unit for determining forest-level effects. For example, the Rio Grande National Forest Plan Final Environmental Impact Statement and Supplemental Information Report projected changes in vegetation structure class by LTA over time for each alternative, enabling the analysis of effects from timber harvest. LTAs were also used to prioritize areas of fuel treatment, determine suitable areas for livestock grazing, and analyze cumulative effects (USDA Forest Service 2002).

Perhaps the most useful application of LTAs is as a stratification tool to quickly organize the planning landscape and rank areas by relative suitability or concern. This application was demonstrated for addressing habitat needs of a rare species in DeMeo (2002), resulting in considerable savings in field inventory costs.

LTAs proved useful addressing many other land management issues such as mapping natural disturbance regimes, managing wildlife populations, and developing integrated landscape models (Smith 2002).

LTAs also are used as the initial stratification for the premapping of the landtype (LT) level mapping described in chapter 3. Because the landscape elements for LTA maps are classified at broader levels, they are effective in organizing the LT survey area for further stratification.

Finally, because they are fairly broad landscape units (hundreds of thousands of acres), LTAs can be grouped by forest vegetation zone, geology, or other factors and easily communicated to the public and land managers.

2.1.2 Products

LTA mapping generates a Geographic Information System (GIS) map layer, designed for display at the 1:100,000 scale with supporting data and map unit descriptions. For an overview of a national forest or subregion, maps at 1:250,000 are also useful, but not as a substitute for the 1:100,000 product. The attribute data for LTAs are similar to those of the LT, but classification of the landscape elements are made at a broader level. Table 2.1 describes the recommended level of classification for each of the landscape elements. Required and recommended map unit attributes (for LTAs only) are listed in table 2.2.

Table 2.1. *Comparison of elements for ecological units at landscape and land-unit scales.*

Planning and analysis scale	Ecological unit levels	Geology	Geomorphology	Soil	Potential natural vegetation
Landscape	Landtype association (LTA)	Primary lithology or groups of secondary	Geomorphic process and subprocess types	Great group and subgroup	Series and subseries
Land unit	Landtype (LT)	Secondary lithology	Landforms, element landforms, and morphometry	Subgroups, families, and series	Subseries and plant associations
	Landtype phase (LTP)	Secondary lithology	Landforms, element landforms, and morphometry	Series and phases of series	Plant associations and plant association phases

2.2 Planning and Design

Plan LTA development in advance of forest plan revisions or other broad-scale assessments.

LTAs are developed using an integrated top-down/bottom-up approach. Top-down refers to subdividing subsections into LTAs using available resource maps, remote sensing, and expert knowledge. Resource maps may include geologic, soils, vegetation, and shaded relief. Bottom-up refers to aggregating LTs into LTAs based on common attributes and ecological interactions. Both methods are acceptable, and both should be used to verify the LTAs are scientifically sound. For example, if LTAs were delineated top-down, use bottom-up information from LTs to verify the larger scale units are coherent. Similarly, bottom-up aggregation of LTs must be rigorously checked to ensure the attributes are described at landscape scale, and are not simply a list of fine-scale unit attributes.

Table 2.2. *Required and recommended attributes (elements) to describe landtype association map units.*

Required	Example	Recommended	Example
Map unit code	M221Aa01	Local climate	See below[1]
Map unit long name	North Fork Mountain/River Knobs	Elevation range	1,000 ft to 2,500 ft above sea level
Bedrock geology: primary	Sedimentary	Geomorphology: landform	Anticline
Bedrock geology: secondary	Sandstone/shales	Disturbance regime(s)	See below[2]
Bedrock geologic age	Ordivician (sandstone) Silurian (shales)	Aquatic systems and types	Few intermittent streams
Surficial geology: primary	Unconsolidated	Drainage density patterns	Low density, trellis pattern
Surficial geology: secondary	Colluvium/residuum	Geologic formation	Braillier, Pocono, others
Surficial geology: origin	Sandstone/shale		
Geomorphology: geomorphic process	Tectonic		
Geomorphology: geomorphic subprocess	Folding		
Soil	Lehew-Dekalb-Hazleton complex		
Potential natural vegetation	Mixed oaks vegetation zone		

[1]*Annual precipitation: 30 inches. Mean temperature April through September: 64.0º F. Mean temperature October through March: 38.6º F.*
[2]*Historic 10-year average fire return interval (frequent low-intensity). Largely removed with fire suppression over past 70 years. Gypsy moth current disturbance; hemlock wooly adelgid entering area.*

Top-down maps should be field verified to check LTA composition. Transects across the landscape, organized in a stratified random design, may be most effective. LTAs assembled from LTs should be rigorously reviewed to ensure they reflect processes and composition at LTA scale, and that the interrelationships of the LTs are understood. Remember to stay true to the processes and composition at landscape scale. LTAs are not simply the aggregation of finer scale units. LTs may be grouped in different ways, but only cohesive LTAs are consistent with landscape scale and processes.

2.2.1 Map Unit Design

At landscape scale, LTA map units are broad, ranging from 1,000 to hundreds of thousands of acres. Ecological types apply as they do at LT scale. Map units can therefore be made up of components of ecological types. Bear in mind, however, that these types must be made up of taxonomic units appropriate for the scale. For example, the potential vegetation attribute of the ecological type at this scale should be described at series or subseries scale—not plant association scale. Because LTAs are landscape units, the map polygons will repeat less often (or not at all) when compared with LT scale.

2.2.2 Standards

- Mapping scale is 1:100,000. Use top-down, bottom-up identification team approach and map unit design criteria in National Hierarchy (Cleland et al. 1997).
- Map unit size ranges from 1,000 to hundreds of thousands of acres.
- Attribute standards are detailed in tables 2.1 and 2.2.
- LTA are correlated within subregions and peer reviewed.

Naming Landtype Associations

No national standards are set for naming LTAs. Geomorphology, however, is often the major driver in delineating an LTA; thus, broad landforms are typically used in the name.

2.2.3 Map Unit Legend

The LTA map unit legend consists of a map unit symbol and a map unit name. LTAs are designated using codes that incorporate the section and subsection of the LTA, as well as a two-digit numeric code for the LTA. For example, the M221Aa01 code denotes the Ridge and Valley section (M221A), Northern Ridge and Valley subsection (a), and North Fork Mountain LTA (01).

Using such mnemonic devices makes the codes more easily recognizable. One drawback is that concatenating information from different hierarchy levels can make analyzing the data more difficult—consider sorting the data by subsection, for example, when the subsection codes are embedded—but generally relatively few LTAs exist per national forest, so the problem is not burdensome.

Valid Values and Codes for Terrestrial Ecological Unit Inventory Elements

It is useful to develop a list of valid values and codes for each inventory area that reflects the range available for each of the landscape elements for that area. These lists are developed based on the best available information and knowledge of the inventory area. They are updated throughout the life of the inventory based on additional knowledge gained through the inventory process. Use appropriate levels of classification listed in table 2.1 as guidelines for each element.

2.2.4 Delineation Criteria for Landtype Association Map Units

Delineation of ecological map units is not always a straightforward process. The delineation process attempts to create meaningful ecological units and break these units where ecological changes occur on the landscape. Fortunately, dependency among landscape elements allows the mapper to delineate significant changes in unseen elements such as potential natural vegetation (PNV) and soils using proxy indicators such as existing vegetation, morphometry, surficial geology, local climate, and landforms. In any case, the interrelationships between these indicators must be thought out and defensible.

To consistently delineate ecologic map units, the criteria for delineations must be easily observable at the level of mapping. For instance, at the LTA level it would unfeasible to use individual soil bodies and PNV as delineation criteria because these elements are not observable at that scale. Instead, more readily available landscape elements such as bedrock geology and vegetation cover types reflecting regional climate would be more appropriate.

LTAs are delineated primarily on the boundaries between broad geomorphic units. Use a combination of tools (bedrock and surficial geology maps, raised relief maps, remote sensing imagery) to discern boundaries between mountains, glacial features, or other geomorphology. A team with geologic, ecological, and soils expertise can quickly draft lines on U.S. Geological Survey (USGS) 1:100,000 topographic maps. Another option is to use the Terrestrial Ecological Unit Inventory (TEUI) Toolkit—a computer package of GIS and other analysis tools—to build the draft LTAs.

Following the initial draft, subsequent review teams from other national forests, other agencies, and academia can improve the maps and make them more consistent with the delineation factors. Avoid splitting out inclusions and small areas of special interest. These should only be delineated at LT or landtype phase (LTP) level.

Observable delineation criteria enable land managers and users of the TEUI to more readily recognize ecological units during land management activities. If the user is unable to distinguish where ecological units diverge, a misinterpretation of the landscape capabilities and management may occur.

Actual line placement criteria (or delineation criteria) are often along areas that show significant change within a single landscape element, such as the change in the slope gradient in a mountain base or footslope position. These delineation criteria will often change, as the landscapes they differentiate change.

The specific delineation criteria must be selected with the goal of creating consistently repeating map units that have distinct capability ratings or management interpretations.

2.3 Mapping Landtype Associations

The following procedures are guidelines that apply to mapping LTAs. Usually, LTA delineation is based on broad geology and/or geomorphology, with climatic, soils, and vegetation effects in a supporting role. For example, a mountain may be used to define the boundary of an LTA, but its highest elevations split out as another LTA because of a distinct change in temperatures and a related striking change in vegetation. A distinct band of different geology/soils would be another reason for splitting out a different LTA on the mountain.

Design criteria should include construction of ecological types in accordance with this document. Ecological types at the landscape scale will of course be broader in nature than at land unit-scale and associated landscape elements are classified at higher (broader) levels (see table 2.1 for recommended levels of classification).

2.3.1 LTA Mapping Process

1. Conduct preliminary field reconnaissance.

    a. Use field visits and overflights of the area to gain a better understanding of the landscape and distribution of ecological types within the inventory area.

    b. Use the TEUI Geospatial Toolkit (USDA Forest Service 2005) to review "virtual flybys," shaded relief models, distribution of vegetation, landforms, aspect, slope, and elevation gradients to better understand the landscape.

2. Create preliminary polygons.

    a. Use 1:100,000 aerial photography, topographic maps, digital elevation models, digital orthophoto quadrangles (DOQs), satellite imagery, and other resource maps as appropriate to delineate preliminary polygons. Employ an interdisciplinary team with geology, ecology, and soils expertise. At this stage, geologic input will probably be the most important.

    b. Use the TEUI Geospatial Toolkit or similar technology to delineate preliminary map polygons. Use the DOQ image as a base while using multiple windows to compare delineations to other resource maps such as satellite imagery, shaded relief, and 3-D views with appropriate themes draped over the base (USDA Forest Service 2005).

c. Base delineation on sound photo interpretive principles using all observable features, as well as the specific criteria and class limits defined in the classification and/or descriptive legends for each of the landscape elements.

d. Develop map-unit concepts by organizing and grouping LT map units with similar combinations of map-unit characteristics such as landforms, vegetation, geology, slope, and elevation ranges. Geomorphology is likely to be the primary driving factor in delineating LTA map units. Describe what makes a map unit different than those surrounding it or the map unit significance.

e. Use observable properties on aerial photography or other imagery when delineating map units.

f. Use caution when relying on visible existing vegetation from aerial photographs or as satellite imagery, as it may not represent PNV. Knowing the disturbance history will help locate areas where potential vegetation and existing vegetation may differ.

3. Develop preliminary map unit legend**.**

   a. Develop a connotative legend using the procedures described in section 3.2.2, "Connotative Legends."

   b. Label polygons on photos, Mylars, and/or the coverage being created using the digitizing method in the TEUI Geospatial Toolkit.

4. Review or develop new classifications as appropriate.

   a. If PNV and geologic information are lacking in some areas, perform limited fieldwork to develop preliminary landscape element classifications and legends.

   b. Use summaries of existing LT to develop ecological classifications or identify LT and their associated patterns using a field sampling process. See 2.3.1 Part 6.

5. Incorporate existing information.

   a. If existing LTs are available, aggregate these to form LTAs. This can be done with GIS, if available, or used to guide delineation of the LTA boundaries, if done by hand.

   b. Use other maps such as geology maps, State Soil Geographic Database soil maps, vegetation maps, shaded-relief maps, and other mapped data to visualize and delineate LTAs.

6. Conduct field sampling.

   a. If existing LTs are not available, verify LTA maps by sampling field data. A systematic sampling method employing transects across the landscape will be most efficient. A lower sample density than for corresponding land-unit mapping should be used for this step. For LTA verification purposes, intensive data are not critical. Transects to document changes in slope, landform, geology, soil subgroups, and vegetation series will typically be adequate.

   b. Ensure data is adequate for correlation of LTA within subregions, and correlation of ET within LTA if a bottom-up process is used.

7. Perform quality control.

   a. Perform quality control checks on mapping, documentation, sampling procedures, and the accuracy and precision of estimates. Design the checks into the work plan development process, and perform them progressively during the mapping and classification process. Quality control checks range from scheduled field reviews to daily assists. The mapping team's primary responsibility is to ensure the application of quality control.

   b. Ensure that LTA meet minimum documentation standards. Correlate LTA within subregions and patterns of LT within LTA.

8. Enter Data.

   a. Progressively enter data into the Natural Resource Information System (NRIS) Terra database. Additional regional tables may be needed to ensure more localized interpretations needs are satisfied.

   b. Minimum data include GISDD requirements and those in table 2.2.

9. Document map units.

   a. Develop block diagrams depicting pattern or associate of map units concepts.

   b. Collect photographs to catalog and document landscapes, vegetations, soils, and geology.

   c. Provide statements of significance (i.e., those characteristics that distinguish the observed LTA from surrounding LTAs).

10. Finalize mapping and classifications.

   a. Finalize legend.

   b. Finalize mapping.

      i. Match adjacent LTA mapping. The completed LTA maps should be joined to adjacent survey areas. A quality join must be maintained along the inventory boundary. Accomplishing a quality join requires that the map-unit delineations, attributes, and interpretations match across the boundary.

      ii. Compile mapping to a stable base. Compilation methods will vary according to specific mapping techniques used on an inventory. Typically, lines are transferred and registered to a stable-based Mylar, and scanned or digitized into the GIS environment. Alternatively, if onscreen digitizing is used to develop, maintain, or adjust mapping products, this step may not be required.

      iii. Scan or digitize mapping. All mapping layers should be prepared for scanning or digitizing according to national cartographic standards. It is also useful to code LTs with LTA identifiers so LTA maps can also displayed at 1:24,000 scale. This step will greatly facilitate analysis for planning purposes.

   c. Finalize any taxonomic classification developments including PNV and ecological type classifications.

11. Finalize descriptions for map units and ecological types.

   a. Distribute draft map and documentation for peer review. Peer review among national forests and partners within your region or subregion is particularly valuable.

   b. Map unit descriptions must meet standards outlined in table 2.1 and table 2.2, GIDD standards, and contain a statement of significance.

12. Develop interpretations.

   a. Develop interpretations for the map unit component and/or landtype association.

   b. Management implications are an important part of this work, and indeed, are the end objective of all ecological unit mapping. Implications are tailored to the needs of the local area, and can include the following information:

- Relative value of biodiversity, as measured by plant or animal species richness, diversity of plant community and patch types (beta diversity), etc.
- Suitability for silvicultural prescriptions, reforestation, methods, etc.
- Prescribed and wildfire implications.
- Habitat for species of management interest.
- Ecosystem productivity, both terrestrial and aquatic.
- Historic range of variation, and what the LTA will likely look like in the future without treatment.
- Susceptibility to acid rain, ozone, etc.
- Susceptibility to insects and diseases.
- Soil erosion and compaction.
- Mass wasting and other geologic hazards.

13. Prepare manuscript.

    Written documentation for LTAs should be organized by national forest, subregion (group of forests), or by region. Document should include objectives, definition of an LTA and explanation of the hierarchy of ecological units, methods used to delineate and attribute LTAs, description for each LTA using table 2.1 as a guide, management implications, and literature cited. See 11.b. for additional instruction on map unit descriptions.

2.3.2 Logistics

Facility and Equipment Needs

Base Maps

USGS topographic maps at 1:100,000 scale are considered the desired publication scale map for LTAs. This map is usually used for forestwide planning efforts.

Aerial Photography

Aerial photography may be used as a base map as well as for field reference. For LTAs, using photography at scales ranging from 1:60,000 to 1:100,000 is generally recommended.

Common types of aerial photography include natural color, infrared, and large format. Using stereo pairs to view landscapes in three dimensions can aid in interpreting landscape elements.

The Aerial Photography Field Office (APFO), Farm Service Agency, is the primary source of aerial imagery for the U.S. Department of Agriculture. More than 10 million images are stored in the APFO library, dating from 1955 through the present. For more information, visit http://www.apfo.usda.gov.

The National High Altitude Photography program, initiated in 1980, was coordinated by the USGS to acquire aerial photography of the 48 conterminous States every 5 years. Visit http://edc.usgs.gov/Webglis/glisbin/guide.pl/glis/hyper/guide/napp.

Digital Orthophoto Quadrangles

A DOQ is a digital representation of an aerial photograph with ground features located in their true positions. Displacements in imagery caused by camera tilt, sensor orientation, and terrain relief are removed. DOQs combine the image characteristics of a photograph with the accuracy and scale associated with a map. Though they cannot be used for stereo interpretation, they are an excellent digital base map for onscreen digitizing or review of registration. For more information about DOQs, visit http://fsweb.gsc.wo.fs.fed.us/.

Digital Elevation Models

A digital elevation model is a digital data file containing an array of elevation information over a portion of the Earth's surface. This array is developed using information extracted from digitized elevation contours from primary base series maps. For more information, visit http://fsweb.gsc.wo.fs.fed.us/.

Satellite Imagery

The USGS National Center for Earth Resources Observation and Science at http://edcwww.cr.usgs.gov/ provides a variety of satellite imagery.

The Remote Sensing Application Center (RSAC) at http://fsweb.rsac.fs.fed.us/ is a detached Washington Office Engineering Staff unit located in Salt Lake City, UT. The mission of RSAC is to provide technical support to U.S. Department of Agriculture (USDA) Forest Service resource specialists and managers in the use of remote sensing, image processing, GIS, and related geospatial technologies for all resource applications. RSAC is collocated with the USDA Forest Service Geospatial Service and Technology Center and the USDA APFO.

Hardware and Software Requirements

Field offices should have the most recent corporate hardware and software upgrades, including requirements for NRIS Terra and the TEUI Geospatial Toolkit.

Field Equipment

Appendix H provides a complete list of equipment and sources.

2.3.3 Personnel Requirements

TEUI Team Expertise and Makeup

The LTA development core team should consist of personnel with expertise in geology, soils, and ecology. The core team should be kept small, with no more than three or four personnel. Other personnel have an important role in reviewing and refining the products. Typically, ad hoc USDA Forest Service review teams, as well as interagency and academic reviewers, are involved.

Training and Qualifications

Competent geologists, soil scientists, and ecologists should already have the basic skills to build LTA map units and descriptions. Training in the TEUI Geospatial Toolkit is certainly called for. The core team should make themselves fully familiar with existing relevant literature, data, and maps.

Job Descriptions

Examples of job descriptions are available in appendix I.

2.4 Data Collection

LTA data collection is much less intensive than for development of LTs or LTPs. LTAs can be described by a panel of experts, drawing on existing maps, imagery, publications, experience, and appropriate landscape data or existing LT data can be summarized or reclassified for use at the landscape scale.

Data collection can also be used to predict or identify LTs and their occurence within potential LTA. Landscape transects are commonly used for this purpose.

2.5 Data Storage

LTA data will typically take the form of attribute tables (such as table 2.2), GIS coverages, and written documentation. Quantitative data are typically summarized from finer scale field data. All LTA data will be stored in the NRIS Terra database. See 2.3.11 part 11b. for additional instructions.

2.6 Analysis

Analysis takes the form of expert teams working with existing maps, data, and publications. Rigorous classification of vegetation or soils usually takes place at finer (LT) scale, and then taxonomic units are aggregated (appropriately) to form units appropriate for LTA scale. For example, for potential vegetation, plant associations can be classified from field plot data, and then these taxa are aggregated and reclassified into new taxa appropriate for use at LTA scale.

2.7 Reporting

See section 2.31, item 13 above. Documentation should at a minimum have rigorous peer review, and ideally be published as a research station general technical report.

Chapter 3. Landtype Protocol

3.1 Objective

The objective of this protocol is to identify the standards and guildelines for developing terrestrial ecological units (TEUs) at the landtype (LT) level of the National Hierarchy. TEUs are areas of relatively stable environments that depict the inherent properties of their ecosystem elements. TEUs are not static, however, and may be refined and updated as knowledge about the ecosystems they capture is accrued. When used in conjunction with information on existing conditions, historical conditions, and ecological processes, TEUs provide a foundation for making sustainable land management decisions.

Ecological units represent consistently repeating portions of landscapes with similar combinations of ecological types. These ecological types represent the distinguishing characteristics of a particular geographic area. Ecological units identify interrelationships among ecological types and establish a tie between observed ecological condition and predicted environmental response. Table 1.1 provides a summary of the Terrestrial Ecological Unit Inventory (TEUI) elements. Detailed descriptions of each element are provided in chapter 1.

3.1.1 Business Requirements

LT and landtype phase (LTP) maps are used for comprehensive forest plan revisions, watershed assessments, burned area emergency rehabilitation efforts, wildlife habitat analysis, and project level implementation and analysis. Interpretations developed from the data are valuable for depicting land capability and potentials.

3.1.2 Products

The LT product is a Geographic Information System (GIS) map layer, developed at a 1:24,000 map scale, which meets all U.S. Department of Agriculture (USDA) Forest Service guidelines for TEUs and is registered to the primary base series maps. TEUI core attribute data are available in the corporate Natural Resource Information System (NRIS) Terra database, and map unit descriptions and ecological type descriptions are documented to the standards described in this technical guide.

3.2 Planning and Design

3.2.1 Ecological Type Classification and Characterization

An ecological type is a category of land with a unique combination of landscape elements. The elements making up an ecological type are climate, geology, geomorphology, soils, and potential natural community. Ecological types differ from other ecological types in the ability to produce vegetation and respond to management and natural disturbances. Classification of ecological types is used to validate landscape stratifications, assist in map unit design and delineation, and describe map unit components.

Classification of Ecological Types

The classification process organizes and describes relationships between the inherent landscape elements. Preliminary or established ecological types are used to design and assist in the delineation of ecological units. Table 3.1 shows the suggested levels of detail for each element.

Table 3.1. *Suggested level of detail used for classification and mapping at the landscape and land-unit scales.*

Planning and analysis scale	Ecological unit levels	Geology	Geomorphology	Soil	Potential natural vegetation
Landscape	Landtype association (LTA)	Primary lithology or groups of secondary	Geomorphic process and subprocess types	Great group and subgroup	Series and subseries
Land unit	Landtype (LT)	Secondary lithology	Landforms, element landforms, and morphometry	Subgroups, families, and series	Subseries and plant associations
	Landtype phase (LTP)	Secondary lithology	Landforms, element landforms, and morphometry	Series and phases of series	Plant associations and plant association phases

Differentiation Between Ecological Types

At the landtype association (LTA) level, ecological types are driven by geomorphology, but strongly influenced by bedrock geology, parent material, soil subgroups, vegetation series, and climatic effects induced by elevation, growing degree days, or precipitation. Synthesis of data will rely more on existing information and expert panels than at the land-unit scale.

At the LT and LTP levels, ecological types are classified based on differences in potential natural vegetation (PNV), soils, local climate or microclimate, geomorphology, surficial geology, bedrock geology, and/or hydrology. Ecological type classification requires analysis and description of relationships among these elements. This work requires simultaneous analysis of these elements based on integrated plots, transect observation sites, and bedrock geology data.

Statistical analysis is appropriate where sampling is conducted in a random or systematic manner and a large enough sample of the population is present to capture the variability in the landscape elements. Pattern analysis is suitable for all sampling designs. Pattern analysis methods include gradient analysis, ordination, and classification. Gradient analysis is used to determine the distribution of plant species and soil properties along easily recognized environmental gradients such as elevation and topographic moisture status. Ordination methods are used to detect less obvious relationships among landscape elements.

Naming Ecological Types

Ecological types are named using a minimum of a two-part soil and plant community name. Use soil series name, family name, or classes of soil taxonomy with or without accompanying terms to name the soil portion. Incorporate geologic, geomorphic, and/or landform names, if changes in them constitute differentia among the ecological types. Use the level of soil taxonomy (series, family, or higher category) that is needed to meet the objectives of the survey. Name the plant community portion according to potential natural community (USDA NRCS 2003). Some examples of names are displayed in table 3.2.

Table 3.2. *Examples of ecological type names.*

Code	Short Name (optional)	Long Name (required)
ET022	ABLA/VASC, Guiser family	Subalpine fir/grouse whortleberry, Guiser family
554.1		Lithic Haplustalfs, shallow LSM Pipos/ Loamy-skeletal, very cobbly 5 Quar mixed, mesic, sandy loam 0 ----
ET3001	Prime Giant Sequoia	Giant Sequoia, Holland soils, Granitic, gently sloped, fluvial process dominated
5	Dry Pine	Pinus/Vaccinium, excessively drained sands

Classes of soil taxonomy with or without accompanying phase terms are used to name the soil portion. Incorporation of geologic, geomorphic, and/or landform names is generally encouraged. Use the categorical level of soil taxonomy (series, family, or higher category) that is intended to meet the objectives of the survey. The vegetation portion is also named at the appropriate level for the objectives of the survey and level of documentation. Examples of map unit codes and names are shown in table 3.4.

Ecological Map Unit Design Criteria

Ecological map units are designed to represent the naturally repeating patterns of ecological types across the landscape. The map unit organizes these patterns and describes the interrelationships between the components that occur together in a continuum across the landscape. Be aware that map unit concepts often grade into one another and are not always distinct.

Map Unit Composition

Map units are typically composed of one or more ecological types or components. Ecological types are the taxonomic unit for which the map unit component is named. Ecological types may occur in one or more map units and their properties are derived from wherever that type occurs. The map unit component may also represent a narrower range of characteristics or properties of an ecological type because they are based on that part of the ecological type that occurs spatially within a specific map unit.

Map Unit Kind

TEUI incorporates the concept of "map unit kind" from traditional soil survey methods to help describe the relationships between map unit components. Map units are divided into four categories: (1) consociations, (2) complexes, (3) associations, and (4) undifferentiated groups (USDA NRCS 2003).

Consociations are map units in which one named component is predominant. These units are typical of uniform areas where one ecological type is dominant and can be delineated separately at the LT and LTP level of mapping.

Complexes and associations are map units in which two or more major components occur in regularly repeating patterns. In a complex, the major components cannot be separated at the scale of mapping. In an association, the major components can be separated (USDA NRCS 2003b).

Undifferentiated groups are used when the components are not consistently associated geographically and, therefore, do not always occur together in the same map delineation. These components are included in the same named map unit because their use and management are the same or very similar for common uses.

Major and Minor Components

Map units are composed of one or more major and minor components. Major components typically comprise 15 percent or more of the map unit. Minor components (inclusions) typically comprise less than 15 percent of the map unit. A minor component in one map unit may be a major component in another. Both major and minor components are used to develop the range in characteristics for the ecological type for which a component is named.

3.2.2 Standards

Mapping Standards

- Mapping scale for LTs is 1:24,000 and LTPs at 1:12,000. Use top-down, bottom-up interdisciplinary team approach (Cleland et al. 1997).

- Recommended minimum size delineations are 2 acres for LTPs and 6 acres for LTs.
- Minimum width is 2 mm or 160 feet on the ground at a 1:24,000 mapping scale.
- Linear features such as riparian or wetland areas less than 2 mm wide or less than 6 acres that encompass a stream may be mapped at the 1:24,000 scale as a TEU line segment or mapped as point features and indicated with the appropriate spot symbol.
- LT and LTP are correlated within LTA.

Documentation Standards

Document reliability of map unit characteristics through a systematic data collection process using transects, traverses, and observations. Determine documentation needs based on sampling intensity, level of taxonomic classification, standards requirements, and ecological type variability. Table 3.3 describes minimum levels of documentation. Design of the map units should be consistent with order of sampling intensity as described in the work plan. Table 3.5 describes sampling intensity levels.

Refer to NSSH Part 627.08 for documentation standards for soils in order to meet NCSS statements. A soil map is not required. However, a TEUI map is required in place of a soil map.

Table 3.3. *Minimum levels of documentation for landtypes.*

Landtypes Ecological type	Components	Map units
A minimum of three complete integrated plots that represent the concept of the ecological type in the survey area are recorded before an ecological type is added to the descriptive legend. Completed documentation must reflect the geographic and environmental range across which the ecological type is mapped. Representative sites for each ecological type are identified.	A minimum of three complete integrated plots that represent the concept of the component in the map unit are needed. Completed documentation must reflect the geographic and environmental range of the map unit. Integrated plots may be used from transects or traverses within the named map units.	A minimum of three transects with a minimum of 30 sample sites (integrated plots and/or observations) across geographic and environmental range of each map unit are recorded. Completed documentation must reflect the geographic and environmental range of the map unit. Each map unit component must have a complete ecological type description.

Naming Ecological Units

Name ecological units for one or more ecological types or for something that distinguishes and provides a brief description of that unit. Numbers or other brief descriptors may be used for complex units that prove difficult to name. Map unit descriptions must include the full technical names for each element used to characterize the ecological unit. Table 3.4 gives examples of ecological unit names.

Table 3.4. *Examples of ecological unit names for landtypes.*

Map symbol	Map unit name
2641	ABLA-PIEN/VASC, Ivywild Family—ABLA/VASC, Hensen Family—complex, 10–30-percent slopes
554	Lithic Haplustalfs, LSM, 5, 0, loamy-skeletal, mixed, mesic, shallow, very cobbly sandy loam, Pipos/Quar—Lithic Eutroboralfs, LSC, 5, 0, loamy-skeletal, mixed, shallow, very cobbly sandy loam, Pipos/Quga association: 15- to 40-percent slopes
3001	Giant Sequoia, Holland soils, Granitic, gently sloped, fluvial process dominated
5	Fire-dependent, multiple-aged, somewhat brushy, jack/red pine forests of somewhat excessively or well drained sandy/gravelly soils, flat to strongly rolling habitats
30SH123	PIPO/QUGA-Burnac—FETH-Acree complex on lower montane shale hills, 15- to 30-percent slopes
3622	Sedimentary Sideslopes, Big Sagebrush—Tall Forb Complex

Table 3.5. *Sampling intensity levels.*

Level of national hierarchy	Sampling intensity	Field procedures	Kinds of map units	Scales for field mapping
Landtype Phase	Sampling intensity 1—Intensive (i.e., watershed and landscape analysis, burned area rehabilitation analysis, forest and grassland project planning, species habitat modeling).	Collect data and document (integrated plots and/or observation sample sites) 90 percent of polygons for each map unit.	Consociations	1:12,000
Landtype	Sampling intensity 2—Intensive (i.e., watershed and landscape analysis, burned area rehabilitation analysis, forest and some broad scale project planning).	Collect data and document (integrated plots and/or observation sample sites) 75 percent of polygons for each map unit.	Mostly consociations and some complexes	1:24,000
Landtype	Sampling intensity 3—Extensive (i.e., forest planning and broad scale assessment, watershed and landscape assessment).	Collect data and document (integrated plots and/or observation sample sites) 50 percent of polygons for each map unit. LTs are delineated by observation and interpretation of remotely sensed data.	Mostly associations or complexes, and some consociations	1:24,000

Table 3.5. *Sampling intensity levels (continued).*

Level of national hierarchy	Sampling intensity	Field procedures	Kinds of map units	Scales for field mapping
Landtype	Sampling intensity 4—Extensive (i.e., general ecological type information for broad statements concerning land-use potential and general land management).	Collect data and document (integrated plots and/or observation sample sites) 25 percent of polygons for each map unit. LTs are delineated by interpretation of remotely sensed data.	Mostly associations; some complexes and consociations	1:24,000
Landtype association	Use existing information and expert panel.	Verify through existing landtypes or transects with intensity similar to sampling intensity 4 above.	Varies but must be at landscape scale	1:100,000

TEU Map Unit Legend

The TEU map unit legend consists of a map unit symbol and a map unit name.

Connotative Legends

Connotative legends may be used to display differentiating information in the map unit symbol. Connotative legends may be used at any level in the National Hierarchy. In this example of a connotative legend, the map unit symbol is connotative of climate zones and lithology in the survey's ecological section. For this survey area, eight distinct climate zones are defined by soil moisture and temperature; broad vegetation type (e.g., pinyon juniper, ponderosa pine, mixed conifer, spruce fir, and alpine); and associated environmental conditions such as precipitation, snowfall, and elevation. Lithology is denoted using either the primary or secondary lithology classes. Figure 3.1 provides an example of a connotative legend.

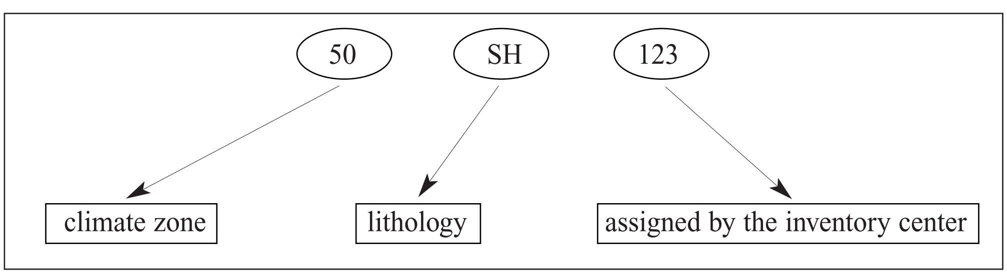

Figure 3.1. *Example of connotative legend.*

The map unit code is the final code applied to a TEU map unit. It is the key field between the database and the TEU GIS map coverage, provides a shorthand reference for map units, and can be used as a tool to query particular information about map units. It also allows the mapper easy recognition and recall of map unit concepts. The map unit code is used in the mapping process to designate polygons on aerial photographs or quad sheets. Other landscape elements may be substituted in the above example as appropriate.

The TEU map unit code should be connotative (where possible), simple, and meaningful for grouping and sorting TEUs by the main differentiating criteria for the survey area. Following these objectives has proved useful for developing LTAs.

Lists of Valid Values and Codes for TEUI Elements

It is useful to develop a list of valid values and codes for each inventory area, reflecting the range available for each of the TEUI elements for that area. These lists are developed based on the best available information and knowledge of the inventory area. Update them throughout the life of the inventory based on additional knowledge gained through the inventory process. All lists use national definitions and codes. Use appropriate levels of classification listed in table 2.1 as guidelines for each element.

Description of TEUI Map Units

The TEUI map unit description is a summary of information about a map unit throughout its area of occurrence. A map unit description contains information about the composition, distribution, and extent of ecological types as well as the relationships between components. Additional map unit descriptors such as elevation, aspect, slope, mean annual precipitation, frost-free days, and average annual snowfall are also included.

The data necessary to develop a map unit description are generated from information gathered in the field (see appendixes C, D, and E), information gathered electronically (e.g., range in elevation for a map unit using a digital elevation model [DEM]), and information from existing data sources such as soil surveys. Examples of ecological map unit descriptions can be found in appendix F.

Mapping Ecological Units

Mapping begins after the development of preliminary map unit concepts. The landscape is stratified into map units according to established ecological type criteria. The objective is to minimize and characterize the variability within an ecological unit while placing the boundaries where significant changes occur within one or more elements.

Delineation Criteria

Delineation of ecological map units is not always a straightforward process. The delineation process attempts to create meaningful ecological units, and break these units where changes occur on the landscape. Fortunately, dependency among landscape elements allows the mapper to delineate significant changes in unseen elements such as PNV and soils through proxy indicators such as morphometry, surficial geology, local climate, and landforms.

To consistently delineate ecologic map units, the criteria for delineations must be easily observable at the scale of mapping. For instance, at the LTA scale (1:100,000) it would unfeasible to use individual soil bodies and PNV as delineation criteria because these elements are not observable at that scale. Instead, more readily available landscape elements such as bedrock geology and vegetation cover types reflecting regional climate would be more appropriate.

Unless all areas of a TEUI are to be field checked, the use of unseen elements such as soils and PNV as delineation criteria will introduce error into the mapping process. Even at sampling intensity 1, in which 90 percent of the polygons are visited, errors will be introduced if these criteria are used to delineate polygons. Instead, the use of readily observable features such as landform, slope morphometry, and local climate would be more appropriate.

The use of observable delineation criteria allows land managers and users of TEUI to more readily recognize ecological units during land management activities. If the user is unable to distinguish where ecological units diverge, then a misinterpretation of the landscape capabilities and management may occur.

Actual line placement criteria (or delineation criteria) are often along areas that show significant change within a single landscape element, such as the change in the slope gradient in a mountain base or footslope position. These delineation criteria will often change as the landscape that they are differentiating changes.

For example, while delineating a polygon of pure quaking aspen, the boundary may be delineated along the vegetative cover change (aspen to sagebrush) segments, along landform positions (backslope to footslope) for other segments, or along aspect changes in yet other segments.

The specific delineation criteria must be selected with the goal of creating consistently repeating map units with one or more components that have distinct capability ratings or management interpretations.

TEUI Attributes Linked to Aquatic Ecological Unit Line Segments, Valley Segments, or Polygons

Map units and components may be linked to a buffered stream line segment or polygon rather than a TEU polygon. This method may be desirable in describing riparian areas that are significant, but either too narrow (i.e., less than 2 mm) or too small (i.e., less than 6 acres) to map as a TEU. In this case, TEU attributes are assigned to the line segment or polygon (in the case of water bodies) associated with the riparian area being described. This attribution of line segments should be coordinated with the existing aquatic inventory if applicable. For example, a small riparian area along a valley segment may coincide with an aquatic ecological unit inventory line segment. In this case, a quality join should be completed with the aquatic inventory, or map units shared between the inventories.

Mapping Landtypes and Landtype Phases

The following procedures are guidelines that apply to mapping the LT or LTP regardless of whether development of the LT or LTP involves new polygon delineation or modification of existing soil survey polygons. The mapping process is more involved than for LTAs and generally takes 2 to 5 years to complete depending on the size, complexity, mapping intensity, and management objectives of the inventory area.

LT and LTP Mapping Process

1. Conduct preliminary field reconnaissance.

    a. Take field trips and/or overflights of the area to gain a better understanding of the landscape and distribution of ecological types within the survey area.

    b. Use the TEUI Geospatial Toolkit (USDA Forest Service 2005) to review "virtual flybys," shaded relief models, distribution of vegetation, landforms, aspect, slope, and elevation gradients to better understand the landscape.

2. Create preliminary polygons.

    a. Use existing or newly created LTA mapping as a starting point.

    b. Use stereo pairs of 1:24,000 aerial photography, topographic maps, DEMs, digital orthophoto quadrangles (DOQs), satellite imagery, and other resource maps as appropriate to assist in delineating preliminary polygons.

    c. Use the TEUI Geospatial Toolkit (USDA Forest Service 2005) to further help define and delineate preliminary map polygons. Use the DOQ image as a base while using multiple windows to compare delineations as they appear on other resource maps such as satellite imagery, shaded relief, and 3-D-thematic views.

d. Base delineation on photo interpretive principles using all observable features, and specific criteria and class limits defined in the classification and/or descriptive legends for each of the LT elements.

e. Develop a map unit concepts by organizing and grouping polygons with similar combinations of map unit characteristics such as landforms, vegetation, geology, slope, and elevation ranges.

f. Use delineation criteria to capture the location of spatial changes in the LT elements, such as landforms, vegetation, geologic structures, and weak and resistant materials whose properties are most observable on aerial photographs.

g. Clearly indicate which information is speculative and which is evaluated or derived from premap tools (e.g., slope, elevation, aspect).

h. Use caution when relying on visible existing vegetation from aerial photographs or satellite imagery, as it may not represent PNV. Knowing the disturbance history of an area will help locate possible areas where PNV and existing vegetation differ.

3. Develop preliminary map unit legend.

   a. Develop a connotative legend using combinations of the valid values and codes. Indicate if the map unit is provisional, additional, or accepted (USDA NRCS 2003).

   b. Label polygons on photos, Mylars, and/or in the coverage being created using appropriate digitizing methods.

4. Review or develop new classifications as appropriate.

   a. Ensure soil classification is up-to-date (USDA NRCS 2003b). In some areas, a lack of PNV and geologic information may require limited fieldwork to develop preliminary classifications and legends.

5. Incorporate existing soil survey polygons.

   a. Develop a thorough understanding of the existing information to make decisions regarding the modification of polygon delineations. The purpose should be to retain the design of the existing map units where they meet all LT criteria. In this case, a simple crosswalk from the old map unit code to the new may suffice.

b. Because not all existing soil survey map units meet TEUI criteria, understand the difference between modifications that affect the intent of the original map unit design, and those that do not. Many modifications to polygon delineations will not change the intent or design of the original soil survey map units. These modifications will not require additional documentation.

c. If necessary, include some modifications that change the central concepts of the original soil survey map units. In this case, additional documentation and field inventory will be necessary to meet NCSS requirements for soils. See 1.5 Soil Survey Program.

d. Apply the same standards for mapping the LT regardless of whether new or existing polygon delineation is considered. A number of variables are involved with using existing information, making it difficult to describe an exact process for developing the LT legend. Some of these variables include quality and availability of base maps, availability of aerial photos with original delineation, quality of original delineation, quality and availability of supporting documentation, and personal knowledge of the development of existing information.

6. Incorporate water bodies.

   a. Do not delineate water bodies and streams that appear as double lines on the primary base series maps as polygons during LT mapping. These features are incorporated from the core water layer during the map compilation process. Where a water body is completely enclosed by a LT polygon, the water body can be ignored during TEU mapping. Delineate any polygons adjacent to a water body by extending the polygon boundaries to an imaginary intersection in the center of the water body. This boundary will be a temporary misrepresentation of the TEU on the hard copy of the TEU map. The electronic overlaying process will place water boundaries from the water layer onto the TEU map. Water bodies may be delineated on the TEU map with a nonscanable color, if desired. Typically, the water bodies may be imported from cartographic feature files or DOQs.

7. Conduct field sampling.

   a. Select a sampling design commensurate with the inventory objectives and standards requirements. Consider the location of the plots on the landscape. In terms of efficiency, a stratified sampling design is best. Other considerations, however, such as time and cost, must be evaluated. Several sampling methods are summarized below. These may include one or a combination of the following methods:

i. *Representative sampling.* Select representative premap polygons and sample typical locations for modal components. Traversing, a method of collecting representative samples, can verify the occurrence of ecological types within map units, develop additional ecological types, and meet documentation standards. Integrated plots should be located in areas of uniform vegetation and environment (i.e., landform, slope characteristics, soils, surficial geology). This technique is not statistically valid, but is suitable for pattern analysis.

> Note: This method is biased toward the mapper's professional interpretation of what components to sample. It requires experience and local knowledge of what is being mapped. Sites are selected to capture the modal or dominant properties of each ecological unit component. This method is often the most time-effective and cost-efficient sampling design for ecological units.

ii. *Random sampling.* Use random-number table or other method to obtain Universal Transverse Mercator coordinates. Establish rule base for handling access problems, disturbance areas, and other situations requiring design alterations.

> Note: In practice this method will not be used often because of its inefficiency and high cost in time and funding. A random sample could result in samples clustered in one area, particularly if the sample size is low. One drawback of random sampling is the possibility that the sample will not represent the population (Barber 1988).

iii. *Systematic sampling.* Select appropriate grid for size and variability of premapped polygons. Establish rule base for handling access problems, disturbance areas, and other situations that require design alterations.

> Note: This method has the strength of avoiding bias but may have logistical weaknesses (possibly many plots in remote areas) or be biased by the spatial distribution of the landscape where regularly repeating patterns are not adequately sampled. To eliminate bias, check for randomness in the sampling frame (Barber 1988).

iv. *Transect sampling.* Generate transect methods to minimize mapping bias. Establish rule base for handling access problems, disturbance areas, and other situations that alter transect layout. Located randomly within each stratification unit, transects should be oriented to capture the maximum variation in key environmental gradients, usually elevation, soil climate,

climate, soil taxa, or site productivity. Transect observation sample sites may include notes and partial descriptions, but must be done consistently.

Note: Transects offer several benefits. They can be used efficiently to incorporate both observation sample sites and intensive plots, thus accomplishing mapping, inventory, and classification objectives in a single field effort. They can be oriented to capture the maximum variation in environmental gradients (usually elevation, but others such as soil drainage or moisture are possible). They are an efficient way to deploy field crews to capture the maximum amount of useful data per hour expended. Their methodology tests the map unit composition for the identified components. If well organized, they eliminate a field crew's need to look for representative sites (or temptation to avoid undesirable types, such as bramble thickets).

v. *Stratified random design.* A stratified random sample is obtained by forming classes, or strata, from within the inventory area and then selecting a simple sample from each (Barber 1988). Select stratification criteria and apply to the study area. The most common stratification is the ecological map unit component. Within a designated stratification, randomly generate the spatial coordinates for sample location sites. Navigate to the assigned coordinates using Global Positioning System (GPS) technology. Establish a rule base for handling access problems, disturbance areas, and other situations that alter sample design layout.

Note: This design is best suited for inventory areas with less variance or heterogeneity in ecological map unit components. At broader scales, or in highly complex landscapes, the randomness of this procedure may introduce error when the sample size is inadequate to capture the diversity of the landscape. This sample design is most statistically defensible and advantageous when an adequate number of sites are sampled to capture the variation within a given stratification.

8. Select sampling location.

   a. For representative sampling design, select a sampling site that reflects the central concept (i.e., typical condition observed) of the map unit and its components. Care should be taken to avoid micro features or ecotones.

   b. For random sample designs and transects, do not avoid micro features or ecotones.

9. Select an area to test the legends, verify initial delineations, and map unit concepts.

   a. Perform site characterization by collecting data at integrated plot sites and other observations according to established protocols.

   b. Complete mapping of the selected area based on information collected during the field sampling, verification, correlation, and quality control processes.

   c. The steps above are iterative. Extrapolate map unit delineations to areas of high confidence.

      Note: The mapping process and field sampling process may be interactive or may occur independently in stages. Important influencing factors include the time of year of mapping, the experience and training of delineators, and the adequacy and completeness of existing TEUI information. In the beginning, the process is generally more interactive with a small amount of delineation followed by field sampling. This process continues until the mappers are comfortable with their ability to accurately photo interpret and extrapolate map unit concept and component concepts of the TEU. As mapping continues, less field verification will be necessary.

10. Track, refine, and correlate ecological units, components, and type characteristics.

   a. Track documentation amounts by type of observation, update preliminary legend in a timely manner, revise any taxonomic changes, and track all correlation decisions.

   b. Update map units to approved status when all documentation requirements have been met.

   c. Check map unit composition through visual inspection and supplemental transects to verify and refine map unit composition estimates.

   d. Merge or correlate ecological units, components, and ecological types that have similar characteristics, composition, and management interpretations. For example, as new mapping areas are visited in the field, the number of ecological units increases. As they are added, each new unit is progressively checked for significant differences with similar established units. As more map units are added, their properties overlap those of competing units. Correlation maintains significantly different ecological units, while reducing the number of units that have similar management implications, capabilities, and composition.

11. Perform quality control.

    a. Perform quality control checks on mapping, documentation, sampling procedures, and the accuracy and precision of estimates. Ensure TEUI and NCSS standards are met. Design the checks to be carried out during the work plan development process, and progressively during the mapping and classification process. Quality control checks range from scheduled field reviews to daily assists. The mapping team has the primary responsibility of ensuring the application of quality control.

    b. For additional instuction see 3.5.5 Correlation of Ecological Types and Units, 3.5.3 Quality Control and Assurance, and 3.5.4 Quality Control/Assurance Roles and Responsibilities.

12. Enter Data.

    a. Progressively enter data into the NRIS Terra database. Additional regional tables may be needed to ensure more localized interpretations needs are satisfied.

13. Document map units.

    a. Develop block diagrams depicting map unit concepts.

    b. Collect photographs to catalog and document landscapes, vegetations, soils, and geologies.

    c. Assign appropriate classifications.

14. Finalize mapping and classifications.

    a. Finalize legend.

        i. The legend is considered finalized when all mapping is complete, no new map units are to be added, and no changes are going to be made to ecological types or ecological unit components.

    b. Finalize mapping.

        i. Match adjacent LT mapping. The completed LT maps should be joined to adjacent survey areas. A quality join must be maintained along the survey boundary. Accomplishing a quality join requires that the map unit delineations, attributes, and interpretations match across the boundary.

ii. Compile mapping onto a stable base. Compilation methods will vary according to specific mapping techniques used on an inventory. Typically, lines are transferred to stable-based Mylar and scanned or digitized into the GIS environment. Alternatively, if onscreen digitizing and/or digitizing tablets are used to maintain or adjust mapping products, this step may not be required.

iii. Scan or digitize mapping. All mapping layers should be prepared for scanning or digitizing according to national cartographic standards.

c. Finalize any taxonomic classification developments including PNV and ecological type classifications.

15. Finalize descriptions for ecological units and ecological types.

a. The descriptions of all mapping products are considered final when no subsequent changes are to be made during the current mapping effort.

b. Examples of ecological unit and ecological type descriptions are provided in appendix F.

16. Develop interpretations.

a. Interpretations are to be developed for the ecological types, ecological unit components, and the ecological unit as determined during the work plan development process. The most common interpretation is made on the ecological unit component, as it has the least variability, the easiest field recognition, and most meaningful management implications at the given mapping scale.

b. Standard interpretations for soils are provided in the *National Forestry Manual* (USDA NRCS 2000) and the *National Soil Survey Handbook (*USDA NRCS 2003b).

17. Prepare manuscript.

a. An example of a manuscript format is provided in appendix F.

Mapping Alternatives

The following alternatives are suggested approaches for mapping the TEU. Choose an appropriate method following the evaluation of individual survey areas described in table 1.5.

Because each situation will be unique, the following list is a guideline. The best alternative may be one or a combination of the following alternatives and should be selected after discussion with the regional TEUI specialist.

Crosswalk Existing Mapping

Develop a list of soil survey map units and the new ecological map units to which they correspond, taking care that all ecosystem elements are adequately incorporated and described. Begin with existing delineations. Retain those delineations that meet TEUI criteria. Document those delineations that do not meet TEUI criteria or NCSS standards and propose changes to the original mapping, and/or develop a plan to gather supplemental data to meet TEUI documentation requirements.

It may be possible to make the majority of drafting changes onscreen using DEMs, DOQs, a Landsat Thematic Mapper, and other TEUI tools to help identify where changes are obvious on the original soil survey.

Update Existing Mapping

Use photos or remote sensing as a background with the original soil survey or other ecological unit inventory mapping to evaluate delineations for TEUI landscape elements. Make changes to the original mapping as needed on overlays or onscreen. New polygons must be documented and correlated to existing or new map units, ensuring that all data standards are met.

Conduct New Mapping

Follow the procedures outlined in sections 2.3.1 and 3.2.2 to delineate TEUs.

The cost effectiveness and timeliness of theses alternatives should be compared against starting over with a new legend. One recommended method is to randomly select a small area or subset of the inventory area and revise the mapping as needed to meet TEU objectives. Compare the new map to the existing map and evaluate the cost of the revision with the gain of additional information and increase in interpretation accuracy. Determine the cost-benefit relationships of proceeding with the given alternative, and develop the work plan according to the selected alternative.

3.2.3 Existing Information Sources

Base Maps

Primary Base Series Maps

Primary base series maps are large-scale USDA Forest Service maps constructed from U.S. Geological Survey (USGS) topographic quadrangle maps. In addition to the information carried on USGS maps, primary base series maps contain additional USDA Forest Service information such as protracted Public Land Survey System landlines, ownership, USDA

Forest Service route numbers, administrative boundaries, and facilities. For more information, visit http://fsweb.gsc.wo.fs.fed.us/.

Aerial Photography

Aerial photography may be used as a base map as well as for field reference. Common types of aerial photography include natural color, infrared, and large format. Using stereo pairs to view landscapes in three dimensions can help interpret landscape elements.

The Aerial Photography Field Office (APFO), Farm Service Agency, is the primary source of aerial imagery for the U.S. Department of Agriculture. More than 10 million images are stored by the APFO, dating from 1955 through the present. For more information, visit http://www.apfo.usda.gov.

The National High Altitude Photography program, initiated in 1980, is coordinated by the USGS to acquire aerial photography of the 48 conterminous States every 5 years. Visit http://edc.usgs.gov/Webglis/glisbin/guide.pl/glis/hyper/guide/napp.

Digital Orthophoto Quadrangles

A DOQ is a digital representation of an aerial photograph with ground features located in their true positions. Displacements in imagery caused by camera tilt, sensor orientation, and terrain relief are removed. DOQs combine the image characteristics of a photograph with the accuracy and scale associated with a map. Though they cannot be used for stereo interpretation, they are an excellent digital base map for onscreen digitizing or review of registration. For more information about DOQs, visit http://fsweb.gsc.wo.fs.fed.us/.

Digital Elevation Models

A DEM is a digital data file containing an array of elevation information over a portion of the Earth's surface. This array is developed using information extracted from digitized elevation contours from primary base series maps. For more information, visit http://fsweb.gsc.wo.fs.fed.us/.

Satellite Imagery

A variety of satellite imagery is available through the USGS National Center for Earth Resources Observation and Science at http://edcwww.cr.usgs.gov/.

The Remote Sensing Application Center (RSAC) at http://fsweb.rsac.fs.fed.us/ is a detached Washington Office Engineering Staff unit located in Salt Lake City, UT. The mission of RSAC is to provide technical support to USDA Forest Service resource specialists and managers in the use of remote sensing, image processing, GIS, and related geospatial technologies for all resource applications. RSAC is collocated with the USDA Forest Service Geospatial Service and Technology Center and the USDA APFO.

Use of Existing Inventories

TEUI Evaluation Criteria

An existing inventory meets the basic requirements of TEUI at the land unit scale if it meets the following criteria:

- Soils and ecological types have been correlated within subregion and/or major land resource areas.
- The inventory must use integrated plots as the basis for ecological types. Integrated plots are defined in section 3.3.1.
- Plots must be geospatially located on aerial photos or on a GIS point layer documentation of map units.
- Plot data must be available either as hard copy or electronically.
- An ecological type classification must have been developed according to the methods described in "Use of Soil Surveys" below.
- Ecological type and TEU LT documentation must meet standards as defined in table 3.3.
- Sampling intensity needs must be determined according to table 2.5, with intensity levels that meet the needs of the users.
- Map unit components are described as ecological types.
- Soil classification, description, and documentation meet NCSS standards. See 1.5 Soil Survey Program.

Updating Existing Inventories

Additional fieldwork and analysis are often necessary to meet the above requirements. For example, vegetation, geologic, and geomorphic information should be collected to the standards described in this technical guide to supplement soil descriptions and create ecological types. When soil sample site data cannot be spatially located, collection of additional soil data is required. Every effort should be made to supplement existing data at the exact location where they were originally collected.

Use of Soil Surveys

One of the first decisions to be made in mapping the TEUI is the extent to which existing or ongoing soil surveys will be used. Soil surveys must be evaluated according to the following criteria:

1. Do they meet current NCSS standards as described in this technical guide?
2. Do they meet additional TEUI criteria and standards for geology, landform, and PNV as described in this document?
3. Can ecological type classifications be created using the data available to the soil survey?

The evaluation of a soil survey includes an evaluation in two categories: written documentation (map unit and taxonomic unit descriptions) and maps or delineations. A primary consideration is an acceptable correlation between the map unit descriptions and the actual polygon delineations and their supporting data.

The evaluation process requires knowledge of local conditions (or access to someone who can provide this knowledge), a familiarity with photo interpretation and mapping, and an understanding of soil survey maps and information and how they were developed. As a minimum, the regional TEUI coordinator, TEUI project leader, and forest soil scientist should be involved in this review. The regional ecologist and forest ecologist should also be consulted.

Additional Evaluation Criteria

Evaluate each soil survey map unit description to determine the extent to which geology, landform, and PNV elements have been incorporated and described. Select a representative sample of delineations from the soil survey area for comparison with map unit descriptions. Aerial photographs must be used to evaluate delineations for the landform component. Aerial photos with the original mapping are most desirable.

From this observation, establish the adequacy of the map unit description for geology, landform, and PNV, compared to the standards described in this technical guide. Evaluate the accuracy of map unit boundaries and the concept of each mapping unit.

Evaluate polygon size. Polygon size should be appropriate to the guidelines for the TEUI. Polygons that are larger than the size recommended should be evaluated to determine if more detail is needed. Polygons that are smaller than the size recommended, particularly less than 6 acres, should be evaluated to determine if they are already recognized as "included," "other," or "similar" in another map unit, and for consistency and accuracy of delineation.

Consider the following questions:

- Does the map unit description include all TEUI elements? Does enough data exist to create ecological types from the map unit descriptions? Are inclusions adequately described for each map unit? Does the map unit description include the interrelationships among components where they can be determined? Are the scale of mapping and size of polygons consistent with the TEUI? Are riparian areas and wetlands delineated according to the TEUI size criteria?

- For geology: What is the source of the geology information used in the soil survey? Is more detailed or updated information available that was not used in the soil survey? Do the soil survey map units and components adequately describe lithology and/or parent/surficial materials? Are the interrelationships between geology and other landscape elements described?

- For landform: Does the soil survey map unit describe landforms? Can the landforms described be crosswalked to the valid values listed in this technical guide? Do soil survey polygon delineations correlate well with descriptions of landform in the map unit? Do delineations of the same map unit consistently identify the same landforms? Are the landforms listed consistent with their related parent material descriptions? Can landforms be combined or aggregated to meet the inventory's purpose?

- For PNV: Do soil survey map units describe PNV? Are relationships to soils and microsite established where possible? Are the variability and level of description acceptable for TEUI mapping (i.e., information appropriate to scale)? Do polygon delineations correlate well with descriptions of PNV in the map unit? Are there species lists and indications of species composition at site locations?

Use of Riparian Inventories

Evaluate existing riparian inventories to determine whether they meet TEUI polygon delineation criteria. Transfer existing riparian delineations that meet TEUI criteria to either aerial photos or the prepunched, matte Mylar. Either riparian polygons should be correlated with existing TEUs or new map units should be proposed and documented.

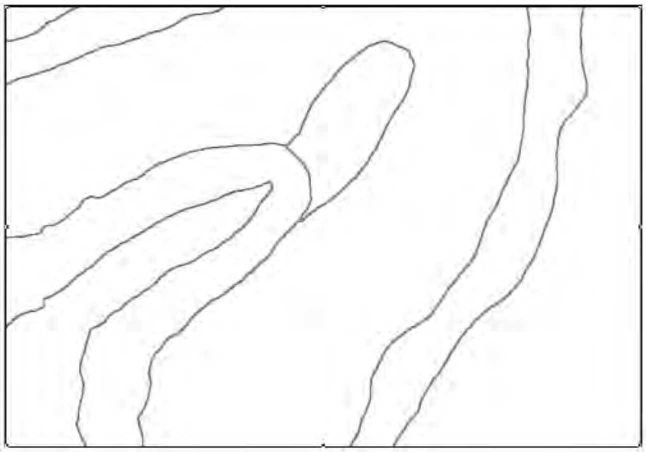

Figure 3.2. *Original soil survey mapping.*

Figure 3.3. *Original soil survey mapping with image in background.*

Figure 3.4. *Black lines represent new delineations meeting TEUI criteria.*

Figure 3.5. *Final TEUI map.*

Incorporation of Valley Segments

Where valley segments have been identified as part of the Aquatic Ecological Inventory, they should be incorporated into TEU mapping.

3.2.4 Work Plans

For LTs and LTAs, execute the following major planning steps:

- Establish memorandum of understanding (MOU) to specify the conduct of TEUI with cooperating agencies. As a minimum, the MOU must address the management and administration of the soils portion of the TEUI and address NCSS standards for classification, description, and documentation.
- Identify primary users of the inventory data. The needs of users affect the design of map units and guide the style of reports.
- Collect and evaluate existing information pertinent to the inventory area, such as previous soil resource inventories, plant community classifications, landform descriptions, and geology legends.
- Determine inventory leadership responsibilities. Verify assignments and clarify understandings between soil scientists, ecologists, and others on the size, purpose, procedures, and products of the inventory. Identify the what, where, who, when, and how to do the job. Document the assignments in the TEUI work plan or the memorandum of understanding.
- Ensure that data collection plans are consistent with the objectives and required standards of the inventory.

- Evaluate adequacy of personnel (time and expertise), equipment, and funding to accomplish the work. Analyze methods (detailers, helicopters, contracting). Clarify management needs for successfully accomplishing the inventory.

- Schedule periodic quality control and assurance reviews.

Work Plans for Inventory Areas

Prepare work plans for all TEUIs. Submit work plans to the regional office for approval/review and incorporation into the region's Inventory and Monitoring Program Plan. In addition to serving as a record of purpose, the work plan provides specifications, participant responsibilities, report plans, and a general work schedule. The work plan also provides the participants with a common understanding of the product to be produced, and guides ecologists, geologists, and soil scientists in organizing and conducting the inventory. The content of a work plan should include the elements described below.

Purpose for Doing the Work

Specify inventory objectives with sufficient detail to support recommended inventory intensity and map unit design. The main objective is to produce a product for current and future resource management and forest planning needs. It must be cost efficient and maintain technical integrity of mapping procedures. Determine specific information requirements by consulting potential users and other specialists, and by reviewing pertinent documents such as the forest plan. Coordinate with other resource specialists to design the inventory to meet multiple needs for information. When survey areas contain large areas of land with different management direction, develop objectives for each area. For example, an area that contains classified wilderness and intensively managed forest will generally require an inventory with two different sampling intensities, map scales, and mapping techniques. The mapping detail should be identified. Use inventory sampling intensity levels as defined in table 2.5.

Description of the Work Area

Describe location, physiography, climate, and vegetation of the inventory area. State the ownership and acreages of lands to be inventoried. Supply a general location map.

Cooperating Agencies and Their Responsibilities

List responsibilities of, and expected contributions from, cooperating agencies, if applicable.

Specifications and Plans

Develop specifications consistent with the objectives of the inventory. Accomplish ecological map unit design and interpretations in an interdisciplinary manner. Identify disciplines and expertise necessary to assist in this effort. Include scientifically defensible methods for data collection needed to describe potential and existing vegetation, soil, topographic features, geology, landform, hydrologic function, and climate information significant for management. Describe classification systems and data analyses to be used for these elements, and procedures for integrating these data into ecological type classifications.

Describe additional needs including map compilation and finishing, word and data processing, and contracting specifications. Identify the final products. Describe manuscript format and content. Identify map scale. Establish timeframes and assign responsibility for manuscript preparation, review, and distribution. Specify plans to consolidate and/or incorporate mapping from other inventory areas to meet management needs.

Special Studies

Work plans should include specifics of special studies conducted to supplement needed survey information. Some examples of special studies may include soil temperature and moisture, management responses, geomorphic studies, botanical sampling, and soil chemical analysis.

Signature Blocks

Include appropriate signature blocks for approving officials.

Memorandum of Understanding

Develop MOUs as appropriate to document the relationships and expectations of agencies involved in TEUI.

Annual Plan of Operation

The annual plan of operation serves as the guide for inventory progress measurements during quality control reviews. It is developed annually as progress brings inventory into new stages of the work plan. Include the amount of work completed and an appraisal of the remaining work. Estimate time required to complete inventory and schedule work for the current fiscal year. Include targeted acres, amount, and kind of supporting data, sampling for lab analysis, interpretation development, a schedule of reviews, plans for report writing and map finishing, and training of personnel and resource managers.

Inventory and Monitoring Program Plan

TEUIs should be incorporated into the region's Inventory and Monitoring Program Plan. The Inventory and Monitoring Program Plan is developed to support assessments, forest plan revisions, and determine program needs. The plan also is used to develop a realistic forecast of national needs and provides a basis for program accountability and funding of inventories.

Note: See section 3.6.2 for further description of the Inventory and Monitoring Program Plan.

3.2.5 Logistics

Schedule

Consider local weather patterns, timing of snowmelt, runoff, and greenup of vegetation when scheduling field activities.

Facility and Equipment Needs

Office Space

Office space for the TEUI crew should be located as close to the survey area as possible and include sufficient room for light tables, desks, and access to Government computers and networks for data acquisition. Ideally the crews will share the same work area to facilitate communication of classification and mapping concepts.

Field Camps

Field camps may need to be located at facilities closer to the sampling areas, including ranger stations, work centers, guard stations, campgrounds, or other government facilites. Sometimes it maybe necessary to set up spike camps to access very remote areas. Accessing such areas may include travel by all-terrain vehicle, by four-wheel-drive vehicle, by boat, on foot, on horseback, or by helicopter. Planning of such trips requires that all crew members have a thorough knowledge of the area including access points, landmarks, trails, and landing zones, and must also take into account safety concerns of backcountry travel. These concerns may include, but are not limited to, steep and rugged topography; weather-related hazards such as lightning, flooding, extreme heat or cold; and the potential for incidents with dangerous animals.

Field Equipment

A complete list of equipment and sources can be found in appendix H.

Hardware and Software Requirements

Field offices should have the most recent corporate hardware and software upgrades including requirements for the NRIS Terra database and the TEUI Geospatial Toolkit.

Personnel Requirements

TEUI Team Expertise and Makeup

TEUI field crews must have expertise in geology, soils, climate, plant taxonomy, and ecology. The TEUI requires expertise in conducting a systematic (cause/effect) evaluation of the relationships among the elements that make up the ecological types. Team members must be able to conduct analyses that integrate those landscape elements into ecological types.

The TEUI team is typically composed of a project leader and crew members with the skills described above. The project leader should have adequate experience conducting TEUI, supervision, and program management. Crewmembers should be specialists in at least one of the above disciplines, but a crew will not always have a specialist representing each field. The TEUI team should also have expertise in GIS and database analysis.

Training and Qualifications

Each team member will have a training and development plan. Suggested training plans and courses are listed in appendix I.

Job Descriptions

Examples of job descriptions are available in appendix I.

3.3 Data Collection

3.3.1 Field Data Collection—Standards and Methods

Integrated Plots

Data must be collected in an integrated manner. Vegetation, soils, landform, surficial geology, and bedrock, where available, must be fully described for every sample site used to establish an ecological type and document a map unit.

At a sample site, a plot should be uniform in environment and vegetation, and large enough to include the normal species composition of the stand. The vegetation must be homogeneous over a large enough area to completely include the sample plot. Obvious ecotones, or sites lacking environmental uniformity, are not suitable for sampling.

The sample site should exhibit minimal effects of historical land use or recent disturbance. Some sites initially targeted for sampling will prove to be unsuitable when examined in the field. Acceptable sample sites include the following criteria:

- Minimum age for the overstory.
- Minimum canopy closure for forested types.
- No evidence of old homesteads, roads, fields, etc.
- Absence of exotics and low abundance of early successional species in the understory.
- Minimal evidence of recent cutting, thinning, underplanting, grazing, or other management-related disturbance.

Required and Optional Fields (Attributes)

Core attributes represent the minimum plot level data required to meet the national TEUI protocol. See 3.3.2 Field Forms and 3.3.3 Integrated Plot Standards for required core attributes or data standards.

Optional attributes are those identified as commonly desired by many regions to facilitate classification and characterization, or to develop interpretations. Optional attributes recognized by the TEUI protocol are included to lend credibility, database support, and standardization of these attributes. Regional TEUI program managers may choose to upgrade certain optional attributes to required attributes (core) for their region.

All core attributes in the national TEUI protocol will be supported in the NRIS Terra database and follow national standards. Support means that data entry and edit forms are provided and applications and reports will be developed to use this information. All optional attributes recognized in the national TEUI protocol can be accommodated in the NRIS Terra database. Data entry screens and database fields can hold this information. Corporate tools, however, will be driven largely by corporate or core data. Data collected at a region's discretion beyond the core and optional attributes listed in this document may not necessarily be accommodated in the NRIS Terra database and might not follow a national standard. Coordinate with regional and national stewards on such matters.

3.3.2 Field Forms

The following TEUI forms organize the elements of TEUI based on theme:

- **General Site Data Form.** Data recorded on this form describe basic information about the site such as location, examiners, slope, elevation, ground cover, etc. This information is collected for both integrated plots and observation sites.

- **Ocular Macroplot Form.** This form contains a basic set of field attributes that characterize vegetation composition and structure at integrated plots to support ecological classification.

- **Tree Measurement Form.** This form is used to record data for individual tree measurements. This type of data should be collected where appropriate to derive productivity, stand structure, and related interpretations.

- **Geologic and Geomorphic Forms.** These forms contain attributes on geologic and geomorphic data that characterize the site.

- **Soil Pedon Description Forms.** These forms contain a detailed set of soil pedon data that characterize the site.

The NRIS Terra database houses the data from the above field forms. Data is entered through the NRIS Terra module using ORACLE forms. Instructions are found in the http://fsweb.sandy.wo.fs.fed.us/terra/.

Use of Other Forms

The TEUI field forms in this document were developed in conjuction with TEUI and NRIS personnel. All data items on all forms can be entered into the NRIS Terra database unless otherwise noted. Regions may choose to use an alternate form, condense the TEUI forms, or alter form layout as long as core data fields are maintained. For example, a region may choose to print forms that show only the fields required for that region (national core plus optional fields determined by region). The data entry forms in the NRIS Terra database, however, closely emulate the field form layout and column order as presented in this document.

3.3.3 Integrated Plot Standards

Standard methods of data collection for soil, geology, geomorphology, and vegetation are referenced or described below.

Sample Site/Plot Locations

Sample site data should be located on air photos by a pinprick identifying the location of the integrated plot and the sample site ID should be clearly labeled in permanent ink on the back. A point layer should then be created. The point layer may be developed by using DOQs as a background for onscreen digitizing, transferring the point from the photo to a Mylar overlay and digitizing, or by building the layer electronically using GPS coordinates recorded in the field. The sample site ID is then entered into the database along with the plot information.

Care should be taken to compare GPS-derived sample site locations with points on the photos or base maps. Because of poor GPS satellite configurations or GPS reception, accuracy of GPS-derived locations may be lower than the location as determined manually in the field. These areas are readily discovered when the GIS point coverage from the GPS coordinates is crosschecked with the locations on the photos or base maps.

Soil Data

Soil pedon data is collected according to NCSS standards. Use codes and procedures in the NRCS publication *Field Book for Describing and Sampling Soils* (Schoeneberger et al. 2002). A soil pedon data form, instructions, and codes are also included in appendix E. For landforms and parent materials, use terms in appendix D. Soil and map unit data are entered into corporate systems.

Geologic Data

Geologic information should be collected according to the standards in the Forest Service Manual 2881. Describe surficial geology origin and kind using the terms and definitions listed in the NRIS Terra data dictionary. Also note depth to bedrock where observed.

Geomorphology

Geomorphic information is collected to the standards in *A Geomorphic Classification System* (Haskins et al. 1998). That volume also describes how to collect the morphometric characteristics listed in table 2.8. Data types and valid values are listed in appendix D. At a minimum, plot locations will be assigned a classification from the list of hierarchy geomorphology classes in appendix E to describe the dominant, active landform-process relationship.

Vegetation Data

Several general methods have been identified as acceptable for collecting vegetation cover data at the scale appropriate for classification of ecological types. These methods include ocular macroplots; multiple small plots or frames; and variable-radius plots (used for determining density and basal area of live trees and snags).

Presampling tests should be conducted to determine minimum plot size and number of replications needed to capture the variability of the site. Plot size must equal or exceed the minimal area of the plant community in the stand. The required minimum plot size varies within wide limits, depending on vegetation formation and stratum. The actual size needed can be determined from a minimum area curve (i.e., by plotting number of species against plot size). As a rule of thumb, a single representative plot meets the minimal area requirements when enlarging the plot adds no or very few new species. Plots larger than the minimal area provide acceptable data but are less efficient in terms of resources required to accomplish the sampling. If plots are too small, floristic data will not be adequate for developing a vegetation classification. Distinct advantages often exist to using different plot layouts depending on site conditions, types and amounts of vegetation, and variability of vegetation.

3.4 Data Storage

Natural Resource Information System Terra

Map unit, component, and ecological type data are entered in the NRIS Terra database. Specific instructions and help are available in the NRIS Terra data entry guide and online in the database application at http://fsweb.sandy.wo.fs.fed.us/terra/.

Geographic Information System Data Dictionary

GIS layers for the LT and LTP levels meet the requirements in the GIS data dictionary. Visit http://fsweb.wo.fs.fed.us/im/standards/gis/coredata/ for more information. GIS layers include the following elements:

- Polygon coverage composed of map units.
- Line coverage.
- Point coverage containing point locations of integrated plots.

National Soil Information System

Data to be entered in NASIS will be governed by the MOU and work plan. As a minimum, field units must provide soils documentation (USDA NRCS 2003b, part 627.08) to NRCS for correlation purposes, with the exception of a soil map.

3.5 Analysis

3.5.1 Data Summaries

Typical data summaries for map units include acres, slope, elevation, aspect, curvature, number of plots, etc. Typical summaries for components include location of integrated plots and type location, ranges in characteristics and properties for soils, vegetation, geology, geomorphology, and slope shape.

3.5.2 Synthesis and Interpretation

Data Analysis to Develop Vegetation Classifications

The entire vegetation classification process, from initial literature review to final published classification, is outlined in section 2.21 of the *Existing Vegetation Classification and Mapping Technical Guide* (Brohman et al. 2005). We focus here on the data analysis step of their process. Discussion is limited to potential vegetation, and assumes familiarity with basic concepts of statistics such as whether data are normally distributed or non-parametric, measures of variance and central tendency, etc. We will further assume that the objective of analysis is to identify patterns in vegetation community data to classify those communities, and then use environmental data (slope, aspect, soil depth, etc.) to relate those communities to environmental gradients. (For examples, see Spies and Barnes 1985, Shumar and Anderson 1986, or McCay et al. 1997). Cleland and Ramm provide a useful, concise literature review of multivariate analysis techniques used in ecological classification (http://www.ncrs.fs.fed.us/gla/reports/ecs-methods.pdf). The reader is also strongly advised to obtain and study *Analysis of Ecological Communities* (McCune et al. 2002) as a guide to the analysis of vegetation community data.

Such analysis goes beyond basic statistical analysis in that it involves many variables (hence multivariate analysis), and we often look for consistent patterns in vegetation abundance rather than compare means. The work, therefore, takes on a descriptive as well as analytic nature. Furthermore, one concise answer does not generally arise from this iterative process that classifies the data with more and more confidence as successive analysis shapes a clearer picture of how the data should be grouped—and how consistently it relates to realities on the ground. Classification is a skill that develops over months.

Figures 3.6 and 3.7 provide useful flowcharts to outline the data analysis process. Figure 3.6 shows that the data are first entered, checked, and cleaned. Ensure that data are entered in a format consistent with the data analysis software package. This time-consuming process can be greatly simplified by using field data recorders.

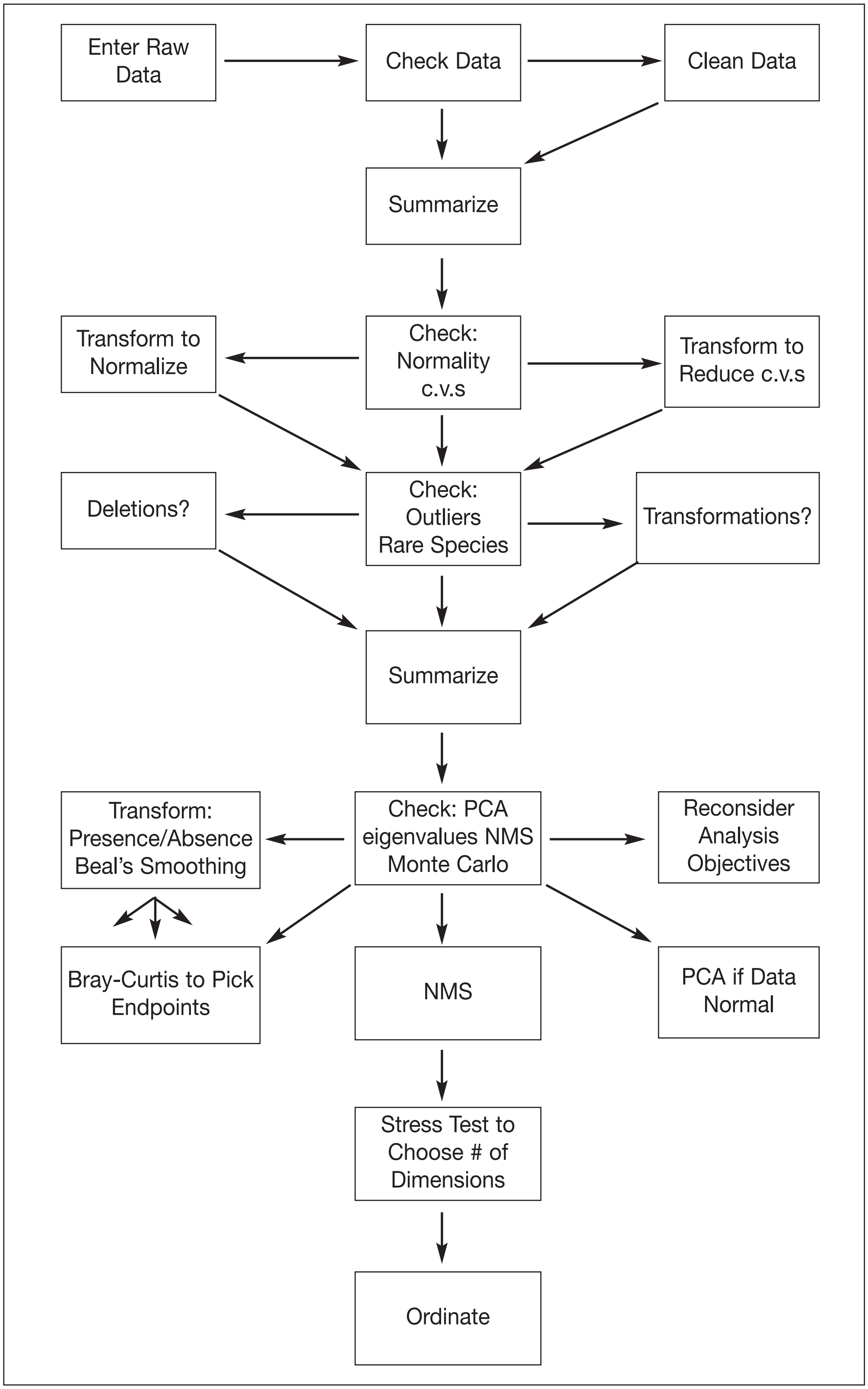

Figure 3.6. *Typical analysis flow for community data. Figure courtesy of Jeri Peck, Ecostats.*

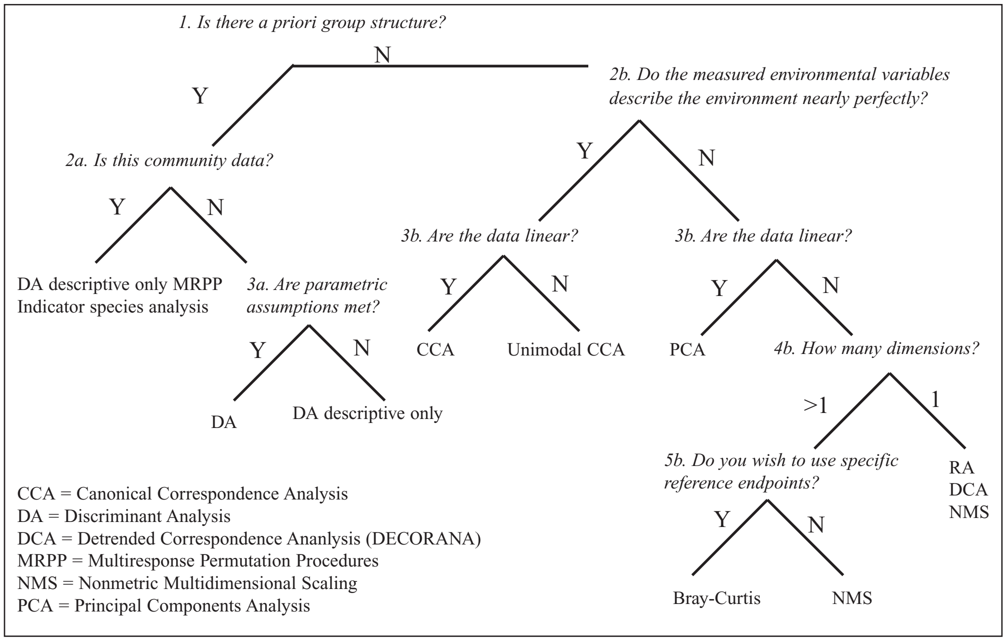

Figure 3.7. *Selecting an analysis technique. Figure courtesy of Jeri Peck, Ecostats, and Bruce McCune, Oregon State University.*

Data are then summarized to get some basic ideas about the data set. Data used to develop vegetation sets typically consists of a species abundance by plots matrix. The plot numbers can identify the rows of species abundance data, with one column for each species. (Alternately, the columns can be plot numbers with one row for each species, known as a transposed matrix.) The count of species, the number of times a species occurs, its average cover, and the range in its cover values are all data summaries typically generated for a data set. Another value of generating a summary is that rare species (those occurring only a few times or less) can be identified. Excluding rare plant data from an analysis often will improve the results because rare occurrences of a species can distort the patterns generated in clustering and ordination routines.

Identifying outliers is related to identifying rare species. Outliers are data points with values far outside the normal range of data variation (more than two standard deviations from the mean is a common rule of thumb). Outliers can greatly skew results and distort plant community data patterns. Software programs can identify outliers. When analysis seeks to identify vegetation patterns, removing outliers from a data set is desirable and is not cheating. We are not looking for significant differences between means, but instead discerning the significance of patterns.

Transformations are also useful during the data preparation process, particularly with environmental data such as slopes, elevations, aspects, tree basal area, etc. If we are comparing tree basal areas ranging from 20 to 160 square feet per acre with elevations that run from 900 to 4,600 feet above sea level, the difference in units and the difference in scales can distort results. In these cases, it is desirable to normalize the data by converting all variables to the same scale but using each value as a percent of the total possible value in its range.

Another common transformation is the arcsin transformation, where percent data is converted to a decimal number to approximate a normal distribution. Aspect data are transformed using the formula in Beers et al. (1966). Other transformations are possible. We aim to standardize and normalize data when necessary, not change it so we get a more desirable answer.

After the completion of these data preparation steps, we are ready to begin analysis. Summaries are a good first step. Species in a species-plot matrix can be summarized by how often they occur, their average occurrence, and their range of values. Sort them by lifeform, listing the overstory tree species first, then the understory trees, followed by shrubs, and then the herbaceous layer. Another value of summarization is that species that seldom occur in the data set can be excluded from future analyses. As with excluding outliers, excluding these uncommon species can avoid distortions.

Analyses now fall into two groups: clustering and ordination. A variety of analysis programs can perform these routines, and are detailed in McCune et al. (2002). Figure 3.7 provides some guidelines on selecting analysis techniques. Note that each method has its strengths and weaknesses. A variety of analysis methods should be used, and if they generate roughly the same result, a correct picture of the ecological reality is probably being developed. In contrast, a method that gives starkly different results from most other methods would be strongly suspect and could be discarded.

Clustering, in which samples are grouped by similarity, is generally performed first. In the more sophisticated ordination analysis, samples are arranged (or ordinated) along axes of ecological space based on the multiple relationships of the plant species and their abundances to each other. The strength of these relationships is measured with eigenvalues. High eigenvalues mean a good deal of variation is being explained by the ordination. The axes of the ordination generally correspond to environmental gradients. Elevation and available moisture are two common gradients explaining most of the variation in a data set. Canonical correlation can be used to formally relate these axes to environmental attributes; with other ordination programs (such as correspondence analysis and mulitdimensional scaling), these relationships are only inferred.

Interpretations

Interpretations can be developed by selecting appropriate attributes for analysis and display and/or combining TEU attributes/interpretations with other sources. The following tables are a subset of typical attributes and interpretations commonly derived from the TEU information. Documentation of new interpretations should include what data are used, how they are developed, and what assumptions are made.

Attributes Used for Analysis and Characterization

Table 3.6 provides a list of commonly used LT component data attributes used in analysis, display, and interpretation.

Soil Interpretations

Standard soil interpretations are generated from the NRCS NASIS database and the criteria are documented in the *National Forestry Manual* (NFM), the *National Soil Survey Handbook* (NSSH), and *National Range and Pasture Handbook*. Generally, the criteria may be supplemented for local or regional use. Table 3.7 provides a list of recommended soil interpretations for LTs. All interpretations are based on the soil component and care should be taken when aggregating ratings to the map unit level. When map units have multiple components, percent composition should be used to adjust ratings depicted on GIS map displays and in analysis procedures. Adjustments may include dominant soil component, dominant interpretive condition, most limiting component, least limiting component, or others as appropriate for the interpretive use being considered.

Table 3.6. *Data attributes used in analysis, display, and interpretation.*

Planning and analysis scale	Interpretation/ attribute	Description	Reference
Land unit	Runoff potential	Surface runoff refers to the loss of water from an area by flow over the land surface. The estimation of the amount of runoff is important to hydrologic models in assessing the streamflow and water storage.	NSSH 2002
Land unit	Available water holding capacity	Available water capacity is the volume of water that should be available to plants if the soil, inclusive of fragments, were at field capacity. It is commonly estimated as the amount of water held between field capacity and wilting point, with corrections for salinity, fragments, and rooting depth.	NSSH 2002
Land unit	Drainage class	Drainage class identifies the natural drainage condition of the soil. It refers to the frequency and duration of wet periods.	NSSH 2002
Land unit	Hydrologic group	Hydrologic group is a group of soils having similar runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonally high water table, intake rate and permeability after prolonged wetting, and depth to a very slowly permeable layer. The influence of ground cover is treated independently.	NSSH 2002
Land unit	Erosion hazard	Erosion hazard is the hazard of soil erosion	Defined locally
Land unit	K-factors	Soil erodibility factors (Kw) and (Kf) are erodibility factors that quantify the susceptibility of soil detachment by water. These erodibility factors predict the long-term average soil loss, which results from sheet and rill erosion under various alternative combinations of crop systems and conservation techniques. Factor Kw considers the whole soil, and factor Kf considers only the fine-earth fraction, which is the material less than 2.0 mm in diameter.	NSSH 2002
Land unit	Hydric soil rating	A hydric soil is a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. Hydric soils along with hydrophytic vegetation and wetland hydrology are used to define wetlands.	NSSH 2002
Land unit	Flooding frequency and duration	Flooding is the temporary covering of the soil surface by flowing water from any source, such as streams overflowing their banks, runoff from adjacent or surrounding slopes, inflow from high tides, or any combination of sources. Shallow water standing or flowing that is not concentrated as local runoff during or shortly after rain or snowmelt is excluded from the definition of flooding.	NSSH 2002
Land unit	Organic matter percent	Organic matter percent is the weight of decomposed plant and animal residue and expressed as a weight percentage of the soil material less than 2 mm in diameter.	NSSH 2002
Land unit	Slope stability	Defined locally	

Table 3.7. *Recommended soil interpretations for landtypes.*

Planning and analysis scale	Interpretation name	Description	Reference
Land unit	Potential erosion hazard (road trail)	Potential erosion hazard is the hazard or risk of soil loss from unsurfaced roads/trails.	NFM (1998)
Land unit	Potential erosion hazard (off-road/off-trail)	Ratings indicate the hazard or risk of soil loss from off-road and off-trail areas after disturbance activities that expose the soil surface.	NFM (1998)
Land unit	Soil rutting hazard	Ratings indicate the hazard or risk of ruts in the uppermost soil surface layers by operation of forest equipment. Soil displacement and puddling (soil deformation and compaction) may occur simultaneously with rutting.	NFM (1998)
Land unit	Road suitability (natural surface)	Road suitability is the suitability for using the natural surface of the soil component for roads by trucks for the transport of logs and other wood products from the site.	NFM (1998)
Land unit	Log landing suitability	Log landing suitability is the suitability of the soil at the forest site to serve as a log landing.	NFM (1998)
Land unit	Construction limitations for haul roads and log landings	Ratings reflect limitations for constructing haul roads and log landings.	NFM (1998)
Land unit	Harvest equipment operability	Harvest equipment operability is the suitability for operating harvesting equipment.	NFM (1998)
Land unit	Mechanical site preparation (surface)	Ratings indicate the suitability of using surface-altering soil tillage equipment.	NFM (1998)
Land unit	Mechanical site preparation (deep)	Ratings indicate the suitability of using deep soil tillage equipment.	NFM (1998)
Land unit	Hand planting suitability	Ratings indicate the expected difficulty of hand planting.	NFM (1998)
Land unit	Mechanical planting suitability	Mechanical planting suitability is the difficulty of planting tree or shrub seedlings using a mechanical planter.	NFM (1998)
Land unit	Shallow excavations 620-1	Shallow excavations are trenches or holes dug in the soil to a maximum depth of 5 or 6 feet. They are used for pipelines, sewer, and telephone, and power lines. Trenching machines or backhoes are used to make shallow. excavations.	NSSH Interpretive Guide (1993)

Table 3.7. *Recommended soil interpretations for landtypes (continued).*

Planning and analysis scale	Interpretation name	Description	Reference
Land unit	Local roads and streets 620-5	Local roads and streets are those roads and streets that have all-weather surfacing (commonly of asphalt or concrete) and that are expected to carry automobile traffic year-round. The roads and streets consist of (1) the underlying local soil material, either cut or fill, which is called "the sub-grade"; (2) the base material, which may be lime-stabilized soil, cement-stabilized soil, gravel, or crushed rock; and (3) the actual road surface or street pavement, which is either flexible (asphalt), rigid (concrete), or gravel with binder in it. They are graded to shed water, and conventional drainage measures are provided. With the probable exception of the hard surface, roads and streets are built mainly from the soil at hand.	NSSH Interpretive Guide (1993)
Land unit	Roadfill 620-7	Roadfill consists of soil material that is excavated from its original position and used in road embankments elsewhere. The evaluations for roadfill are for low embankments that generally are less than 6 feet in height and are less exacting in design than high embankments, such as those along superhighways. The rating is given for the whole soil, from the surface to a depth of about 5 feet, based on the assumption that soil horizons will be mixed in loading, dumping, and spreading. Criteria, limits, and restrictive features for rating soils for local roads and streets are provided in the NSSH (1993). Soils are rated as to the amount of material available for excavation, the ease of excavation, and how well the material performs after it is in place.	NSSH Intepretive Guide (1993)
Land unit	Sand source 620-8	Sand as a construction material is usually defined as particles ranging in size from 0.074 mm (sieve #200) to 4.75 mm (sieve #4) in diameter. Sand is used in great quantities in many kinds of construction. Specifications for each purpose vary widely. The intent of this rating is to show only the probability of finding material in suitable quantity. The suitability of the sand for specific purposes is not evaluated.	NSSH Interpretive Guide (1993)
Land unit	Gravel source 620-9	Gravel as a construction material is defined as particles ranging in size from 4.76 mm (sieve #4) to 76 mm (3 inches) in diameter. Gravel is used in great quantities in many kinds of construction. Specifications for each purpose vary widely. The intent of this rating is to show only the probability of finding material in suitable quantity. The suitability of the gravel for specific purposes is not evaluated.	NSSH Interpretive Guide (1993)
Land unit	Topsoil 620-10	The term "topsoil" has several meanings. As used here, the term describes soil material used to cover an area so as to improve soil conditions for the establishment and maintenance of adapted vegetation.	NSSH Interpretive Guide (1993)
Land unit	Soil reconstruction material for drastically disturbed areas 620-11	Soil reconstruction of areas drastically disturbed, as in surface mining, is the process of replacing layers of soil material or unconsolidated geologic material, or both, in a vertical sequence of such quality and thickness that a favorable medium for plant growth is provided.	NSSH Interpretive Guide (1993)

Table 3.7. *Recommended soil interpretations for landtypes (continued).*

Planning and analysis scale	Interpretation name	Description	Reference
Land unit	Camp areas 620-12	Camp areas are tracts of land used intensively as sites for tents, trailers, campers, and the accompanying activities of outdoor living. Camp areas require such site preparation as shaping and leveling in the areas used for tents and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic.	NSSH Interpretive Guide (1993)
Land unit	Picnic areas 620-13	Picnic areas are natural or landscaped tracts used primarily for preparing meals and eating outdoors. These areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking lots. Soils are rated on the basis of properties that influence the development costs of shaping the site, trafficability, and the growth of vegetation after development.	NSSH Interpretive Guide (1993)
Land unit	Paths and trails 620-15	Paths and trails are used for walking, horseback riding, and similar uses and require little or no cutting or filling. The soils are rated based on the properties and qualities that influence trafficability and erodibility.	NSSH Interpretive Guide (1993)
Land unit	Off-road motorcycle trails	Off-road motorcycle trails are primarily for recreational use. Trails for other off-road vehicles may have similar criteria. Little or no preparation is done to the trail, and the surface is not vegetated or surfaced. Considerable compaction of the soil on the trail is expected.	NSSH Interpretive Guide (1993)
Land unit	Pond reservoir area 620-28	A pond reservoir area is an area that holds water behind a dam or embankment.	NSSH Interpretive Guide (1993)
Land unit	Excavated ponds (aquifer-fed) 620-30	An aquifer-fed excavated pond is a body of water created by excavating a pit or dugout into a ground-water aquifer. Excluded are ponds that are fed by surface runoff and embankment ponds that impound water 3 feet or more above the original surface.	NSSH Interpretive Guide (1993)
Land unit	Pesticide loss potential—leaching 620-35	"Pesticide loss potential—leaching" is the potential for pesticides to be transported by percolating water below the plant root zone. Pesticides in ground-water solution are leached from the soil surface layer and transported vertically or horizontally through the soil and vadose zone by percolating water. Leaching pesticides have the potential to contaminate shallow and deep aquifers, springs, and local water tables.	NSSH Interpretive Guide (1993)

Table 3.7.—*Recommended soil interpretations for landtypes (continued).*

Planning and analysis scale	Interpretation name	Description	Reference
Land unit	Pesticide loss potential–soil surface runoff 620-36	"Pesticide loss potential—soil surface runoff" is the potential for pesticides to be transported by surface runoff beyond the field boundary where the pesticide was applied. Pesticides are transported by surface runoff as either pesticides in solution or pesticides adsorbed to sediments suspended in runoff. Pesticides that are surface transported have a potential to contaminate surface waters, such as lakes, ponds, streams, and rivers	NSSH Interpretive Guide (1993)
Land unit	Equipment operability for logging areas 620-37	Equipment operability for logging areas applies to the use of rubber-tired skidders in the general logging area, including the yarding area for felled or bunched trees or logs and that extends to a designated skid trail.	NSSH Interpretive Guide (1993)
Land unit	Total tree harvesting 620-40	Total tree harvesting consists of yarding the entire tree to the landing area. Factors considered in rating soils for this practice are the nutrient status of the soil and the effects of removing the tops of trees, which would otherwise be incorporated back into the soil. Also considered is the erosion potential of the soil and the effects of removing slash, which would be a protective factor for the soil.	NSSH Interpretive Guide (1993)
Land unit	Prescribed burning 620-43	Prescribed burning is the deliberate ignition of a combustible material. Foresters use fire to perform three basic functions: consume dead organic material, alter living vegetation, and produce a desired ecological effect. The three functions are not mutually exclusive. Burning dead material inevitably affects the vegetation. The ecological function is, to some extent, a synthesis of other functions. Soil properties are considered in prescriptions for burning not from the standpoint of the actual ignition but from the standpoint of the management objectives of thedesired ecological effect.	NSSH Interpretive Guide (1993)
Land unit	Seedling mortality 620-44	Seedling mortality refers to the probability of the death of naturally occurring or planted tree seedlings, as influenced by kinds of soil or topographic conditions.	NSSH Interpretive Guide (1993)
Land unit	Plant competition 620-45	Plant competition is the likelihood that plants other than the desired species will become established during revegetation efforts and that their presence will affect seedling establishment and the growth of desired species.	NSSH Interpretive Guide (1993)

3.5.3 Quality Control and Assurance

Quality control and quality assurance are important at all levels of the TEUI process to ensure that TEUI products are accurate, consistent, and meet the objectives outlined in the memorandum of understanding, work plan, and this technical guide. NCSS standards are required elements of TEUI at the LT and LTP level.

NCSS standards include those for soil classification as found in *Keys to Soil Taxonomy*; those for soil description as found in *The Field Book for Describing and Sampling Soils*; and those for documentation as found in the *National Soil Survey Handbook* Part 627.08, with exception that the TEUI map is substituted for the soil map.

Quality Control

Quality control is the process of providing direction, inspection, and coordination of TEUI activities to ensure that all products meet the defined standards in this guide. The TEUI project leader and crew must ensure that day-to-day activities meet TEUI and NCSS standards.

Quality Assurance

Quality assurance is the process of providing technical standards, review, and training to support TEUI quality control. Quality assurance is the primary responsibility of the regional and national TEUI and NCSS staff.

3.5.4 Quality Control/Quality Assurance Roles and Responsibilities

National

The national TEUI coordinators are responsible for the formulation, coordination, and updates of technical guides and procedural manuals, including the development of national work plans and training courses. Additional responsibilities include setting national policy and ensuring mapping consistency and data quality between regions.

Regional

Regional offices are responsible for the coordination and quality assurance for all TEUI activities including data collection, documentation, interpretation, and correlation. Regional offices will ensure that TEUI meet standards, including NCSS standards, and that documentation is completed and available for correlation. They must ensure the consistency of mapping and data quality between inventory areas, including quality assurance of the data entered into the NRIS Terra database, such as ecological unit, component, site, and geospatial data. In addition, regional offices should compile mapping and complete map unit descriptions at the section and subsection levels of the National Hierarchy.

TEUI Project

The TEUI project staff is responsible for meeting TEUI standards at the LTA, LT, and LTP levels of the National Hierarchy. The TEUI project leader ensures that the proper quality control measures are being conducted by crewmembers. Crewmembers are responsible for ensuring that all data and mapping standards are applied consistently.

3.5.5 Correlation of Ecological Types and Units

Correlation is a process for ensuring consistency in naming, classifying, and interpreting ecological types. The correlation process also provides quality control for consistent description and documentation of the landscape elements.

Field Reviews

Field reviews of TEUIs are scheduled to critically examine design of ecological types and mapped ecological units in the field. The field review serves as a quality assurance procedure to ensure that the database, mapping, classification, and associated documentation of the inventory area meets standards.

The review team leader will give particular attention to the review of soils documentation to ensure NCSS standards are met as outlined in Section 1.5, Soil Survey Program. Field units are encouraged to use progressive correlation for the soils portion of the TEUI, and are required to meet NCSS standards, including documentation necessary for final correlation. TEUI are certified as meeting NCSS standards by NRCS only through a final correlation memorandum (USDA NRCS 2003b).

The TEUI project staff organizes the field review to examine representative map units and sites of major ecological types and units in the area. The field review should also be used to address and correct problems encountered with classification, mapping concepts, and specific needs of the inventory. During this process, the work plan is reviewed and the annual plan of operations is updated. Field review reports are developed by the regional staff and submitted to the regional forester for signature. Any items identified during this process are submitted to the forest supervisor and/or TEUI project office for action.

Review Participants

The field review should include national and regional specialists who have responsibility for each of the landscape elements. Resource specialists and managers familiar with the area, scientists working on nearby ecological unit inventory projects, and representatives of cooperating agencies are encouraged to participate. All field review participants should be encouraged to state their observations and opinions relative to each ecological type and unit observed, and all discussion should be noted for consideration in making correlation decisions.

Scheduling Field Reviews

Field reviews are to be scheduled as part of the annual plan of operations for each survey area. There should be at least an initial field review at the end of the beginning of the project, one or more progress field reviews during the life of the project, and a final field review at the end of the project.

3.5.6 Mapping and Interpretative Reliability

Accuracy Assessment

The following procedure is a suggested method for performing accuracy assessment of ecological units:

1. Conduct office assessment.

    a. Assess distributions and ranges of each map unit for environmental variables such as elevation, slope, aspect, and spectral reflectance values.

    b. Review frequency distribution curves produced from the analysis to determine ranges and variability in the environmental variables.

    c. Review existing documentation to determine if representative values are within the ranges for these variables.

    d. Where discrepancies are apparent, refine polygons and use procedures below to conduct field assessment.

2. Conduct field-accuracy assessment for mapping, classification, and description.

    a. Randomly select 10 percent of the total number of map units for the survey area.

    b. From the above sample, randomly select individual delineations (polygons) to assess.

    c. Develop a transect design commensurate with polygon shape and ecological patterns.

    d. Sample at predetermined intervals according to established intensity levels. At higher intensity levels, more sampling is required to meet the desired interpretative reliability.

    e. Compare results of sampling to ecological unit and type descriptions.

f. Document results and compare to established standards in the work plan.

g. Adjust line work and correlate mapping and taxonomic units as necessary to meet established standards.

3.6 Reporting

3.6.1 Format and Content

NCSS Publications

Publications must meet the minimum requirements as described in part 644 of the *National Soil Survey Handbook* (USDA NRCS 2003b).

3.6.2 Accomplishment Reporting and Scheduling

Report accomplishments by appropriate budget line item and associated activity code.

Appendix A. Glossary

abiotic. Pertaining to the nonliving parts of an ecosystem, such as soil particles, bedrock, air, water (Helms 1998).

abundance. The total number of individuals of a taxon or taxa in an area, volume, population, or community. Often measured as cover in plants (Lincoln et al. 1998).

accuracy. The degree to which a measured quantity approaches the true value of what is being measured (Lincoln et al. 1998).

accuracy assessment. The process by which the accuracy or correctness of an image (or map) is evaluated.

alliance. (1) A grouping of associations with a characteristic physiognomy, and sharing one or more diagnostic species, which, as a rule, are found in the uppermost or dominant stratum of the vegetation (Jennings et al. 2004). (2) A physiognomically uniform group of associations sharing one or more diagnostic (dominant, differential, indicator, or character) species that, as a rule, are found in the uppermost stratum of the vegetation (FGDC 1997).

arc. In GIS, within a spatial context, a locus of points that forms a curve that is defined by a mathematical expression (FGDC 1998).

attribute. One of a set of descriptive terms; a characteristic (Lincoln et al. 1998).

bedrock geology. Characteristics of the consolidated material at the Earth's surface or that immediately underlies soil or other unconsolidated, surficial deposits, specifically lithology (rock type), weathering, structure (e.g., fracturing or bedding), and stratigraphy (the rock-unit age and designation).

business needs. Ongoing tasks related to a particular business or project and the information and other support contributing to the completion of these tasks.

canopy closure. The proportion of ground, usually expressed as a percentage, that is occupied by the perpendicular projection downward of the aerial parts of the vegetation of one or more species. It usually refers to the tree life form of the uppermost canopy, as seen from above, and cannot exceed 100 percent. It is similar in concept to absolute canopy.

canopy cover. (1) The proportion of ground, usually expressed as a percentage, that is occupied by the perpendicular projection downward of the aerial parts of the vegetation or the species under consideration. The additive cover of multiple strata or species may exceed 100 percent (FGDC 1997). (2) The percentage of ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of plants. Small openings within the canopy are included (SRM 1998, USDA NRCS 1997). Canopy cover is synonymous with canopy closure (Helms 1998). For woody plants, canopy cover is synonymous with crown cover (USDA NRCS 1997, Helms 1998).

canopy cover, absolute. The canopy cover of a species in a plant community, regardless of the presence of other species.

canopy cover, relative. The canopy cover of a species in a plant community, expressed as a percentage of the total cover of all species.

canopy structure. The arrangement of vegetation layers in a plant community.

class. A group of individuals or other units similar in selected properties and distinguished from all other classes of the same population by differences in these properties (Buol et al. 1973).

classification. (1) The process of grouping similar entities together into named types or classes based on shared characteristics. (2) The grouping of similar types according to criteria that are considered significant for this purpose. The rules for classification must be clarified before identifying the types within the classification standard. The classification methods should be clear, precise, quantitative (where possible), and based on objective criteria so that the outcome would be the same whoever performs the definition (or description). Classification necessarily involves definition of class boundaries (FGDC 1997, citing UNEP/FAO 1995).

climax. A self-replacing plant community or species with no evidence of replacement by other plants.

climax plant community. The stable community in an ecological succession that is able to reproduce itself indefinitely under existing environmental conditions in the absence of disturbance. Viewed as the final stage or end-point in plant succession for a site. The climax community develops and maintains itself in steady state conditions.

community. (1) A general term for an assemblage of plants living together and interacting among themselves in a specific location; no particular ecological status is implied. (2) Any group of organisms interacting among themselves (Daubenmire 1978).

community composition. The kinds, absolute amounts, or relative proportions of plant species present in a given area or stand. It can be described qualitatively or quantitatively. The latter may use either absolute amounts or relative proportions of the plant taxa present. The amount of each plant taxon should be expressed as percent cover (FGDC 1997, Jennings et al. 2004).

community type. An aggregation of all plant communities with similar structure and floristic composition. A unit of vegetation within a classification with no particular successional status implied.

component. A subset of an ecological type used to describe the spatial arrangement of an ecological type within the map unit. A component may represent a narrower range of characteristics than the ecological type for which it is named.

composition. (1) The amount or proportion of the plant species on a given area (SRM 1989). (2) A list of the species that comprise a community or any other ecological unit (Lincoln et al. 1998).

constancy. The number of occurrences of a species in a group of plots divided by the total number of plots, expressed as a percentage. All plots must be the same size. For example, if a particular community has 10 plots and a species is found in 8 of the 10, the constancy of that species is 80 percent.

coordinates. In mapping, coordinates are pairs of numbers expressing horizontal distances along orthogonal axes; alternatively, triplets of numbers measuring horizontal and vertical distances (FGDC 1998).

cover. Usually meant as canopy cover that is the gross outline of the foliage of an individual plant or group of plants within a stand or plot. Expressed as a percent of the total area of the plot and may exceed 100 percent if more than one layer is considered. See **canopy cover** and **vegetation cover**.

cover type. A designation based on the plant species forming a plurality of composition within a given area (e.g., oak-hickory) (FGDC 1997). The Society of American Foresters Forest Cover Types (Eyre 1980) and the Society for Range Management Rangeland Cover Types (Shiflet 1994) are examples of cover types.

data element. A logically primitive item of data (FGDC 1998).

delineation. The process of separating map units (repeating sets of polygons) using a consistent set of criteria.

diagnostic species. Any species or group of species whose relative constancy or abundance clearly differentiates one type from another (Jennings et al. 2004). This definition implies that diagnostic species must be determined empirically through analysis of plot data (Mueller-Dombois and Ellenberg 1974).

differential species. A plant species that, because of its greater fidelity in one kind of community than in others, can be used to distinguish vegetation units (Gabriel and Talbot 1984 as cited in Jennings et al. 2004).

differentiating characteristics. Properties selected as the basis for grouping individuals into classes (Buol et al. 1973).

digital elevation model. Digital data file containing an array of elevation information over a portion of the Earth's surface (USDA Forest Service 1999).

digital orthophoto quadrangle. Digital representation of an aerial photo with ground features located in their "true" positions (Clarke 1999).

division. (1) In terrestrial ecological unit inventory, an ecological unit in the ecoregion planning and analysis scale of the National Hierarchy Framework corresponding to subdivisions of a domain that have the same regional climate (ECOMAP 1993). (2) In the Federal Geographic Data Committee (FGDC) physiognomic hierarchy, the level separating Earth cover into either vegetated or nonvegetated categories (Grossman et al. 1998).

dominance. The extent to which a given species has a strong influence in a community because of its size, abundance, or coverage. Strong dominance affects the fitness of associated species (Lincoln et al. 1998).

dominant. An organism exerting considerable influence on a community by its size, abundance, or coverage (Lincoln et al. 1998).

dominant species. The species with the highest percentage of cover, usually in the uppermost layer (Kimmins 1997, as cited in Jennings et al. 2004).

ecological units. Map units designed to identify land and water areas at different levels of resolution based on similar capabilities and potentials for response to management and natural disturbance. These capabilities and potentials derive from multiple elements: climate, geomorphology, geology, soils, water, and potential natural vegetation. Ecological units should, by design, be rather stable. They may, however, be refined or updated as better information becomes available.

ecological type. A category of land with a distinctive (i.e., mappable) combination of landscape elements. The elements making up an ecological type are climate, geology, geomorphology, soils, and potential natural vegetation. Ecological types differ from each other in their ability to produce vegetation and respond to management and natural disturbances.

ecosystem. A functional system of interacting organisms and their environment (Whittaker 1962). Ecosystems have six major attributes: structure, function, complexity, interaction/interdependency, scale, and change over time (Kimmins 1997).

ecotone. The boundary or transitional zone between adjacent communities or biomes. A tension zone (Lincoln et al. 1998).

elements. In this document, the attributes of a landscape that describe its environmental characteristics. Examples include climate, bedrock geology, surficial geology, soils, and potential vegetation.

evaluation. The comparison of dynamic sampling results to management objectives consisting of predetermined standards, expected norms, threshold values, and/or trigger points.

existing vegetation. **(**1) The plant cover, or floristic composition and vegetation structure, occurring at a given location at the current time. (2) The plant species existing at a location at the present time. Contrast with potential natural vegetation.

Federal Geographic Data Committee (FGDC). An interagency committee, organized in 1990 under the Office of Management and Budget Circular A-16, that promotes the coordinated use, sharing, and dissemination of geospatial data on a national basis. The FGDC is composed of representatives from 17 Cabinet level and independent Federal Agencies (FGDC 1998).

fidelity. The degree of restriction of a plant species to a particular situation, community, or association (Lincoln et al. 1998).

flora. (1) All the plant species that make up the vegetation of a given area (Allaby 1994). (2) The plant life of a given region, habitat, or geological stratum (Lincoln et al. 1998).

floristic composition. A list of plant species of a given area, habitat, or association (Lincoln et al. 1998).

forbs. Broad-leaved herbaceous plants (FGDC 1997).

fuzzy logic. A type of reasoning designed to accommodate ambiguity. Using fuzzy sets in accuracy assessment permits explicit recognition of the possibility of ambiguity regarding appropriate map labels for some locations on a map/classification. This recognition can help the user determine the relative (not absolute) accuracy of a particular classification, and thus the usefulness of that classification for applications requiring varying levels of accuracy (Wirth et al. 1996).

Geographic Information System (GIS). A set of computer tools for collecting, storing, retrieving, transforming, and displaying spatial data from the real world for a particular set of purposes. Spatial data in GIS are characterized by their position, attributes, and spatial interrelationships (topology) (Burrough 1986).

geomorphology. The classification, description, nature, origin, and development of present landforms and their relationships to underlying structures, and of the history of geologic changes as recorded by these surface features.

geospatial data. Information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the Earth. This information may be derived from, among other things, remote sensing, mapping, and surveying technologies (FGDC 1998).

Global Positioning System (GPS). An array of space satellites and ground receivers that use geometry to provide information about the precise latitude, longitude, and elevation of a particular point (Wirth et al. 1996).

grid. A rectilinear arrangement. Examples include the Public Land Survey, raster GIS, and systematic field sampling schemes.

group. An aggregation of similar items. The word can also have specific meanings that vary with discipline (e.g., soil Great Groups and National Vegetation Classification System vegetation groups are very different entities).

image processing. A general term referring to manipulation of digital image data. Processing includes image enhancement, image classification, and image preprocessing (or rectification) operations (Wirth et al. 1996).

indicator species. (1) A species whose presence, abundance, or vigor is considered to indicate certain environmental conditions (Gabriel and Talbot 1984, as cited in Jennings et al. 2004). (2) A species that is sensitive to important environmental features of a site such that its constancy or abundance reflects significant changes in environmental factors. (3) A plant whose presence indicates specific site conditions or a type.

inventory. The systematic acquisition, analysis, and organization of resource information needed for planning and implementing land management (USDA NRCS 1997).

Landsat. Name for the series of Earth-observing satellites first launched in 1972 by National Aeronautics and Space Administration (originally named ERTS, for Earth Resource Technology Satellite). Landsat satellites serve as platforms for several sensors, including the return beam vidicon, Landsat Multispectral Scanner, and Landsat Thematic Mapper (Wirth et al. 1996).

landtype association (LTA). Landscape scale map units defined by a dominant geomorphic process type, similar landforms, surficial and near-surface geologic formations, and associations of soil families and potential natural vegetation at the series level (Forman and Godron 1986, ECOMAP 1993, Cleland et al. 1997).

layer (GIS). A digital information storage unit, also known a theme. Different kinds of information (e.g., roads, boundaries, lakes, and vegetation) can be grouped and stored as separate digital layers or themes in GIS (Wirth et al. 1996).

layer or stratum. (1) A structural component of a community consisting of plants of approximately the same height structure (e.g., tree, shrub, and herbaceous layers). (2) The definition and measurement of these structural components in their vertical and height relationships to each other (e.g., tree subcanopy layer, shrub understory layer) (Grossman et al. 1998).

life form. (1) The characteristic structural features and method of perennation of a plant species; the result of the interaction of all life processes, both genetic and environmental (Lincoln et al. 1998). Life form is related to growth form, physiognomy, and habit, but also includes consideration of the type and position of renewal (perennating) buds that the other terms typically do not include. (2) Includes gross morphology (size, woodiness, etc.), leaf morphology, life span, and phonological (or life cycle) phenomena (Barbour et al. 1980).

map. **(**1) A spatial representation, usually graphic on a flat surface, of spatial phenomena (FGDC 1998). (2) A representation, usually on a plane surface, of a region of the Earth or heavens (Robinson et al. 1978).

mapping. In its most generic sense, the process of using points, lines, polygons, or pixels to represent geographic features spatially.

map scale. The extent of reduction required to display a portion of the Earth's surface on a map and is defined as a ratio of distances between corresponding points on the map and on the ground (Robinson et al. 1978). Scale indirectly determines the information content and size of the area being represented. The mapping scale is determined by the agency's business needs and the characteristics of the data obtained for the project area. Maps generated from digital imagery can appropriately be displayed at a range of scales.

map unit. A collection of features defined and named the same in terms of a unifying theme (USDA NRCS 1993). Each map unit differs in some respect from all others within a geographic extent. Map units are differentiated in map unit design and defined in a map unit description. Design of map units generalizes the taxonomic units present to the smallest set that meets the objectives of the map at that scale, and that are feasible to delineate with available resources and technology.

map unit characterization. The description of the elements in a map unit. In regard to ecological units, includes the "primary five" (geomorphology, geology, climate, soils, and potential vegetation), but also often includes supporting elements, such as hydrology, disturbance regimes, etc.

map unit delineation. The criteria used to spatially differentiate between map units. For ecological units, the relative importance of these criteria varies with scale. For example, at landtype association scale, differences in geomorphology and geology are normally the primary delineation criteria between map units, whereas at land unit scale, soils and potential vegetation become more important.

map unit description (MUD). Describes the composition of ecological types (or components) as they occur in a map unit. These descriptions form the primary reference document for identifying the ecological types that occur within a map unit.

map unit design. The process establishing the relationship between classifications and map products depicting them. In this document, design considerations include the interrelationships between elements, component relationships within the map unit, and how the map unit relates to other scales.

map unit legend. A list of the map units that occur in a specific inventory area, including the map unit code and map unit name, and is developed using national coding and naming procedures.

map unit validation. In this paper, the process of verifying the accuracy of ecological unit differentiation, delineation, and characterization.

metadata. Data about the data: the content, quality, condition, and other characteristics of a given set of data. Metadata is intended to provide a capability for organizing and maintaining an institution's investment in data as well as to provide information for the application and interpretation of data received through a transfer from an external source (Jennings, et al. 2004, as modified from FGDC 1997). Metadata often includes details on the methodologies used in data collection, relevant literature references, purpose of data collection, etc.

modeling. In reference to geospatial data, the process of creating a new GIS layer by combining or operating on existing layers. Modeling creates an image (or images) that contains several types of information comprised of several GIS variables (e.g., a scene could be considered in terms of its vegetation, elevation, water, and climate at the same time) (Wirth et al. 1996).

monitoring. (1) The systematic collection, analysis, and interpretation of resource data to evaluate progress toward meeting management objectives (SRM 1998). (2) The collection and analysis of resource data to measure changes in the amounts, spatial distribution, or condition of resource types or parameters over time.

morphometry. The measurement and mathematical analysis of the configuration of the Earth's surface and of the shape and dimensions of its landforms (i.e., relief, elevation range, slope aspect, gradient, shape, and position, dissection frequency and depth, and drainage pattern and density).

National Hierarchy of Ecological Units. The Forest Service's multiple-scale, multiple-element system of map units used to characterize the natural world and provide a framework for national forest planning and management (Cleland et al. 1997). Other State and Federal agencies also use the National Hierarchy, particularly at broader scales.

outlier. Referring to data, a sample or datum that has low similarity to all the other samples in the dataset.

overstory. The canopy layer of a forest.

patch. A relatively homogenous nonlinear area that differs from its surroundings (Forman 1995). It can specifically describe forested patches, nonforest vegetation patches, rock/barren patches, or water patches.

patterns. Repeating coordinated species abundances and groups of samples with similar species composition.

physiognomy. (1) The characteristic feature or appearance of a plant community or vegetation (Lincoln et al. 1998). (2) The overall appearance of a kind of vegetation (Daubenmire 1968, Barbour et al. 1980). (3) The expression of the life forms of the dominant plants and vegetation structure (Mueller-Dombois and Ellenberg 1974, Barbour et al. 1980).

pixel. Two-dimensional picture element that is the smallest nondivisible element of a digital (raster) image (FGDC 1998). Common pixel resolutions are 30 m and 90 m (i.e., each pixel represents a square of the Earth's surface 30 m or 90 m on a side).

plant association. A recurring potential natural plant community with a characteristic range in species composition, specific diagnostic species, and a defined range in habitat conditions and physiognomy or structure (Jennings et al. 2004). These occur as repeatable patterns across the landscape (FGDC 1997).

plot. (1) A circumscribed sampling area for vegetation (Lincoln et al. 1998). (2) Any two-dimensional sample area of any size, including quadrates, rectangular plots, circular plots, and belt-transects (which are merely very long rectangular plots). Belt-transects are often simply called strips or transects (Mueller-Dombois and Ellenburg 1974).

point. In reference to geospatial data, a dimensional-dimensional object that specifies geometric location. One coordinate pair or triplet specifies the location. Area point, entity point, and label point are special implementations of the general case (FGDC 1998).

polygon. An areal feature that occupies a unique spatial location.

potential natural vegetation (PNV). The plant community that would become established if all successional sequences were completed without human interference under the present environmental and floristic conditions, including those created by man (Tüxen 1956, as cited in Mueller-Dombois and Ellenberg 1974).

reflectance. The total solar energy incident on a given feature minus the energy that is either absorbed or transmitted by the feature. Reflectance is dependent on the material type and condition, and allows different features in a visual image to be distinguished (Wirth et al. 1996).

representative sampling. Employs systematic or random location of plots within strata, but rejection criteria may be necessary to avoid sampling obvious ecotones, which are of limited use for classifying vegetation. The gradsect technique or gradient-directed sampling is one example of this approach (Austin and Heylingers 1991, as cited in Jennings et al. 2004). It is a form of stratified random sampling that may be cost effective for sampling vegetation patterns along environmental gradients (Gillison and Brewer 1985).

resolution. The minimum difference between two independently measured or computed values that can be distinguished by the measurement or analytical method being considered or used (FGDC 1998).

remote sensing. (1) The gathering of data regarding an object or phenomenon by a recording device (sensor) that is not in physical contact with the object or phenomenon under observation (Wirth et al. 1996). (2) The science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by device that is not in contact with the object, area, or phenomenon under investigation (Lillesand and Kiefer 1994).

scale. (1) The relationship between a distance on a map and the corresponding distance on the Earth. (2) In general, the degree of resolution at which ecological processes, structures, and changes across space and time are observed and measured (ECOMAP 1993). (3) Describes the proportion that defines the relationship of a map, image, or photograph to that which it represents, such as distance on the ground (Burrough 1986).

sensor. A device that records electromagnetic radiation or other data about an object and presents it in a form suitable for obtaining information about the environment (Wirth et al. 1996).

series. (1) In vegetation classification, an aggregation of taxonomically related plant associations that takes the name of climax species that dominate the principle layer. It is a group of associations or habitat types with the same dominant climax species. Conceptually it is analogous to an alliance, with the series being a potential natural vegetation concept (Driscoll et al. 1984). (2) In soil science, a group of soils having horizons similar in differentiating characteristics and arrangement in the soil profile, except for texture of the surface horizon (USDA NRCS 1993).

shrubs. Woody plants that generally exhibit several erect, spreading, or prostrate stems, and have a bushy appearance. In instances where life form cannot be determined, woody plants less than 5 meters in height will be considered shrubs (FGDC 1997).

site. An area delimited by fairly uniform climatic and soil conditions (similar to habitat).

spatial data. Data that record the geographic location and shape of geographic features and their spatial relationships to other features (FGDC 1998).

spatial resolution. The measure of sharpness or fineness in spatial detail. It determines the smallest object that can be resolved by a given sensor, or the area on the ground represented by each pixel. For digital imagery, spatial resolution corresponds to pixel size and may be understood as roughly analogous to "grain" in photographic images (Helms 1998).

species. In biological classification, the category below genus and above the level of subspecies and variety. It is the basic unit of biological classification (Lincoln et al. 1998).

stand. A community, particularly of trees, possessing sufficient uniformity as regards to composition, age, spatial arrangement, or condition, to be distinguishable from adjacent communities, so forming a silvicultural or management entity (Ford-Robertson 1971).

stratum. In general, one of a series of layers, levels, or gradations in an ordered system. In the natural environment, the term is used in the sense of (1) a region of sea, atmosphere, or geology that is distinguished by natural or arbitrary limits or (2) a layer of vegetation, usually of the same or similar height (FGDC 1998).

structure. (1) The spatial arrangement of the components of vegetation (Lincoln et al. 1998). (2) A function of plant size and height, vertical stratification into layers, and horizontal spacing of plants. Physiognomy refers to the general appearance of the vegetation, while structure describes the spatial arrangement of plants in more detail. Physiognomy should not be confused with structure (Mueller-Dombois and Ellenberg 1974).

succession. Partial or complete replacement of one community by another (Daubenmire 1978).

surficial geology. The mode of deposition of unconsolidated deposits lying on bedrock or occurring on the Earth's surface, and the rock type(s) from which those deposits are derived, known as "kind" and "origin," respectively.

taxa. The plural form of taxon, which is a classification entity.

taxonomic unit. The basic set of classes or types that comprise a classification; in this document, a classification of environmental elements or integrated enviornmental elements (ecological types). Taxonomic units represent a conceptual description of ranges and/or modal conditions in environmental characteristics. A taxonomic unit (or taxon) is a class developed through the scientific classification process, or a class that is part of a taxonomy (USDA NRCS 1993). A taxonomic unit is the physical representation of a taxon, or the physical representation of a unit of a classification.

theme. (1) A group of data that represent a place or thing such as soils, vegetation, or roads. A theme could be less concrete such as population density, school districts, or administrative boundaries (FGDC 1998). (2) For a GIS context, see **layer**.

trees. Woody plants that generally have a single main stem and have more or less definite crowns. In instances where life form cannot be determined, woody plants equal to or greater than 5 meters in height will be considered trees (FGDC 1997).

user's accuracy. In reference to accuracy assessment, an accuracy measure based on a commission error as shown in the error matrix. Also known as reliability, user's accuracy is the probability that pixels classified on the map actually represent the category on the ground. User's accuracy is calculated by dividing the total number of correctly classified sites of a certain category by the total number of the certain category classified by the map (Wirth et al. 1996).

vascular plant. Plant with water and fluid conductive tissue (xylem and phloem), including seed plants, ferns, and fern allies (FGDC 1997).

vegetation cover. Vegetation that covers or is visible at or above the land or water surface. It is a subcategory of Earth cover. The percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of the foliage of plants (FGDC 1997).

vegetation data. The attributes of the vegetation that are used to classify and characterize the vegetation type and to map vegetation stand. These data come from the interpretation of remotely sensed imagery, fieldwork, and other thematic data sources (FGDC 1997).

vegetation mapping. The process of delineating the geographic distribution, extent, and landscape patterns of vegetation types based on composition, physiognomy, and structure.

vegetation type. A named class of plant community or vegetation defined on the basis of selected shared floristic, physiognomic, and/or structural characteristics, which distinguish it from other classes of plant communities or vegetation (Jennings et al. 2004).

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Appendix C. Vegetation Ocular Forms and Codes

This appendix includes examples of forms for recording plot metadata, environmental attributes, and vegetation data for ocular macroplots which provides a minimum set of vegetation data required for Terrestrial Ecological Unity Inventory (TEUI).

Plot Location

Locate the plot within a representative and uniform portion of the vegetation and site conditions to be sampled. The plot should not cross-obvious ecotones of vegetation or site conditions. In some cases, you may locate the plot to sample vegetation and site conditions within broad ecotones.

Mark the center of the plot, measure, and flag the outside edge. Place flagging or metal pins upslope, downslope, and along the contour to the left and right of plot center. Once you mark the plot boundary, walk around the plot and become familiar with the plant species, ground cover, vegetation layering, and other ecological characteristics.

Calibration

Conduct ocular estimate calibration at the beginning of inventory projects and periodically throughout the life of the project. Calibrate ocular estimates by using cover frequency and/or line intercept transect methods (refer to *National Range Protocols* [USDA Forest Service 2003c] for these methods). Examiners usually calibrate their ocular estimates by periodically double sampling with cover frequency transects. Minimal variability usually exists between trained examiners on canopy cover estimates and is negated by the many samples that can be obtained with this method.

Cover Frequency

The cover frequency method uses a 20 cm x 50 cm Daubenmire frame systematically placed along a transect to record quantitative values for canopy cover and ground cover. Species composition is then determined from canopy cover, frequency, and ground cover. The cover frequency method is best for vegetation types of less then 1 meter in height. Specific methods for conducting cover frequency are identified in the *National Range Protocol*'s "Cover Frequency Field Guide" (USDA Forest Service 2003a). Note: While the protocol requires a minimum of 3 transects and 60 frames, we recommend a total of only 30 frames.

Line Intercept

The line intercept method consists of a line transect, usually in multiples of 100 feet, where measurements are made of the crown spread of the various plants that are bisected by the transect line. The line intercept method is commonly used for measurement of semi-arid shrub and bunchgrass vegetation types. Specific methods for conducting line intercept sampling method are identified in the *National Range Protocol*'s "Line Intercept Field Guide" (USDA Forest Service 2003b).

Absolute numbers facilitate the ease of data sharing, can be easily converted to cover classes, and, in the case of classes with wide ranges at the lower end, may increase accuracy in analysis. Absolute percent cover of the fixed area plot is the standard and is required. Cover classes are optional and are accommodated in the Natural Resource Information System (NRIS) Terra database. Class code sets will be stewarded by regions.

Species Identification

Vascular Species

Integrated plots require a list of all vascular species and their percent canopy cover. Lichens/nonvascular species are optional. Species should be organized on the field form by life form class. Use taxonomy supported by locally/regionally accepted floras. Identify to species level. In identifying subspecies/varietal level, default to local/regional direction. (The NRIS Terra data form will display all four levels of scientific name when plant code is entered.) Natural Resources Conservation Service (NRCS) PLANTS database symbols (plant code) are the standard national coding system for plants. All codes in the NRCS PLANTS database are valid choices.

Coding and Collection of Unknown Species

Immature plants that cannot be identified to the species level should be identified to the genus level. The NRCS PLANTS database has symbols for the genus level when species cannot be determined. When species or genus cannot be determined, use the most appropriate general organism code for an unknown plant. Mature plants that cannot be identified in the field should be collected and pressed for later identification. Assign a collection number to the collection and record on a data line on the field form along with other required information (percent cover, etc.). For unknown species and/or species collected for subsequent identification, use an appropriate NRCS general organism code for the plant symbol (e.g., 2FORB = unknown forb). See the National PLANTS database (http://plants.usda.gov) for a complete list of these codes.

Collection Numbers

Assign collection numbers that enable pressed samples to be easily related back to field forms or database entries later. At a minimum, record collection number, examiner, and date on the collection. For example, label the collected plant with the site ID followed by a unique number for the plant collected on that plot. The collection number identifies that plant on the field form. For example, if three unknown plants were collected on plot 642, they could be recorded as 642-1, 642-2, and 642-3. It is not necessary to re-collect the same unknown species on every plot. If the same unknown species obviously is present on additional plots, that same collection number could be referenced on the field form for that plot. For example, if two unknown species occurred on plot 645, one a "new" discovery and the other collected previously on plot 642, they could be recorded as 645-1 (the new unknown) and 642-3 (the collection number assigned to a previously collected plant).

Legacy Plant Coding Systems

NRCS PLANTS database symbols (plant codes) are the required standard national coding system for plants. While the maintenance and continued use of local or "legacy" plant coding systems (such as Regional code sets) is discouraged, such codes still may have utility in working with non-Forest Service partners and with legacy data sets/publications. The NRIS Terra database accommodates legacy-coding systems by supporting a crosswalk table between legacy systems and the NRCS PLANTS database that is managed by the Regional Plants database steward. Coordinate with your Regional Plants database steward for access to legacy coding systems.

Productivity

Numerous methods can estimate the productivity potential for an ecological type or map unit component. TEUI projects should provide at least one measure of site productivity. Examples of productivity measures include site index, growth basal area, potential productivity, stand density index, and growth estimates.

Site index is a measure of site productivity expressed by the height-to-age relationship of dominant and co-dominant trees of a given species at a given base age. It is an index of site yield capability.

Growth basal area is an index of forest stand stockability (Hall 2003) It uses the relationship between current radial increment or dominant trees, current total stand basal area, and age to index the capability of a site to support and grow wood volume.

Potential productivity can be determined for rangelands by clipping and weighing vegetation, which is often done by either species or life form. Clipping by species should be done when characterizing ecological sites and correlating with NRCS.

Stand density-index based volume index is an index of yield capacity that uses spatial data interference adjustments to normal yield tables.

C.1 Instructions for General Site Data Form

Collect the following data elements at all sample sites: **R**=*Required,* O=*Optional.*

Field Name		Instructions
Site ID	**R**	Record a plot number or site identifier that is unique within the project.
Project Name	**R**	Record the name of the project.
Date	**R**	Record the month, day, and year in the format MM-DD-YYYY.
Sample Type(s)	**R**	Record the type(s) of data collected on the plot using the following codes: **OCMA** = Ocular macroplot; **FLLI** = Flora line intercept **FLCO** = Flora cover/frequency; **FLPO** = Flora point cover **FLTR** = Flora tree data (individual tree measurements); **SOPE** = Soil pedon
Examiner(s)	**R**	Record the last name, first name, and middle initial of all crewmembers. Record the name of the principal investigator first.
Plot Location Type	**R**	Record the approach used to locate the plot using the following codes: **P** = Preferential **R** = Random **S** = Stratified random (or systematic) See section C.2.3 for a discussion of sampling strategies.
Species List Type	**R**	Record the completeness of the plant species list for the plot using the following codes: **C** = Complete. All plant species present at time of sampling are recorded. **R** = Reduced. Not all plant species are recorded. The list may be limited by a cover threshold (e.g. > 5% cover) or relative abundance (e.g., five most abundant species). **S** = Selected. Not all plant species recorded. A protocol- or project-specific list of species are recorded whenever they are present on a plot. **L** = Life form only. No species are recorded. Cover is only recorded for life forms, and usually by layer or size class within life form. A complete species list is required for developing and describing new associations and alliances. See section C.2.4.3 for more information.
Plot Area	**R**	Record the area of the macroplot or belt-transect in either acres or square meters, and the unit of measure (UOM) used. See section C.2.4.1 for guidelines for determining plot size.
Plot Size	**R**	Record actual plot dimensions, using radius for circular plots, and width and length for rectangular plots. Also record the UOM used.

Field Name		Instructions
Vegetation Classification	**R**	Record as much classification information as known at the time of sampling including the potential natural vegetation (PNV) series, association, and reference; existing vegetation alliance, association, and reference; ecological type; and Federal Geographic Data Committee (FGDC) subclass. Subclass is determined in the field using the key in appendix 1C of the *Existing Vegetation Classification and Mapping Technical Guide* (Brohman and Bryant, eds. 2005).
GPS Location	**R**	Record the location of the sample site using latitude-longitude or Universal Transverse Mercator with zone.

Field Name		Instructions
Aerial Photo ID	O	Record the photo identification number.
Flight Line	O	Record the three-digit photo flight line.
Roll #	O	Record the three-digit roll number and contract fiscal year. For example, “189” identifies roll 1 taken in fiscal year 1989.
Plot Photo Label	O	Record a descriptive alpha/numeric label to track photos. For example, roll number followed by exposure # “2-14” to help label and track photos after processing.
Photo Description	O	Record a description of the photo subject.
Film Type	O	Record the type of film when a film camera is used.
Digital Photo File Name	O	Record the filename of the photo when a digital camera is used.
Elevation	**R**	Record the sample site elevation, in feet, to the nearest 10 feet.
Slope	**R**	Record the sample site average slope, in percent.
Aspect	**R**	Record the sample site aspect, in degrees. For slopes that have no aspect, record a zero. For due north, record 360.
Horizontal Slope Shape	O	Record the horizontal shape of the plot. See section C.1.1 and figure C.1 for values and codes.
Vertical Slope Shape	O	Record the vertical shape of the plot. See section C.1.1 and figure C.1 for values and codes.
Slope Complexity	O	Record the slope complexity of the plot using the following codes: **S =** Simple. Linear, convex, or concave in shape. **C** = Complex. Broken, undulating, or patterned in shape.
Slope Position	**R**	Record the two-dimensional position of the plot on the landform using the following codes: **SU** = Summit **SH** = Shoulder **BS** = Backslope **FS** = Footslope **TS** = Toeslope
Slope Position Modifier	**R**	Record the modifier which best describes the primary slope position using the following codes: **LR** = Lower **MD** = Mid **UP** = Upper
Ground Surface Cover Type	**R**	Record each ground surface cover type present in the plot. See sections C.1.2 and C.1.3 for types, descriptions, and codes.
Ground Surface Cover Percent	**R**	Record an ocular estimate of the percentage of the plot covered by each ground surface cover type.

Field Name		Instructions
Disturbance Type	O	Record major disturbance events. See Section C.1.4 for a list of disturbance types and codes.
Disturbance Extent Affected	O	Record the vegetation affected and/or the ground cover affected, in percent.
Disturbance Date	O	Record the disturbance date, in years, to the nearest year.
Disturbance Notes	O	Record notes relating to major disturbance event. Include the type of vegetation or species affected.

C.1.1 Vertical and Horizontal Shape Code

The following codes should be used for vertical and horizontal slope shape:

Code	Description
BR	**Broken**. Cliffs, knobs, and/or benches interspersed with steeper slopes; generally characterized by sharp, irregular breaks.
CV	**Convex**. Raised, arched up, curved out.
LI	**Linear/Planar**. Straight, even, or smooth.
CC	**Concave**. Depressional, curved in.
UN	**Undulating (also rolling**). Pattern of one or more low relief ridges or knolls and draws
PA	**Patterned.** Relief of hummocks and swales with several feet
FL	**Flat**. Straight and level.
XX	**Unable to assess**.

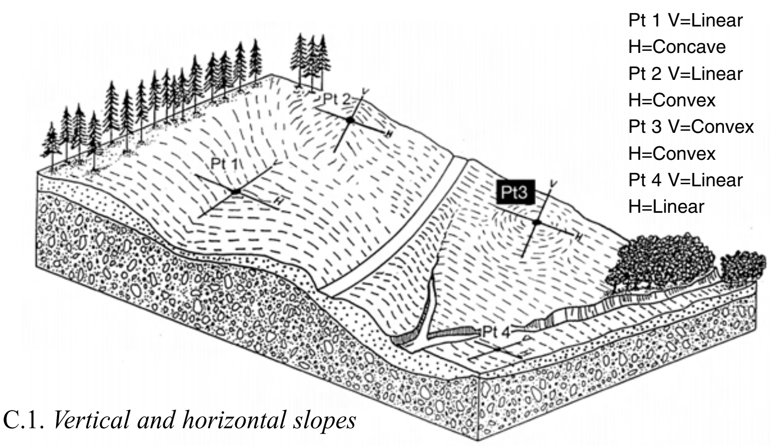

Figure C.1. *Vertical and horizontal slopes*

C.1.2 Ground Surface Cover

Ground surface cover estimates are ocular. Absolute percent cover of the fixed area plot is the standard and required. Ground surface cover is defined as the percentage of plot surface area that is occupied by the ground cover type. Estimate to the nearest 1 percent in the 1 to 10 percent range, to the nearest 5 percent for amounts exceeding 10 percent. Figure C.2 illustrates some ground cover types. The following reduced set of ground cover categories is used in existing vegetation classification to describe and develop interpretations for ground cover and document disturbance effects:

Code	Description
BARE	**Bare soil.** Soil particles < 2 mm not covered by rock, cryptogams, or organic material. Does not include any part of a road, but does include foot trails.
Live Vegetation Categories	
BAVE	**Basal vegetation.** Basal vegetation is the soil surface occupied by live basal or root crown portion of vascular plants, including live trees. Typically ranges between 3 and 7%; 15% is very high and rarely encountered.
NONV	**Nonvascular.** Plants or plant-like organisms without specialized water or fluid conductive tissue (xylem and phloem). Includes mosses, liverworts, hornworts, lichens, algae, and bacterial soil crusts.
Organic Debris Categories	
LITT	**Litter.** Plant litter and duff not yet incorporated into the decomposed top humus layer. Includes twigs < 1/4 inch in diameter, ash from burned plants, dead nonvascular plants, and dung.
WOOD	**Wood.** Any dead woody material > 1/4 inch in diameter, small and large woody debris, regardless of depth. Includes bases of standing dead trees and shrubs.
Rock Categories	
BEDR	**Bedrock.** A general term for the rock, usually solid, that underlies soil or other unconsolidated, superficial material.
BOUL	**Boulders.** Rock > 600 mm (24 inches) in diameter or length.
COBB	**Cobbles.** Rock fragments between 75 and 250 mm (3 and 10 inches) in diameter.
GRAV	**Gravel.** Rock fragments between 2 and 75 mm in diameter.
PAVE	**Pavement.** A natural concentration of closely packed and polished stones at the soil surface in a desert (may or may not be an erosional lag). Also, rock fragments < 19.1mm in diameter.
ROCK	**Total rock.** Relatively hard, naturally formed mineral or petrified matter > 2mm in diameter.
RROC	**Range rock.** Rock fragments > 3/4 inch (19.1 mm) in diameter.
STON	**Stones.** Rock fragments between 250 and 600 mm (10 and 24 inches) in diameter.
Miscellaneous Categories	
PEIS	**Permanent ice and snow.** Surface area covered by apparently permenent ice and/or snow at the time of plot measurement.
ROAD	**Road.** Any road or vehicle trail that is regularly maintained or in long-term continuous use. Includes cutbanks and fills.
TRIS	**Transient ice and snow.** Surface area covered by apparently transient ice and/or snow at the time of plot measurement.
WATE	**Water.** Includes transient water that obscures other cover cover types and permanent water where the water table is above the ground bogs, swamps, marshes, and ponds.

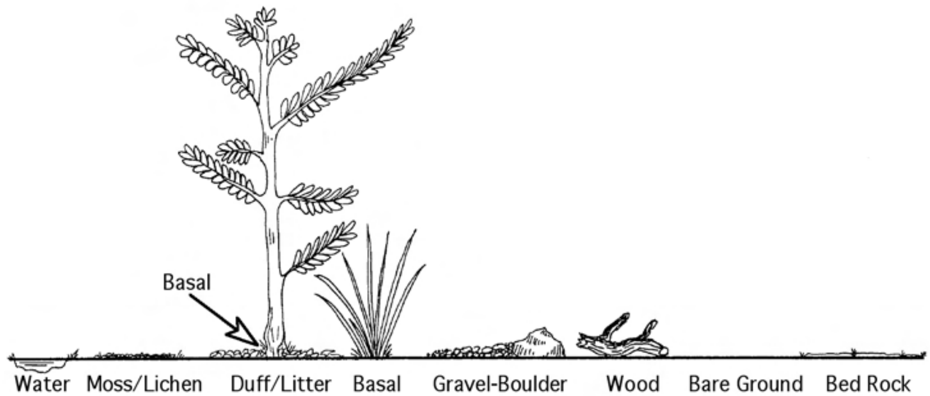

Figure C.2. *Ground surface cover types*

The following ground cover types should be recorded whenever present and are included on the example General Site Data form: bare soil, basal vegetation, nonvascular, litter, and wood. More detailed subdivisions of these categories are available in the NRIS Terra database, but are not recommended for vegetation classification. The miscellaneous categories should also be recorded whenever present. Rock cover must be recorded using one of the three sets of categories described below.

C.1.3 Rock Ground Cover Types

Rock cover on the ground surface should be described using one of the following sets of ground cover types. Set 1 is the minimum requirement. Set 2 is used primarily for specific rangeland monitoring methods. Set 3 is recommended for vegetation classification and description done in conjunction with TEUI.

Rock Set 1		Rock Set 2		Rock Set 3	
ROCK	All rock from gravel to bedrock.	PAVE	Pavement (2–19.1 mm diam.)	GRAV	Gravel (2–75 mm diam.)
				COBB	Cobbles (75–250 mm diam.)
		PROC	Rock (> 19.1 mm diam.)	STON	Stones (250–600 mm diam.)
				BOUL	Boulders (> 600 mm diam.)
				BEDR	Bedrock

C.1.4 Disturbance Event Code Categories

The following codes should be used for disturbance and treatment types:

Code	Disturbance or Treatment	Code	Disturbance or Treatment
10000	Insects (general)	50003	Drought
10011	Ant (Formicidae)	50004	Flooding/high water
11000	Bark beetles	50011	Snow/ice
12000	Defoliators	50013	Wind/tornado
13000	Chewing insects	50015	Avalanche
14000	Sucking insects	50016	Mud/landslide
15000	Boring insects	51001	Channel erosion
16000	Seed/cone/flower/fruit insects	51002	Soil creep
17000	Gallmaker insects	51010	Slump
18000	Insect predators	70005	Land clearing
19000	General diseases	70006	Land use conversion
20000	Biotic damage	70008	Mechanical
21000	Root/butt diseases	71000	Timber harvest
22000	Stem decay/cankers	71002	Firewood harvest
23000	Parasitic/epiphytic plants	71027	Natural changes (no cut)
23001	Mistletoe	73000	Regeneration activities (general)
24000	Decline complexes/dieback/wilts	73004	Seeding (trees-natural)
25000	Foliage diseases	73005	Seeding (trees-artificial)
26000	Stem rusts	73008	Grass seeding
27000	Broom rusts	73015	Site preparation
30000	Fire	73016	Brush control
41002	Beaver	74000	Timber stand improvement (general/noncommercial)
41003	Big game (e.g., deer)	75000	Prescribe burning (general)
41016	Browsing	75004	Planned ignition/prescribed burnnatural fuels
41021	Rodents	75005	Unplanned ignition/prescribed burn/natural fuels
41022	Elk	78007	Miscellaneous upland recreation activities
42001	Cattle	78008	Miscellaneous riparian recreation activities
42004	Sheep	80000	Multi-damage (insects/diseases)
		90000	Unknown

General Site Data Form

USDA Forest Service

Site ID #	Project Name		
Date (mm-dd-yyyy)	Sample Type(s)		
Examiner: Last	First	Initial	
Plot Location Type:	Species List Type:	Plot Area:	UOM
Plot Size: Radius	Width	Length	UOM
State:			

Vegetation Classification

PNV Series:	PNV Assoc:	PNV Reference:
EV Alliance:	EV Assoc:	EV Reference:
Ecological Type:		FGDC Subclass:

GPS Location

Lat.	UTM	North
Long.	Zone	East

Aerial Photo Information

Date	Source	Scale	Proj/Code	Flight Line	Roll #	Exp. #

Plot Photo Information

Label	Photo Description	Film Type	Digital Photo File Name

Morphometry

Elevation	Slope	Aspect	Shape Hor.	Shape Vert.	Complexity	Position ________________ mod_____________

Ground Surface Cover

Type	Percent	Type	Percent	Type	Percent	Type	Percent
BAVE		BARE					
NONV							
LITT							
WOOD							

Major Disturbance Events

Disturbance Type	Extent Affected		Disturbance Date	Notes:
	Vegetation	Ground Cover		

Remarks:

C.2 Instructions for Vegetation Composition Form

The Vegetation Composition Form can be used to record or summarize data for a number of sampling methods. Its use for the ocular macroplot method is described here.

C.2.1 Vegetation Sampling Metadata

The first part of the Vegetation Composition Form records metadata about the vegetation sampling methods and who collected the data. The plot location should be recorded on the General Site Data Form.

Field Name		Instructions
Site ID	**R**	Record a plot number or site identifier that is unique within the project. This must match the Site ID on the General Site Data Form.
Date	**R**	Record the month, day, and year in the format MM-DD-YYYY.
Examiner(s)	**R**	Record the last name, first name, and middle initial of all crewmembers. Record the name of the principal investigator first.
Sample Type	**R**	Record the type of data collected on the plot using one of the following codes: **OCMA** = Ocular macroplot **FLCO** = Flora cover/frequency **FLTR** = Flora tree data **FLLI** = Flora line intercept **FLPO** = Flora point cover
Species List Type	**R**	Record the completeness of the plant species list for the plot using the following codes: **C** = Complete. All plant species present at time of sampling are recorded. **R** = Reduced. Not all plant species are recorded. The list may be limited by a cover threshold (e.g., > 5% cover) or relative abundance (e.g., five most abundant species). **S** = Selected. Not all plant species recorded. A protocol- or project-specific list of species are recorded whenever they are present on a plot. **L** = Life form only. No species are recorded. Cover is only recorded for life forms, and usually by layer or size class within life form. A complete species list is required for developing and describing new associations and alliances. See section C.2.4.3 for more information.
Plot Area	**R**	Record the area of the macroplot or belt transect in either acres or square meters, and the UOM used. See section C.2.4.1 for guidelines for determining plot size.
Area UOM	**R**	Record the UOM for the plot area, either acres or square meters.
Plot Size	**R**	Record actual plot dimensions, using radius for circular plots, and width and length for rectangular plots. Also record the UOM used.
Size UOM	**R**	Record the UOM for the plot dimensions, either feet or meters.
Height UOM	**R**	Record the UOM for plant heights, either feet or meters.
Diameter UOM	**R**	Record the UOM for tree diameters.

C.2.2 Canopy Cover by Life Form

Record the canopy cover for each item in this part of the form. Canopy cover is "the percentage of ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of plants. Small openings within the canopy are included" (SRM 1998, USDA NRCS 1997). See sections 2.2.3.3 and 2.4.5 of the *Existing Vegetation Classification and Mapping Technical Guide* (Brohman and Bryant, eds. 2005) for more information about canopy cover and ocular estimation techniques.

Complete the fields in this part of the form as follows:

All vegetation	**Total vegetation cover.** Record the percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of foliage of all vascular plants within the sample unit (plot or transect).
Trees	**Tree cover.** Record the total cover of trees, defined as woody plants that generally have a single main stem, have more or less definite crowns, and are usually equal to or greater than 5 meters in height at maturity (see section 2.4.2.1 of Brohman and Bryant 2005).
Shrubs	**Shrub cover.** Record the total cover of shrubs, defined as woody plants that generally have several erect, spreading, or prostrate stems which give it a bushy appearance, and are usually less than 5 meters in height at maturity (see section 2.4.2.1 of Brohman and Bryant 2005). Shrub cover includes the cover of dwarf shrubs.
Dwarf shrubs	**Dwarf shrub cover.** Record the total cover of dwarf shrubs, defined as caespitose, suffrutescent, matted, or cushion-forming shrubs which are typically less than 50 cm tall at maturity due to genetic and/or environmental constraints (see section 2.4.2.1 of Brohman and Bryant 2005).
Herbs	**Herb cover.** Record the total cover of herbs, defined as vascular plants without significant woody tissue above the ground, with perennating buds borne at or below the ground surface (see section 2.4.2.1 of Brohman and Bryant 2005). Includes forbs, graminoids, ferns, and fern allies. Herb cover must be equal to or less than the sum of graminoid cover and forb cover.
Graminoids	**Graminoid Cover.** Record the total cover of graminoids, defined as flowering herbs with relatively long narrow leaves and inconspicuous flowers with parts reduced to bracts. Include grasses, sedges, rushes, and arrowgrasses (see section 2.4.2.1 of Brohman and Bryant 2005).
Forbs	**Forb Cover:** Record the total cover of forbs, defined as spore-bearing herbs or flowering herbs with relatively broad leaves and/or showy flowers (see section 2.4.2.1 of Brohman and Bryant 2005). Include ferns or fern allies.

Dwarf shrubs are a subcategory of shrubs. Forbs, graminoids, and fern-likes are subcategories of herbs. Total canopy cover of additional life forms can be recorded in part 3 of the Vegetation Composition Form as needed.

C.2.3 Canopy Cover by Species

The third part of the Vegetation Composition Form is used to record data about vegetation layers and individual plant species. This portion of the form is divided into a section for trees and shrubs and a section for herbs and nonvascular organisms.

Record a complete list of all plant species within the sampling unit. Record only those species present in the plot. Do not record species that are present in the stand but do not occur within the plot. Record the canopy cover for each species. Do not use cover classes. Estimate percent canopy cover of each species, life form, layer, or size class within the plot as follows:

- Use 0.1 as "trace" for items present but clearly less than 1 percent cover.
- Estimate to the nearest 1 percent between 1 and 10 percent cover.
- Estimate to at least the nearest 5 percent between 10 and 30 percent cover.
- Estimate to at least the nearest 10 percent for values exceeding 30 percent cover.

Record a life form and life form modifier for each species using the codes in tables 2.5 and 2.6, respectively, of the *Existing Vegetation Classification and Mapping Technical Guide* (Brohman and Bryant, eds. 2005). These codes are used for crosswalking to the FGDC physiognomic hierarchy and describing physiognomy of associations and alliances (Jennings et al. 2004).

C.2.4 Canopy Cover and Structural Data by Layer

Species data may also be recorded by layer if desired. The following instructions describe how to record data for tree and shrub layers, and for tree and shrub species by layer.

C.2.4.1 Tree Layer Definitions

Trees vary widely in mature height, from 5 meters to more than 50 meters (FGDC 1997). This variation must be taken into account when defining layers or height classes for trees. For this purpose, a dwarf tree is defined as a tree that is typically less than 12 meters tall at maturity due to genetic and/or environmental constraints. A stand of dwarf trees typically has a site-specific potential height growth of less than 12 meters. The layers described below are defined separately for dwarf trees where necessary.

The following tree layers must be described whenever they are present in the sampling unit (e.g., macroplot or transect):

Overstory (TO) The overstory layer includes all trees greater than or equal to 5 meters in height that make up the forest canopy. In dwarf tree stands, the overstory consists of trees that have attained at least half of their site-specific potential height growth and make up the forest canopy.

Regeneration (TR) The regeneration layer includes all trees less than 5 meters in height. In dwarf tree stands the regeneration layer includes trees that have attained less than half of their site-specific potential height growth and are clearly overtopped by the overstory trees.

The overstory may optionally be subdivided into the following sublayers, if they occur, to describe stand structure in more detail:

Main canopy (TOMC) The dominant and co-dominant overstory trees that receive direct sunlight from above and make up the majority of the forest canopy.

Supercanopy (TOSP) Scattered overstory trees that clearly rise above the main canopy.

Subcanopy (TOSB) Overstory trees that are clearly overtopped by and separate from the main canopy, but are larger and taller than the regeneration layer.

The regeneration layer may optionally be subdivided into the following sublayers:

Saplings (TRSA) Regenerating trees greater than 1.4 meters (4.5 feet) in height, ***or*** regenerating dwarf trees greater than 1 meter in height.

Seedlings (TRSE) Regenerating trees less than 1.4 meters (4.5 feet) in height, ***or*** regenerating dwarf trees less than 1 meter in height.

C.2.4.2 Tree Layer Data Requirements and Instructions

Canopy cover, predominant plant height, and predominant crown height must be recorded for the tree overstory and regeneration layers. Predominant diameter must also be recorded for the overstory. Record these attributes using the following procedures:

Canopy cover	Record percent canopy cover for each layer and optional sublayer occurring within the sampling unit. Canopy cover of a layer cannot be greater than the sum of the canopy cover values of its sublayers. Layer cover, however, typically is less than the sum of the sublayer covers due to overlapping of the sublayers.
Predominant plant height	Record the predominant, or prevailing, tree height for the overstory and regeneration layers to the nearest meter and nearest foot, respectively. This attribute is determined by selecting a representative tree for the layer and estimating its height using a clinometer and measuring tape. The representative tree for the overstory layer must be in the main canopy. The representative tree for the regeneration layer must be from the sublayer (sapling or seedling) with the most canopy cover. Predominant plant height may also be recorded for each optional sublayer.

Predominant crown height	Record the predominant, or prevailing, crown height for the overstory and regeneration layers to the nearest meter. Crown height is the vertical distance from ground level to the lowest whorl with live branches in at least three of four quadrants around the stem. It is determined by selecting a representative tree for the layer and estimating its crown height using a clinometer and measuring tape. The representative tree for the overstory layer must be in the main canopy. The representative tree for the regeneration layer must be from the sublayer (sapling or seedling) with the most canopy cover. Predominant crown height may also be recorded for each optional sublayer.
Predominant diameter	Record the predominant, or prevailing, tree diameter for the overstory layer to the nearest inch. Predominant diameter is the prevailing diameter of the most abundant tree species in a layer or sublayer. It is determined by selecting a representative tree and measuring it with a diameter tape, using procedures described in the *Common Stand Exam Field Guide*. The representative tree for the overstory layer must be in the main canopy. Measure the diameter at breast height (d.b.h.) whenever possible; otherwise, measure diameter at root crown (d.r.c.), and record the diameter in the appropriate column (d.b.h. or d.r.c.) of the Vegetation Composition Form.

An example of both the required and optional data for tree layers is shown below.
Required layers and data are in bold text. Heights are in meters and diameters in inches.

Table C.1. *Example of completed data for tree layers and sublayers.*

Life form	LF mod.	Layer	Species	Canopy cover	Pred. plant height	Pred. crown height	Pred. d.b.h.	Pred. d.r.c.
T	—	**TO**	—	***45***	***10***	***6***	***12***	**—**
T	—	TOSP	—	*5*	*12*	*8*	*15*	—
T	—	TOMC	—	*40*	*10*	*6*	*12*	—
T	—	TOSB	—	*10*	*7*	*2.5*	*8*	—
T	—	**TR**	—	***10***	***4***	***0.3***		
T	—	TRSA	—	*5*	*4*	*0.3*		
T	—	TRSE	—	*5*	*0.3*	*0*		

C.2.4.3 Data for Shrub Layers

The following shrub layers may optionally be described when present in the sampling unit (e.g., macroplot or transect):

Tall shrubs Shrubs greater than 2 meters in height. (May occasionally include shrubs over 5 meters tall but clearly multi-stemmed.)

Medium shrubs Shrubs 0.5 to 2 meters in height.

Low shrubs Shrubs less than 0.5 meter in height.

When shrub layers are described, canopy cover and predominant plant height should be recorded for each layer. Predominant crown height may also be recorded. Record these attributes using the following procedures:

Canopy cover	Record percent canopy cover for each shrub layer occurring within the sampling unit. Total shrub cover cannot be greater than the sum of the individual layer cover values, but may be less.
Predominant plant height	Record the predominant, or prevailing, height of each shrub layer to at least the nearest foot. Predominant plant height is the prevailing upper height of the shrubs within a layer. It is determined by selecting a representative individual shrub and measuring its height with an appropriate method (e.g. tape measure for low to medium shrubs or clinometer for tall shrubs).
Predominant crown height	Record the predominant crown height for each shrub layer to at least the nearest foot. Crown height for shrubs is the vertical distance from ground level to the lowest live foliage or branches. It is determined by selecting a representative shrub for the layer and measuring or estimating its crown height.

An example of completed shrub layer data is shown below. Heights are in meters.

Table C.2. *Example of completed data for shrub layers.*

Life form	LF mod.	Layer	Species	Canopy cover	Pred. plant height	Pred. crown height
S	—	ST	—	*1*	*3*	*1*
S	—	SM	—	*9*	*1*	*0.3*
S	—	SL	—	*Tr*	*0.3*	*0*

C.2.5 Optional Canopy Cover and Structural Data by Species by Layer

Canopy cover and structural data may optionally be recorded separately for each species for each layer or sublayer in which it occurs.

C.2.5.1 Data for Tree Species by Layer

Canopy cover. Record the total canopy cover of each tree species and the canopy cover of each species within each layer in which it occurs. Cover by sublayer may also be recorded,requiring up to eight rows of data, depending on the number of sublayers in which a species occurs. An example is shown in table C.3 with required data in bold text. In this example, the canopy cover of Ponderosa pine (*Pinus ponderosa*) is 45 percent. Within the overstory and regeneration layers, its canopy cover is 35 and 10 percent, respectively, indicating no overlap between the two layers. No sapling or seedling occurs directly under an overstory tree. Overlap occurs, however, between main canopy and subcanopy trees. Ponderosa pine cover is 30 percent in the main canopy and 10 percent in the subcanopy, while overstory cover is only 35 percent. This indicates 5 percent overlap between main canopy and subcanopy Ponderosa pine.

The possibility of overlap between sublayers requires that overstory and regeneration cover for each tree species be estimated or measured directly, not calculated by summing the sublayer values. When recording species cover by sublayer using the ocular macroplot method, it is most efficient to first estimate canopy cover by sublayer, then estimate the overlap (if any) between sublayers to derive canopy cover for the overstory and regeneration layers.

Table C.3. *Example of tree species by layer canopy cover data.*

Life Form	LF Mod	Layer	Species	Canopy Cover
T	*TN*	—	*PIPO*	*45*
T	***TN***	***TO***	***PIPO***	***35***
T	*TN*	*TOMC*	*PIPO*	*30*
T	*TN*	*TOSB*	*PIPO*	*10*
T	***TN***	***TR***	***PIPO***	***10***
T	*TN*	*TRSA*	*PIPO*	*6*
T	*TN*	*TRSE*	*PIPO*	*4*

Predominant plant height. Record predominant height of each tree species for each layer in which it occurs. It is determined by selecting a representative tree and estimating its height using a clinometer and measuring tape, using procedures described in the *Common Stand Exam Field Guide* (2005).

Predominant crown height. Record predominant crown height of each tree species for each layer in which it occurs. It is determined by selecting a representative tree and estimating or measuring the vertical distance from the ground to the canopy base.

Predominant age. Record the predominant age of each tree species in the overstory layer. Refer to the *Common Stand Exam Field Guide* (2005) for methods of determining tree age.

Predominant diameter. Record predominant diameter (d.b.h. or d.r.c. as appropriate) for the overstory layer. It is determined by selecting a representative tree and measuring it with a diameter tape, using procedures described in the *Common Stand Exam Field Guide* (2005).

Stem count. Record stem counts for each tree species occurring in the regeneration layer. Stems may optionally be recorded by sublayer (sapling and seedling). Counts can be made on the entire plot or on a portion of the plot depending on the density of each species. When stems are counted on a portion of the plot, the fraction of the plot and the raw count are recorded in the remarks section of the form. These are then used to calculate a count for the entire plot, which is recorded in the stem count column of the form.

An example of a completed data set for one tree species is shown in table C.4. Predominant plant height, crown height, diameter, age, and stem count have been added

Life form	LF mod.	Layer	Species	Canopy cover	Pred plant ht.	Pred. crown height	Pred. d.b.h.	Pred. d.r.c.	Pred. age	Stem count
T	*TN*	—	*PIPO*	*45*						
T	*TN*	*TO*	*PIPO*	*35*	*40*	*15*	*30*	—	*150*	
T	*TN*	*TOMC*	*PIPO*	*30*	*40*	*15*	*30*	—	*150*	
T	*TN*	*TOSB*	*PIPO*	*10*	*20*	*5*	*12*	—	*80*	
T	*TN*	*TR*	*PIPO*	*10*	*4*	*0.5*				*13*
T	*TN*	*TRSA*	*PIPO*	*6*	*4*	*0.5*				*4*
T	*TN*	*TRSE*	*PIPO*	*4*	*0.3*	*0*				*9*

C.2.5.2 Data for Shrub Species by Layer

Canopy cover. Record the total canopy cover of each shrub species. The canopy cover of each species within each layer in which it occurs may be recorded optionally. This process may require up to four rows of data, depending on the number of layers in which a shrub species occurs. The possibility of overlap between layers requires that total canopy cover for each shrub species be estimated or measured directly, not calculated by summing the species by layer cover values.

Predominant crown height. Record predominant crown height of each shrub species for each layer in which it occurs. It is determined by selecting a representative shrub and estimating or measuring the vertical distance from the ground to the lowest live foliage.

Predominant height. Record predominant height of each shrub species or optionally for each layer in which the species occurs. Predominant height is the prevailing upper height of the shrub species within a layer. It is determined by selecting a representative individual shrub and measuring its height with an appropriate method (e.g., tape measure for low to medium shrubs or clinometer for tall shrubs).

An example of completed shrub species and species by layer data is shown below. Heights are in meters.

Table C.5. *Example of completed data for shrub species by layers.*

Life form	LF mod.	Layer	Species	Canopy cover	Pred. plant height	Pred. crown height
S	*SBD*	—	*QUGA*	*9*	*1*	*0.2*
S	*SBD*	*ST*	*QUGA*	*1*	*3*	*1*
S	*SBD*	*SM*	*QUGA*	*8*	*1*	*0.2*
S	*SM*	—	*ARTRP4*	*1*	*0.7*	*0.2*
S	*SM*	*SM*	*ARTRP4*	*1*	*0.7*	*0.2*

C.2.6 Basal Area Data

Basal area may optionally be collected using a single prism point at the center of a macroplot or midpoint of a transect. Follow the procedures in the *Common Stand Exam Field Guide* (2005). Record the basal area, in square feet per acre, and the expansion factor of the prism used.

C.2.7 Blank Vegetation Composition Form and Completed Examples

A blank Vegetation Composition Form is provided below, followed by examples of a completed General Site Data Form and Vegetation Composition Form.

VEGETATION COMPOSITION FORM

Site ID #:	Date: __ __ / __ __ / __ __ __ __	Examiner(s): ____________________
Sample Type:	Species List: C or R or S or L	

Plot Area:	Area UOM:	Height UOM:
Plot Size: Radius Length Width	Size UOM:	Diameter UOM:

Percent Canopy Cover by Life Form

Life Form:	**All Veg**	**Trees**	**Shrubs**	**Dwarf Shrubs**	**Herbs**	**Grasses**	**Forbs**
% Cover:							

Percent Canopy Cover and Structure Data by Layer and Species

Trees and Shrubs

Form	LF Mod.	Layer	Plant Code	Can. Cover	Pred. Plant Ht.	Pred. Crown Ht.	Pred. d.b.h.	Pred. d.r.c.	Pred. Age	Stem Count
T	**—**	**TO**	**—**							
T	—	TOSP	—							
T	—	TOMC	—							
T	—	TOSB	—							
T	**—**	**TR**	**—**							
T	—	TRSA	—							
T	—	TRSE	—							
S	—	ST	—							
S	—	SM	—							
S	—	SL	—							

Herbaceous and Nonvascular Life

Form	LF Mod.	Layer	Plant Code	Can. Cover	Pred. Ht.

Basal Area:	**BAF Used:**

Remarks:

General Site Data Form

USDA Forest Service

SITE ID # *FSR4BT92DT127*	PROJECT NAME *B-T East TEUI*		
DATE (MM-DD-YYYY) *08-23-1995*		SAMPLE TYPE(S) *OCMA, SOPE*	
EXAMINER: LAST *Tart* *Ferwerda*		First *David* *Martin*	Initial *L*
PLOT LOCATION TYPE: *P*	SPECIES LIST TYPE: *C*	PLOT AREA: 1/10	UOM *ACRE*
PLOT SIZE: RADIUS *37.2*	WIDTH	LENGTH UOM *FEET*	STATE: *WY*

VEGETATION CLASSIFICATION

PNV SERIES: *ABLA*	PNV ASSOC: *VASC, PIAL*	PNV REFERENCE: *Steele&1983*
EV ALLIANCE: *PIAL*	EV ASSOC: *VASC*	EV REFERENCE: *NONE*
ECOLOGICAL TYPE:		FGDC SUBCLASS: *IIA*

GPS LOCATION

LAT. *43º 18' 44"* UTM		NORTH
LONG. *110º 12' 33"* ZONE		EAST

AERIAL PHOTO INFORMATION

DATE	SOURCE	SCALE	PROJ/CODE	FLIGHT LINE	ROLL #	EXP. #
09-01-1989					*1715*	*87*

PLOT PHOTO INFORMATION

LABEL	PHOTO DESCRIPTION	FILM TYPE	DIGITAL PHOTO FILE NAME

MORPHOMETY

ELEVATION	SLOPE	ASPECT	SHAPE HOR.	SHAPE VERT.	COMPLEXITY	POSITION	MOD
9900'	*9%*	*19º*	*UN*	*UN*	*C*	*BS*	*UP*

GROUND SURFACE COVER

TYPE	PERCENT	TYPE	PERCENT	TYPE	PERCENT	TYPE	PERCENT
BAVE	*8*	BARE	*2*	*STON*	*7*		
NONV	*4*	*BEDR*	*5*	*BOUL*	*5*		
LITT	*50*	*GRAV*	*1*				
WOOD	*15*	*COBB*	*3*				

MAJOR DISTURBANCE EVENTS

DISTURBANCE TYPE	EXTENT AFFECTED		DISTURBANCE DATE	NOTES:
	VEGETATION	GROUND COVER		

Remarks: *Stop# B0606B. Location from pin-pricked photo, not GPS.*

VEGETATION COMPOSITION FORM

Site ID #: *FSR4BT92DT127*	Date: *08-23-1995*	Examiner(s): *David L. Tart*
Sample Type: OCMA	Species List: (C) or R or S or L	*Martin Ferwerda*

Plot Area: 1/10			Area UOM: *acre*	Height UOM: *feet*
Plot Size: *37.2*	Length	Width	Size UOM: *feet*	Diameter UOM:

Percent Canopy Cover by Life Form

Life Form:	All Veg	Trees	Shrubs	Dwarf Shrubs	Herbs	Grasses	Forbs
% Cover:	*(80)*	*45*	*35*	*35*	*12*	*7*	*5*

Percent Canopy Cover and Structure Data by Layer and Species

Trees and Shrubs

Form	LF Mod.	Layer	Plant Code	Can. Cover	Pred. Plant Ht.	Pred. Crown Ht.	Pred. d.b.h.	Pred. d.r.c.	Pred. Age	Stem Count
T	—	**TO**	—	*37*	*50*	*17*				
T	—	TOSP	—	—	—	—				
T	—	TOMC	—	*29*	*50*	*17*				
T	—	TOSB	—	*12*	*30*	*12*				
T	—	**TR**	—	*17*	—	—				
T	—	TRSA	—	*8*	—	—				
T	—	TRSE	—	*9*	—	—				
S	—	ST	—	—	—	—				
S	—	SM	—	—	—	—				
S	—	SL	—	*35*	*1*	—				
T	*TN*	—	*ABLA*	*20*	—	—				
T	*TN*	*TO*	*ABLA*	*7*	*30*	*12*				
T	*TN*	*TR*	*ABLA*	*16*	—	—				
T	*TN*	—	*PIAL*	*20*	—	—				
T	*TN*	*TO*	*PIAL*	*20*	*45*	*15*				
T	*TN*	*TR*	*PIAL*	*0.1*	—	—				
T	*TN*	—	*PIEN*	*13*	—	—				
T	*TN*	*TO*	*PIEN*	*12*	*60*	*20*				
T	*TN*	*TR*	*PIEN*	*1*	—	—				
S	*SD*	*SL*	*VASC*	*35*	*1*	*0*				

Herbaceous and Nonvascular Life

Form	LF Mod.	Layer	Plant Code	Can. Cover	Pred. Ht.
H	*HF*		*ASTER*	*0.1*	*1*
H	*HF*		*EPAN2*	*0.1*	*1*
H	*HF*		*ERIGE2*	*0.1*	*0*
H	*HF*		*HIGR*	*0.1*	*1*
H	*HG*		*CARO5*	*2*	*0*
H	*HG*		*JUDR*	*0.1*	*1*
H	*HG*		*POCU*	*0.1*	*2*
H	*HG*		*PONEW*	*5*	*3*
H	*HG*		*POPA3*	*0.1*	*1*

Basal Area:	BAF Used:

Remarks:

Appendix D. Geology and Geomorphology Form

Site ID #	Date (mm-dd-yyyy)	Examiner:

Bedrock Geology

Sequence Number	Primary Lithology	Secondary Lithology	Texture Modifier	Depth to Bedrock Class	Weathering	Chemistry Modifier	Structure Type	Azimuth Inclination	Fracture Interval	Strati-graphy

Parent/Surficial Material

Sequence Number	Origin	Kind	Kind Modifier	Chemistry Modifier	Size Class	Stratigraphy

Geomorphology

Generation	geomorphic classification
Active	
Dormant	
Relict	

Notes

Geology and Geomophology Form Instructions

Field Name	Description and Action To Be Taken
Site ID	Record the identifier that is unique within a specific project or inventory area.
Date	Enter the date the site was described. Example: 7-8-97.
Examiner	Enter the name of the person(s) describing the site.

Bedrock Geology

Field Name	Description and Action To Be Taken
Sequence Number	If more than one rock type will be described at the site, number from the top down.
Primary Lithology	Select primary lithology term from the table on page 152. Example: Sedimentary.
Secondary Lithology	Select secondary lithology term from the table on page 152. Example: Sandstone.
Texture Modifier	Select term from the table on page 160. Example: Clastic.
Depth to Bedrock Class	Estimate the depth to bedrock and place in appropriate class from the table on page 152. Example: DEEP.
Weathering	Determine weathering state from the table on page 152. Example: PDS – Partially Decomposed.
Chemistry Modifier	Select appropriate term from the table on page 163. Example: AC – Acidic.
Structure Type	Select appropriate term from Appendix A. Example: BE – Bedding.
Azimuth/Inclination	Record the azimuth of the strike and inclination of the dip in degrees. Example: 200/15.
Fracture Interval	Select appropriate class from the table on page 163. Example: 1 < 10 cm between fractures.
Stratigraphy	Locally determined values for unit name and age. Example: Kbb – Blind Bull Formation.

Parent/Surficial Material

Field Name	Description and Action To Be Taken
Sequence Number	If more than one rock type will be described at the site, number from the top down.
Origin	Select either primary lithology or secondary lithology from the table on page 152. Example: Sandstone.

Field Name	Description and Action To Be Taken
Kind	Select secondary lithology code from Parent/Surficial Materials table on page 163.
Kind Modifier	Select modifier from the table on page 166 if kind needs to be further defined.
Weathering	Determine weathering state from the table on page 152. Example: PDS – Partially Decomposed.
Chemistry Modifier	Select appropriate term from the table on page 163. Example: AC – Acidic.
Size Class	Select appropriate term from the table on page 167. Example: 7 – Loamy.
Stratigraphy	Locally determined values for unit name and age. Example: Kbb – Blind Bull Formation.

Geologic Terms and Definitions

Bedrock Characteristics

Depth to Bedrock Class

Depth Class	Definition
DEEP	Deep – 10 to 20 feet deep
MOD	Moderate – 5 to 10 feet deep
SHAL	Shallow – < 5 feet deep
VDEP	Very deep – > 20 feet deep

Bedrock Weathering

Weathering Code	Meaning – Definition
MFS	Micro fresh state – absence of oxidation alteration under hand lens.
VFS	Visually fresh state – uniform color with unaided eye.
STS	Stained state – partial or complete discoloration of mineral.
PDS	Partially decomposed state – solid in place, disaggregate by hand.
CDS	Completely decomposed – disaggregated or remolded to soil.

Bedrock Lithologies

Primary Lithology	Secondary Code	Secondary Description
Igneous Extrusive	ANBA	Analcite Basalt
Igneous Extrusive	ANDE	Andesite
Igneous Extrusive	ANPO	Andesite Porphyry
Igneous Extrusive	BASA	Basalt
Igneous Extrusive	BAPO	Basalt Porphyry
Igneous Extrusive	BAAN	Basaltic Andesite
Igneous Extrusive	BASN	Basanite
Igneous Extrusive	DACI	Dacite
Igneous Extrusive	DAPO	Dacite Porphyry
Igneous Extrusive	FELS	Felsite
Igneous Extrusive	LATI	Latite
Igneous Extrusive	LAPO	Latite Porphyry
Igneous Extrusive	LEBA	Leucite Basanite
Igneous Extrusive	LEPH	Leucite Phonolite
Igneous Extrusive	LETE	Leucite Tephrite
Igneous Extrusive	LIMB	Limburgite
Igneous Extrusive	LIPO	Limburgite Porphyry

Primary Lithology	Secondary Code	Secondary Description
Igneous Extrusive	MELI	Melilitite
Igneous Extrusive	NELA	Nepheline Latite
Igneous Extrusive	NELAPO	Nepheline Latite Porphyry
Igneous Extrusive	NEPH	Nephelinite
Igneous Extrusive	OBSI	Obsidian
Igneous Extrusive	OCEA	Oceanite
Igneous Extrusive	OLBA	Olivine Basalt
Igneous Extrusive	OLNE	Olivine Nephelinite
Igneous Extrusive	PERL	Perlite
Igneous Extrusive	PHON	Phonolite
Igneous Extrusive	PHPO	Phonolite Porphyry
Igneous Extrusive	PITC	Pitchstone
Igneous Extrusive	PUMI	Pumice
Igneous Extrusive	QUBA	Quartz Basalt
Igneous Extrusive	QULA	Quartz Latite
Igneous Extrusive	QULAPO	Quartz Latite Porphyry
Igneous Extrusive	RHYO	Rhyolite
Igneous Extrusive	RHPO	Rhyolite Porphyry
Igneous Extrusive	SCOR	Scoria
Igneous Extrusive	TEPR	Tephrite
Igneous Extrusive	TEPO	Tephrite Porphyry
Igneous Extrusive	TING	Tinguaite
Igneous Extrusive	TRAC	Trachyte
Igneous Extrusive	TRPO	Trachyte Porphyry
Igneous Extrusive	TRAP	Trap
Igneous Extrusive	VITR	Vitrophyre
Igneous Extrusive	WYOM	Wyomingite
Igneous Intrusive	ALSK	Alaskite
Igneous Intrusive	ALGR	Alkali Granite
Igneous Intrusive	ALSY	Alkali Syenite
Igneous Intrusive	ANOR	Anorthosite
Igneous Intrusive	APLI	Aplite
Igneous Intrusive	CHAR	Charnockite
Igneous Intrusive	DIAB	Diabase
Igneous Intrusive	DIOR	Diorite
Igneous Intrusive	DIPO	Diorite Porphyry
Igneous Intrusive	DITR	Ditroite
Igneous Intrusive	DUNI	Dunite
Igneous Intrusive	FERG	Fergusite
Igneous Intrusive	FOYA	Foyaite
Igneous Intrusive	GABB	Gabbro

Primary Lithology	Secondary Code	Secondary Description
Igneous Intrusive	GAPO	Gabbro Porphyry
Igneous Intrusive	GADI	Gabbro/Diorite
Igneous Intrusive	GRAN	Granite
Igneous Intrusive	GRPO	Granite Porphyry
Igneous Intrusive	GRAO	Granodiorite
Igneous Intrusive	GDPO	Granodiorite Porphyry
Igneous Intrusive	GRGR	Graphic Granite
Igneous Intrusive	HARZ	Harzburgite
Igneous Intrusive	LAMP	Lamprophyre
Igneous Intrusive	LARV	Larvikite
Igneous Intrusive	LESY	Leucite Syenite
Igneous Intrusive	LUXU	Luxullianite
Igneous Intrusive	MALI	Malignite
Igneous Intrusive	MISS	Missourite
Igneous Intrusive	MONZ	Monzonite
Igneous Intrusive	MOPO	Monzonite Porphyry
Igneous Intrusive	NEMO	Nepheline Monzonite
Igneous Intrusive	NEMOPO	Nepheline Monzonite Porphyry
Igneous Intrusive	NESY	Nepheline Syenite
Igneous Intrusive	NESYPO	Nepheline Syenite Porphyry
Igneous Intrusive	NORD	Nordmarkite
Igneous Intrusive	NORI	Norite
Igneous Intrusive	OLGA	Olivine Gabbro
Igneous Intrusive	PEGM	Pegmattite
Igneous Intrusive	PERI	Peridotite
Igneous Intrusive	PICR	Picrite
Igneous Intrusive	PULA	Pulaskite
Igneous Intrusive	PYRO	Pyroxenite
Igneous Intrusive	QUDI	Quartz Diorite
Igneous Intrusive	QUDIPO	Quartz Diorite Porphyry
Igneous Intrusive	QUGA	Quartz Gabbro
Igneous Intrusive	QUMO	Quartz Monzonite
Igneous Intrusive	QUMOPO	Quartz Monzonite Porphyry
Igneous Intrusive	QUSY	Quartz Syenite
Igneous Intrusive	SHON	Shonikite
Igneous Intrusive	SOSY	Sodalite Syenite
Igneous Intrusive	SYEN	Syenite
Igneous Intrusive	SYPO	Syenite Porphyry
Igneous Intrusive	SYEO	Syenodiorite
Igneous Intrusive	THER	Theralite
Igneous Intrusive	THPO	Theralite Porphyry

Primary Lithology	Secondary Code	Secondary Description
Igneous Intrusive	TROC	Troctolite
Igneous Intrusive	UNCO	Uncompahgrite
Igneous Intrusive	UOLI	Uolite
Metamorphic	ACHO	Actinolite Hornfels
Metamorphic	ACMA	Actinolite Marble
Metamorphic	ACSC	Actinolite Schist
Metamorphic	ACEPMA	Actinolite-Epidote Marble
Metamorphic	ALMISC	Albite-Mica Schist
Metamorphic	AMPH	Amphibolite
Metamorphic	AMGN	Amphibolite Gneiss
Metamorphic	ANHO	Andalusite Hornfels
Metamorphic	ANSC	Andalusite Schist
Metamorphic	ANSPSL	Andalusite Spotted Slate
Metamorphic	ANBIHO	Andalusite-Biotite Hornfels
Metamorphic	ANGN	Anorthosite Gneiss
Metamorphic	ATHO	Anthophyllite Hornfels
Metamorphic	ARGN	Arkose Gneiss
Metamorphic	AUGN	Augen Gneiss
Metamorphic	BIGN	Biotite Gneiss
Metamorphic	BISPSL	Biotite Spotted Slate
Metamorphic	BICLSC	Biotite-Chlorite Schist
Metamorphic	BLSL	Black Slate
Metamorphic	BRMA	Brucite Marble
Metamorphic	CAHO	Calc-silicate Hornfels
Metamorphic	CLSL	Calcareous Slate
Metamorphic	CASC	Calcite Schist
Metamorphic	CASL	Carbonaceous Slate
Metamorphic	CHSC	Chiastolite Schist
Metamorphic	CHSPSL	Chiastolite Spotted Slate
Metamorphic	CLMA	Chlorite Marble
Metamorphic	CLSC	Chlorite Schist
Metamorphic	CDSC	Chloritoid Schist
Metamorphic	CHMA	Chondrodite Marble
Metamorphic	COGN	Conglomerate Gneiss
Metamorphic	COHO	Cordierite Hornfels
Metamorphic	COANHO	Cordierite-Anthophyllite Hornfels
Metamorphic	CRME	Crystalline Metamorphic
Metamorphic	DBGN	Diabase Gneiss
Metamorphic	DIMA	Diopside Marble
Metamorphic	DIGN	Diorite Gneiss
Metamorphic	ECLO	Eclogite

Primary Lithology	Secondary Code	Secondary Description
Metamorphic	EPAM	Epidote Amphibolite
Metamorphic	EPGN	Epidote Gneiss
Metamorphic	EPHO	Epidote Hornfels
Metamorphic	EPCHSC	Epidote-Chlorite Schist
Metamorphic	FLCO	Flaser Conglomerate
Metamorphic	FLDI	Flaser Diorite
Metamorphic	FLGR	Flaser Granite
Metamorphic	GBGN	Gabbro Gneiss
Metamorphic	GABIGN	Garnet Biotite Gneiss
Metamorphic	GAGN	Garnet Gneiss
Metamorphic	GAHO	Garnet Hornfels
Metamorphic	GACLSC	Garnet-Chlorite Schist
Metamorphic	GAPYAM	Garnet-Pyroxene Amphibolite
Metamorphic	GLSC	Glaucophane Schist
Metamorphic	GNEI	Gneiss
Metamorphic	GRGN	Granite Gneiss
Metamorphic	GDGN	Granodiorite Gneiss
Metamorphic	GRNO	Granofels
Metamorphic	GRNU	Granulite
Metamorphic	GRMA	Graphite Marble
Metamorphic	GRSC	Graphite Schist
Metamorphic	GWGN	Graywacke Gneiss
Metamorphic	GRSL	Green Slate
Metamorphic	GREN	Greenschist
Metamorphic	GREE	Greenstone
Metamorphic	HOBISC	Hornblende-Biotite Schist
Metamorphic	HORN	Hornfels
Metamorphic	KYHO	Kyanite Hornfels
Metamorphic	KYSC	Kyanite Schist
Metamorphic	MAGN	Magnetite
Metamorphic	MARB	Marble
Metamorphic	MEAR	Meta-Argillite
Metamorphic	METC	Metaconglomerate
Metamorphic	METQ	Metaquartzite
Metamorphic	MEME	Metasedimentary Melange
Metamorphic	METS	Metasedimentary Rocks
Metamorphic	MSCA	Metasedimentary calcareous
Metamorphic	MSNC	Metasedimentary non-calcareous
Metamorphic	METV	Metavolvanic Rocks
Metamorphic	MISC	Mica Schist
Metamorphic	MIGM	Migmatite

Primary Lithology	Secondary Code	Secondary Description
Metamorphic	MOGN	Monzonite Gneiss
Metamorphic	MYLO	Mylonite
Metamorphic	OLMA	Olivine Marble
Metamorphic	PEGN	Peridotite Gneiss
Metamorphic	PHYL	Phyllite
Metamorphic	PHLN	Phyllonite
Metamorphic	PLGN	Plagioclase Gneiss
Metamorphic	PYSC	Pyrophyllite Schist
Metamorphic	PRGN	Pyroxene Gneiss
Metamorphic	PYHO	Pyroxene Hornfels
Metamorphic	PRSC	Pyroxene Schist
Metamorphic	QUDIGN	Quartz Diorite Gneiss
Metamorphic	QUPOGN	Quartz Porphyry Gneiss
Metamorphic	QUMISC	Quartz-Mica Schist
Metamorphic	QUSESC	Quartz-Sericite Schist
Metamorphic	QUAR	Quartzite
Metamorphic	QUGN	Quartzite Gneiss
Metamorphic	RHGN	Rhyolite Gneiss
Metamorphic	SAGN	Sandstone Gneiss
Metamorphic	SCHI	Schist
Metamorphic	SCQU	Schistose Quartzite
Metamorphic	SERP	Serpentine
Metamorphic	SEMA	Serpentine Marble
Metamorphic	SEME	Serpentine Melange
Metamorphic	SIGASC	Sillimanite Garnet Schist
Metamorphic	SIGN	Sillimanite Gneiss
Metamorphic	SISC	Sillimanite Schist
Metamorphic	SISL	Silty Slate
Metamorphic	SKAR	Skarn
Metamorphic	SKGN	Skarn Gneiss
Metamorphic	SLAT	Slate
Metamorphic	SOAP	Soapstone
Metamorphic	SPSL	Spotted Slate
Metamorphic	STGN	Staurolite Gneiss
Metamorphic	STSC	Staurolite Schist
Metamorphic	SYGN	Syenite Gneiss
Metamorphic	TASC	Talc Schist
Metamorphic	TOHO	Tourmaline Hornfels
Metamorphic	TOSC	Tourmaline Schist
Metamorphic	TOMISC	Tourmaline-Mica Schist
Metamorphic	TRGN	Trachyte Gneiss

Primary Lithology	Secondary Code	Secondary Description
Metamorphic	TRHO	Tremolite Hornfels
Metamorphic	TRMA	Tremolite Marble
Metamorphic	ULTR	Ultramylonite
Metamorphic	WOHO	Wollastonite Hornfels
Metamorphic	WOMA	Wollastonite Marble
Sedimentary	AGGL	Agglomerate
Sedimentary	ANHY	Anhydrite
Sedimentary	ARGI	Argillite
Sedimentary	ARKO	Arkose
Sedimentary	ARAR	Arkose Argillaceous
Sedimentary	ARCA	Arkose Calcareous
Sedimentary	ARSI	Arkose Siliceous
Sedimentary	ASPH	Asphalt
Sedimentary	BENT	Bentonite
Sedimentary	BREC	Breccia
Sedimentary	CALI	Caliche
Sedimentary	CHAL	Chalk
Sedimentary	CHER	Chert
Sedimentary	CHOO	Chert Oolitic
Sedimentary	CLAS	Claystone
Sedimentary	CLSI	Claystone Siliceous
Sedimentary	COAN	Coal, Anthracite
Sedimentary	COBI	Coal, Bituminous
Sedimentary	CONG	Conglomerate
Sedimentary	COQU	Coquina
Sedimentary	DIAT	Diatomite
Sedimentary	DOLO	Dolomite
Sedimentary	GILS	Gilsonite
Sedimentary	GRAY	Graywacke
Sedimentary	GRCA	Graywacke Calcareous
Sedimentary	GRSA	Greensand
Sedimentary	GYPS	Gypsum
Sedimentary	HALI	Halite
Sedimentary	HEMA	Hematite
Sedimentary	INLISA	Interbedded Limestone and Sandstone
Sedimentary	INLISH	Interbedded Limestone and Shale
Sedimentary	INLISI	Interbedded Limestone and Siltstone
Sedimentary	INSASH	Interbedded Sandstone and Shale
Sedimentary	INSASI	Interbedded Sandstone and Siltstone
Sedimentary	IRON	Ironstone

Primary Lithology	Secondary Code	Secondary Description
Sedimentary	LIGN	Lignite
Sedimentary	LIME	Limestone
Sedimentary	LIAN	Limestone Arenaceous
Sedimentary	LIAR	Limestone Argillaceous
Sedimentary	LIBI	Limestone Bituminous
Sedimentary	LICR	Limestone Carbonaceous
Sedimentary	LICH	Limestone Cherty
Sedimentary	LICL	Limestone Clastic
Sedimentary	LIFE	Limestone Iron-rich
Sedimentary	LIOO	Limestone Oolitic
Sedimentary	LIOR	Limestone Organic
Sedimentary	LIPH	Limestone Phosphatic
Sedimentary	LISI	Limestone Siliceous
Sedimentary	LISICL	Limestone Siliciclastic
Sedimentary	LIMO	Limonite
Sedimentary	MARLST	Marlstone
Sedimentary	MUDS	Mudstone
Sedimentary	MUSI	Mudstone Siliceous
Sedimentary	OOCA	Oolite Calcareous
Sedimentary	OOFE	Oolite Iron-rich
Sedimentary	OOPH	Oolite Phosphatic
Sedimentary	OOSI	Oolite Siliceous
Sedimentary	ORTH	Orthoquartzite
Sedimentary	ORFS	Orthoquartzite Feldspathic
Sedimentary	ORLI	Orthoquartzite Lithic
Sedimentary	PHOS	Phosphorite
Sedimentary	PORC	Porcellanite
Sedimentary	RADI	Radiolarite
Sedimentary	ROSA	Rock Salt
Sedimentary	SANS	Sandstone
Sedimentary	SAAR	Sandstone Argillaceous
Sedimentary	SAARFS	Sandstone Argillaceous Feldspathic
Sedimentary	SAARLI	Sandstone Argillaceous Lithic
Sedimentary	SAARQU	Sandstone Argillaceous Quartz
Sedimentary	SACA	Sandstone Calcareous
Sedimentary	SACAFS	Sandstone Calcareous Feldspathic
Sedimentary	SACALI	Sandstone Calcareous Lithic
Sedimentary	SACAQU	Sandstone Calcareous Quartz
Sedimentary	SACRQU	Sandstone Carbonaceous Quartz
Sedimentary	SAFS	Sandstone Feldspathic
Sedimentary	SAFE	Sandstone Iron-rich

Primary Lithology	Secondary Code	Secondary Description
Sedimentary	SAFEQU	Sandstone Iron-rich Quartz
Sedimentary	SALI	Sandstone Lithic
Sedimentary	SAQU	Sandstone Quartz
Sedimentary	SHAL	Shale
Sedimentary	SHBI	Shale Bituminous
Sedimentary	SHCA	Shale Calcareous
Sedimentary	SHCR	Shale Carbonaceous
Sedimentary	SHFE	Shale Iron-rich
Sedimentary	SHPH	Shale Phosphatic
Sedimentary	SHSI	Shale Siliceous
Sedimentary	SIDE	Siderite
Sedimentary	SILS	Siltstone
Sedimentary	SICA	Siltstone Calcareous
Sedimentary	SICR	Siltstone Carbonaceous
Sedimentary	SIFE	Siltstone Iron-rich
Sedimentary	SUBG	Subgraywacke
Sedimentary	SUCA	Subgraywacke Calcareous
Sedimentary	TRAV	Travertine
Sedimentary	TUFA	Tufa
Sedimentary	TUFF	Tuff
Sedimentary	VOBR	Volcanic Breccia
Sedimentary	VOLC	Volcaniclastic
Undifferentiated	MIEXME	Mixed Extrusive and Metamorphic
Undifferentiated	MIEXSE	Mixed Extrusive and Sedimentary
Undifferentiated	MIIG	Mixed Igneous (extrusive & intrusive)
Undifferentiated	MIIGME	Mixed Igneous and Metamorphic
Undifferentiated	MIIGSE	Mixed Igneous and Sedimentary
Undifferentiated	MIINME	Mixed Intrusive and Metamorphic
Undifferentiated	MIINSE	Mixed Intrusive and Sedimentary
Undifferentiated	MIMESE	Mixed Metamorphic and Sedimentary

Bedrock Texture Modifiers

Code	Modifier	Definition
AMOR	Amorphous	Sediment or sed. rock composed of noncrystaline, authigenic material.
AMYG	Amygdaloidal	Igneous rock with vesicle fillings composed of secondary minerals.
APHA	Aphanitic	Igneous rock composed of grains not individually visable to unaided eye.

Code	Modifier	Definition
AUGE	Augen	Metamorph texture of larger eye-shaped mineral masses in finer grained matrix.
BIOC	Bioclastic	Composed of fragments of fossils.
BOUL	Bouldery	Sediment or sed. rock containing more than 15% particles with a diameter greater than 256 mm.
CATA	Cataclastic	Metamorph texture developed by severe mechanical crushing of the component grains.
CHEM	Chemical	Sediment or sed. rock rock composed primarily of material formed by precip. from soln or colloidal suspension.
CLAS	Clastic	Sediment or sed. rock composed of frags made of preexisting rocks or minerals transported from their origins.
COBB	Cobbly	Sediment or sed. rock with more than 15% rock fragments with a diameter between 64 mm and 256 mm.
CRYP	Cryptocrystalline	Rock composed of crystals or grains not visable with a microscope.
CRYS	Crystalline	Rock composed of interlocking mineral crystals or grains.
DETR	Detrital	Sediment or sed. rock rock composed mostly of particles eroded or weathered from preexisting rocks.
DIAB	Diabasic	Igneous rock composed of anhedral pyrox. between unoriented laths of plag.
EQUI	Equigranular	Igneous rock composed of grains of nearly uniform size.
FISS	Fissile	Sediment or sed. rock rock with very thin bedding planes easily split.
FLAS	Flaser	Metamorph rock with lenses of original minerals surrounded by highly sheared and crushed material.
FOLI	Foliation	Met. rock with planar structure that results from flattening the constituent grains.
GLAS	Glassy	Holohyaline igneous rock.
GNEI	Gneissose	Met. rock with foliation due to alteration of granulose and schistose bands.
GRAT	Granitic	Igneous rock composed of a mixture of anhedral and subhedral grains.
GRAN	Granular	Igneous rock composed of nearly equidimensional mineral xls.
GRAL	Granulose	Met. rock with granular texture with nondirectional structure.
GRAV	Gravelly	Sediment or sed. rock with at least 15% of particles between 2 mm and 10 mm in diameter.
HOLO	Holocrystalline	Igneous rock composed of essentially all crystalline grains.
HLHY	Holohyaline	Igneous rock that is essentially all glass.
HORN	Hornfelsic	Metamorph rock with nondirectional structure.

Code	Modifier	Definition
HYPO	Hypocrystalline	Igneous rock in part composed of glass.
LINE	Lineation	Met. rock with parallel directional structure of mineral grains.
MICR	Microcrystalline	Igneous rock composed of xls individually visable with a microscope.
MIGM	Migmatic	Metamorphic host rocks with granitic layers or lenses.
MYLO	Mylonitic	Met. rock with foliated, fine-grained cataclastic structure.
OOLI	Oolitic	Sediment or sed. rock rock composed of spheroids less than 2 mm in diameter.
OPHI	Ophitic	Igneous rock composed of plag laths enclosed in plates of pyroxene.
PEBB	Pebbly	Sediment or sed. rock with more than 15% particles between 2 mm and 64 mm in diameter.
PEGM	Pegmatitic	Igneous rock composed of xls conspicuously larger than surrounding rock.
PHCG	Phan-coarse grained	Igneous rock composed of xls more than 5 mm in diameter.
PHFG	Phan-fine grained	Igneous rock composed of xls less than 1 mm in diameter.
PHMG	Phan-medium grained	Igneous rock composed of xls 1-5 mm in diameter.
PHAN	Phaneritic	Igneous rock composed of xls individually visable to the unaided eye. PHYL Phyllitic Met. rock with foliation intermediate between slaty and schistose.
PISO	Pisolitic	Sediment or sed. rock rock composed of spheroids greater than 2 mm in diameter.
PORP	Porphyritic	Igneous rock composed of larger xls in a fine-grained groundmass.
PUMI	Pumiceous	Igneous rock that is highly vesicular and finely cellular.
SAND	Sandy	Sediment or sed. rock with more than 15% grains between 1/16 mm and 2mm in diameter.
SCHI	Schistose	Met. rock with foliation due to parallel orientation of phan., flaky minerals.
SCOR	Scoriaceous	Igneous rock that is highly vesicular and coarsely cellular.
SILT	Silty	Sediment or sed. rock with more than 15% particles between 1/256 mm and 1/16 mm in diameter.
SLAT	Slaty	Met. rock with foliation in aphanitic metamorphic rocks.
SPHE	Spherulitic	Igneous rock with spherical bodies of xls.
VESI	Vesicular	Igneous rock with spherical, ovoid, or tubular openings (vesicles).

Bedrock and Surficial Materials Chemistry Modifiers

Code	Meaning	Definition
AC	Acidic	Igneous rocks or seds that contain more than 65% SiO2.
BA	Basic	Igneous rocks or seds with a relatively low silica content: 44–53%.
CA	Calcareous	Rocks or seds containing calcium carbonate up to 50%.
CB	Carbonaceous	Seds that contain considerable original or introduced organic material.
IM	Intermediate	Igneous rocks or seds transitional between basic and acidic, with silica content of 54–64%.
SI	Siliceous	Rocks or seds containing abundant free silica (rather than silicate minerals).
UL	Ultrabasic	Igneous rocks or seds with a silica content lower than 44%.

Bedrock Fracture Interval

Code	Meaning
1	< 10 cm between fractures.
2	10 cm to 45 cm between fractures.
3	45 cm to 1.0 m between fractures.
4	1.0 to 2.0 m between fractures.
5	> 2.0 m between fractures.

Geological Structure Type

Code	Meaning	Definition
BE	Bedding	Planar surfaces that visibly separate layers of stratified rock.
FA	Fold Axis	The line that, moved parallel to itself, generates the form of a fold.
FO	Foliation	Planar structure from flattening of the rock's constituent grains.
FT	Fault	Fracture or a zone of fractures along which displacement has occurred.
JO	Joint	Fracturing or parting in rock, without displacement.
LI	Lineation	Any linear structure in a rock; e.g., mineral streaking and stretching from compression.

Parent/Surficial Materials

Primary and Secondary Lithology

Primary Lithology	Secondary Code	Secondary Description	Definition
Unconsolidated	ALLU	Alluvium	Clastic material deposited by moving water.
Unconsolidated	ASLO	Ash/Loess Mixture	Mixed volcanic ash and wind-blown silt.

Primary Lithology	Secondary Code	Secondary Description	Definition
Unconsolidated	CIND	Cinders	Pyroclastic material > 2 mm in size.
Unconsolidated	COLL	Colluvium	Nonsorted materials deposited on or at the base of a slope through gravitational forces.
Unconsolidated	CRYO	Cryoturbate	Earth material moved or disturbed by frost action.
Unconsolidated	DIAM	Diamicton	Nonsorted or poorly sorted, noncalcareous, terrigenous sediment that contains a wide range of particle sizes.
Unconsolidated	DIEA	Diatomaceous Earth	Light-colored siliceous sediment, consisting chiefly of opaline frustules of the diatom.
Unconsolidated	EOLI	Eolian Deposit	Deposit of wind-blown sediment.
Unconsolidated	GLAC	Glacial Deposit	Material deposited by a glacier.
Unconsolidated	GLMO	Glacial Moraine Deposit	Distinct accumulaion of unsorted, unstratified material deposited chiefly by direct action of glacial ice.
Unconsolidated	GLTI	Glacial Till Deposit	Unsorted and unstratified material deposited directly by and underneath a glacier without subsequent reworking by meltwater.
Unconsolidated	GLFL	Glaciofluvial Deposit	Material transported and deposited by running water emanating from a glacier.
Unconsolidated	GLLA	Glaciolacustrine Deposit	Deposit composed of suspended material brought by meltwater streams flowing into lakes bordering a glacier.
Unconsolidated	GLMA	Glaciomarine Deposit	Deposit composed of suspended material brought by meltwater streams flowing into seas bordering a glacier.
Unconsolidated	GRSA	Greensand	Marine sediment consisting largely of dark greenish grains of glauconite.
Unconsolidated	GYSA	Gypsum Sand	Sediment consisting primarily of gypsum particles > 0.05 mm.

Primary Lithology	Secondary Code	Secondary Description	Definition
Unconsolidated	HUCA	Human Caused/Constructed	Sediments deposited by direct human action.
Unconsolidated	LACU	Lacustrine Sediments	Deposit composed of suspended material brought by streams flowing into lakes.
Unconsolidated	LAHA	Lahar	Water-saturated volcanic materials that flowed down the volcano's slopes.
Unconsolidated	LADE	Landslide Deposit	Deposit of material resulting from the downslope transport, under gravitational influence, of soil and rock material en masse.
Unconsolidated	MARI	Marine Sediments	Deposit composed of suspended material brought by streams flowing into seas.
Unconsolidated	MARL	Marl	Deposits consisting chiefly of an intimate mixture of clay and calcium carbonate.
Unconsolidated	MIXE	Mixed	Deposits of undifferentiated materials.
Unconsolidated	MUCK	Muck	Dark, finely divided, well-decomposed organic material, intermixed with a high percentage of mineral matter, usually silt.
Unconsolidated	ORGA	Organic Deposits	Deposit in which carbon is an essential, substantial component.
Unconsolidated	PEAT	Peat	Deposit of semicarbonized plant remains in a water-saturated environment.
Unconsolidated	RESI	Residuum	Deposit of rock debris formed by weathering, remaining essentially in place after all but the least soluble constituents have been removed.
Unconsolidated	TALU	Talus Deposit	Rock fragments of any size or shape (usually coarse and angular) derived from and lying at the base of a cliff or very steep, rocky slope.

Primary Lithology	Secondary Code	Secondary Description	Definition
Unconsolidated	TEPH	Tephra (Undifferentiated)	Deposit of particles ejected during a volcanic eruption.
Unconsolidated	TRAN	Transitional Marine/Continental Deposits	Undifferentiated materials deposited at or near the land/sea interface.
Unconsolidated	VOAS	Volcanic Ash	Pyroclastic material under 2 mm diameter.

Parent/Surficial Materials Modifiers

Modifier	Modifies	Modifier Definition
Creep	Colluvium	Deposit of earthy materials accumulating at or near a slope base through slow gravitational movement.
Scree	Colluvium	Deposit of coarse, rock debris mantling a slope with no rock overhang or cliff.
Dune Sand	Eolian Deposit	Wind-blown deposit composed of material > 0.05 mm in diameter.
Loess	Eolian Deposit	Wind-blown deposit composed of material < 0.05 mm in diameter.
Ablation	Glacial Till Deposit	Till deposited though down-wasting of a glacier (also called supraglacial).
Basal	Glacial Till Deposit	Till deposited at the base of a moving glacier (also called subglacial, lodgement, melt-out, flow).
Block Glide	Landslide Deposit	Deposit of largely intact rock/earth units that slid downslope along a planar surface.
Debris Avalanche	Landslide Deposit	Deposit of mixed rock and earth that moved rapidly-downslope as a dry, incoherent mass.
Debris Flow	Landslide Deposit	Deposit of mixed rock, earth, and mud (> 50% > 2 mm in size) that moved rapidly downslope as a wet to saturated, incoherent mass.
Debris Slide	Landslide Deposit	Hummocky deposit of mixed rock and earth that slid or rolled downslope as a relatively dry mass.
Earth Flow	Landslide Deposit	Deposit of mixed earth, mud, and rock (> 50% <2 mm in size) that moved rapidly downslope as a wet to saturated, incoherent mass (also called mudflow).
Rockfall	Landslide Deposit	Deposit that accumulates at the base of a cliff from detached bodies of rock free-falling from above.
Rockfall Avalanche	Landslide Deposit	Deposit resulting from a massive rockfall that triggers an avalanche as it continues to the base of a slope and beyond.
Solifluction	Landslide Deposit	Deposit of water-saturated regolith that flowed slowly downslope; commonly occurring in frozen or permafrost terrain.
Topple	Landslide Deposit	Deposit created when a large block of rock falls over, rotating away from a low pivot point, and breaks apart.

Modifier	Modifies	Modifier Definition
Coprogenic	Organic Deposit	Deposit composed primarily of fecal material derived from acquatic animals.
Grassy	Organic Deposit	Deposit composed mostly of grassy materials.
Herbaceous	Organic Deposit	Deposit composed mostly of sedges, reeds, cattails, etc.
Mossy	Organic Deposit	Deposit composed mostly of mossy (e.g., sphanum) materials.
Woody	Organic Deposit	Deposit composed mostly of woody debris.

Parent/Surficial Material Size Classes

Code	Meaning	Definition
1	Clayey	> 40% of material is clay (< .002 mm in diameter).
2	Coarse-loamy	> 15% of particles are 0.1 to 76 mm and < 18% of material is clay.
3	Coarse-silty	Material is < 18% clay, and < 15% of particles are 0.1 to 76 mm in size.
4	Fine-loamy	Material is 18 to 35% clay and > 15% of particles are 0.1 to 76 mm in diameter.
5	Fine-silty	Material is 18 to 35% clay and < 15% particles are .1 to 76 mm in size.
6	Gravelly	Material contains 15% or more rock fragments (particles between 2 and 76 mm in diameter).
7	Loamy	Material is 7 to 27% clay, 28 to 50% silt, and < 52% sand.
8	Sandy	At least 70% sand (between 0.05 and 2 mm in diameter).
9	Sandy and gravelly	At least 70% sand and 15% gravel.
10	Sandy and silty	At least 15% of grains between .05 and 2 mm in diameter, and 15% of grains between .002 mm and .05 (sand or loamy sand and silt or silt loam).
11	Silty	> 50% of particles between 0.02 and 0.5 mm in diameter.
12	Silty and clayey	> 40% of material is clay and > 40% is silt.
13	Stony	> 50% of particles between 250 and 600 mm in diameter.
14	Bouldery	> 50% of particles larger than 600 mm in diameter.
15	Cobbly	> 50% of particles between 76 and 250 mm in diameter.

Geomorphic Definitions and Codes

Hierarchy Geomorphology

Fluvial

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
Process	Fluvial	Fl	FL
Subpr	Basin Processes-Fluvial	Bapr-Fl	BAPR
LF	Bolson-Basin Processes-Fluvial	Bols-Bapr-Fl	BOLS-BAPR
ElemLF	Playa-Bolson-Basin Processes-Fluvial	Play-Bols-Bapr-Fl	PLAY-BOLS-BAPR
LF	Semi-Bolson-Basin Processes-Fluvial	Sebo-Bapr-Fl	SEBO-BAPR
ElemLF	Basin Floor Remnant-Semi-Bolson-Basin Processes-Fluvial	Bafr-Sebo-Bapr-Fl	BAFR-SEBO-BAPR
ElemLF	Playa-Semi-Bolson-Basin Processes-Fluvial	Play-Sebo-Bapr-Fl	PLAY-SEBO-BAPR
ElemLF	Valley Flat-Semi-Bolson-Basin Processes-Fluvial	Vafl-Sebo-Bapr-Fl	VAFL-SEBO-BAPR
ElemLF	Valley Floor-Semi-Bolson-Basin Processes-Fluvial	Vafo-Sebo-Bapr-Fl	VAFO-SEBO-BAPR
Subpr	Fluvial Slope Processes-Fluvial	Flsp-Fl	FLSP
Modifier	Deposition-Fluvial Slope Processes-Fluvial	Deps-Flsp-Fl	DEPS-FLSP
LF	Alluvial Fan-Deposition-Fluvial Slope Processes-Fluvial	Alfa-Deps-Flsp-Fl	ALFA-DEPS
ElemLF	Fan Apron-Alluvial Fan-Deposition-Fluvial Slope Processes-Fluvial	Faap-Alfa-Deps-Flsp-Fl	FAAP-ALFA-DEPS
ElemLF	Fanhead Collar-Alluvial Fan-Deposition-Fluvial Slope Processes-Fluvial	Fahc-Alfa-Deps-Flsp-Fl	FAHC-ALFA-DEPS
ElemLF	Fanhead Trench-Alluvial Fan-Deposition-Fluvial Slope Processes-Fluvial	Faht-Alfa-Deps-Flsp-Fl	FAHT-ALFA-DEPS
ElemLF	Fan Skirt-Alluvial Fan-Deposition-Fluvial Slope Processes-Fluvial	Fask-Alfa-Deps-	FASK-ALFA-DEPS
ElemLF	Inset Fan-Alluvial Fan-Deposition-Fluvial Slope Processes-Fluvial	Infa-Alfa-Deps-Flsp-Fl	INFA-ALFA-DEPS
LF	Bajada-Deposition-Fluvial Slope Processes-Fluvial	Baja-Deps-Flsp-Fl	BAJA-DEPS

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Fan Apron-Bajada-Deposition-Fluvial Slope Processes-Fluvial	Faap-Baja-Deps-Flsp-Fl	FAAP-BAJA-DEPS
ElemLF	Fanhead Collar-Bajada-Deposition-Fluvial Slope Processes-Fluvial	Fahc-Baja-Deps-Flsp-Fl	FAHC-BAJA-DEPS
ElemLF	Fanhead Trench-Bajada-Deposition-Fluvial Slope Processes-Fluvial	Faht-Baja-Deps-Flsp-Fl	FAHT-BAJA-DEPS
ElemLF	Fan Skirt-Bajada-Deposition-Fluvial Slope Processes-Fluvial	Fask-Baja-Deps-Flsp-Fl	FASK-BAJA-DEPS
ElemLF	Inset Fan-Bajada-Deposition-Fluvial Slope Processes-Fluvial	Infa-Baja-Deps-Flsp-Fl	INFA-BAJA-DEPS
LF	Mountain Valley Fan-Deposition-Fluvial Slope Processes-Fluvial	Movf-Deps-Flsp-Fl	MOVF-DEPS
ElemLF	Fan Apron-Mountain Valley Fan-Deposition-Fluvial Slope Processes-Fluvial	Faap-Movf-Deps-Flsp-Fl	FAAP-MOVF-DEPS
ElemLF	Fanhead Collar-Mountain Valley Fan-Deposition-Fluvial Slope Processes-Fluvial	Fahc-Movf-Deps-Flsp-Fl	FAHC-MOVF-DEPS
ElemLF	Fanhead Trench-Mountain Valley Fan-Deposition-Fluvial Slope Processes-Fluvial	Faht-Movf-Deps-Flsp-Fl	FAHT-MOVF-DEPS
ElemLF	Fan Skirt-Mountain Valley Fan-Deposition-Fluvial Slope Processes-Fluvial	Fask-Movf-Deps-Flsp-Fl	FASK-MOVF-DEPS
ElemLF	Inset Fan-Mountain Valley Fan-Deposition-Fluvial Slope Processes-Fluvial	Infa-Movf-Deps-Flsp-Fl	INFA-MOVF-DEPS
LF	Fan Piedmont-Deposition-Fluvial Slope Processes-Fluvial	Fapi-Deps-Flsp-Fl	FAPI-DEPS
Modifier	Differential Fluvial Erosion W/ Structural Control-Fluvial Slope Processes-Fluvial	Dfec-Flsp-Fl	DFEC-FLSP
LF	Butte-Differential Fluvial Erosion W/ Structural Control-Fluvial Slope Processes-Fluvial	Butt-Dfec-Flsp-Fl	BUTT-DFEC
LF	Cuesta-Differential Fluvial Erosion W/ Structural Control-Fluvial Slope Processes-Fluvial	Cues-Dfec-Flsp-Fl	CUES-DFEC
ElemLF	Dipslope-Cuesta-Differential Fluvial Erosion W/ Structural Control-Fluvial Slope Processes-Fluvial	Disl-Cues-Dfec-Flsp-Fl	DISL-CUES-DFEC

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Scarpslope-Cuesta-Differential Fluvial Erosion W/ Structural Control-Fluvial Slope Processes-Fluvial	Scsl-Cues-Dfec-Flsp-Fl	SCSL-CUES-DFEC
LF	Dike-Differential Fluvial Erosion W/ Structural Control-Fluvial Slope Processes-Fluvial	Dike-Dfec-Flsp-Fl	DIKE-DFEC
LF	Hogback-Differential Fluvial Erosion W/ Structural Control-Fluvial Slope Processes-Fluvial	Hogb-Dfec-Flsp-Fl	HOGB-DFEC
ElemLF	Dipslope-Hogback-Differential Fluvial Erosion W/ Structural Control-Fluvial Slope Processes-Fluvial	Disl-Hogb-Dfec-Flsp-Fl	DISL-HOGB-DFEC
ElemLF	Scarpslope-Hogback-Differential Fluvial Erosion W/ Structural Control-Fluvial Slope Processes-Fluvial	Scsl-Hogb-Dfec-Flsp-Fl	SCSL-HOGB-DFEC
LF	Hoodoo-Differential Fluvial Erosion W/ Structural Control-Fluvial Slope Processes-Fluvial	Hood-Dfec-Flsp-Fl	HOOD-DFEC
LF	Mesa-Differential Fluvial Erosion W/ Structural Control-Fluvial Slope Processes-Fluvial	Mesa-Dfec-Flsp-Fl	MESA-DFEC
LF	Structural Bench-Differential Fluvial Erosion W/ Structural Control-Fluvial Slope Processes-Fluvial	Strb-Dfec-Flsp-Fl	STRB-DFEC
Modifier	Uniform Fluvial Erosion W/O Structural Control-Fluvial Slope Processes-Fluvial	Unfe-Flsp-Fl	UNFE-FLSP
LF	Badland-Uniform Fluvial Erosion W/O Structural Control-Fluvial Slope Processes-Fluvial	Badl-Unfe-Flsp-Fl	BADL-UNFE
LF	Ballena-Uniform Fluvial Erosion W/O Structural Control-Fluvial Slope Processes-Fluvial	Ball-Unfe-Flsp-Fl	BALL-UNFE
LF	Erosion Fan Remnant-Uniform Fluvial Erosion W/O Structural Control-Fluvial Slope Processes-Fluvial	Erfr-Unfe-Flsp-Fl	ERFR-UNFE
LF	Fan Remnant-Uniform Fluvial Erosion W/O Structural Control-Fluvial Slope Processes-Fluvial	Fare-Unfe-Flsp-Fl	FARE-UNFE

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Inselberg-Uniform Fluvial Erosion W/O Structural Control-Fluvial Slope Processes-Fluvial	Inse-Unfe-Flsp-Fl	INSE-UNFE
LF	Monadnock-Uniform Fluvial Erosion W/O Structural Control-Fluvial Slope Processes-Fluvial	Mona-Unfe-Flsp-Fl	MONA-UNFE
LF	Non-Buried Fan Remnant-Uniform Fluvial Erosion W/O Structural Control-Fluvial Slope Processes-Fluvial	Nbfr-Unfe-Flsp-Fl	NBFR-UNFE
LF	Partial Ballena-Uniform Fluvial Erosion W/O Structural Control-Fluvial Slope Processes-Fluvial	Paba-Unfe-Flsp-Fl	PABA-UNFE
LF	Pediment-Uniform Fluvial Erosion W/O Structural Control-Fluvial Slope Processes-Fluvial	Pedi-Unfe-Flsp-Fl	PEDI-UNFE
LF	Surface Eroding Slope-Uniform Fluvial Erosion W/O Structural Control-Fluvial Slope Processes-Fluvial	Sues-Unfe-Flsp-Fl	SUES-UNFE
Subpr	Stream Processes-Fluvial	Stpr-Fl	STPR
Modifier	Deposition-Stream Processes-Fluvial	Deps-Stpr-Fl	DEPS-STPR
LF	Bank-Deposition-Stream Processes-Fluvial	Bank-Deps-Stpr-Fl	BANK-DEPS
LF	Bar-Deposition-Stream Processes-Fluvial	Bar-Deps-Stpr-Fl	BAR-DEPS
ElemLF	Longitudinal Bar-Bar-Deposition-Stream Processes-Fluvial	Loba-Bar-Deps-Stpr-Fl	LOBA-BAR-DEPS
ElemLF	Point Bar-Bar-Deposition-Stream Processes-Fluvial	Poba-Bar-Deps-Stpr-Fl	POBA-BAR-DEPS
LF	Channel-Deposition-Stream Processes-Fluvial	Chan-Deps-Stpr-Fl	CHAN-DEPS
LF	Cutoff Channel-Deposition-Stream Processes-Fluvial	Cuch-Deps-Stpr-Fl	CUCH-DEPS
LF	Depositional Stream Terrace-Deposition-Stream Processes-Fluvial	Dest-Deps-Stpr-Fl	DEST-DEPS
LF	Floodplain-Deposition-Stream Processes-Fluvial	Flpl-Deps-Stpr-Fl	FLPL-DEPS
ElemLF	Alluvial Flat-Floodplain-Deposition-Stream Processes-Fluvial	Alfl-Flpl-Deps-Stpr-Fl	ALFL-FLPL-DEPS

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Levee-Floodplain-Deposition-Stream Processes-Fluvial	Leve-Flpl-Deps-Stpr-Fl	LEVE-FLPL-DEPS
ElemLF	Meander Scar-Floodplain-Deposition-Stream Processes-Fluvial	Mesr-Flpl-Deps-Stpr-Fl	MESR-FLPL-DEPS
ElemLF	Meander Scroll-Floodplain-Deposition-Stream Processes-Fluvial	Mesc-Flpl-Deps-Stpr-Fl	MESC-FLPL-DEPS
ElemLF	Oxbow-Floodplain-Deposition-Stream Processes-Fluvial	Oxbo-Flpl-Deps-Stpr-Fl	OXBO-FLPL-DEPS
LF	Floodplain Playa-Deposition-Stream Processes-Fluvial	Flpp-Deps-Stpr-Fl	FLPP-DEPS
LF	Floodplain Splay-Deposition-Stream Processes-Fluvial	Flps-Deps-Stpr-Fl	FLPS-DEPS
LF	Island-Deposition-Stream Processes-Fluvial	Isla-Deps-Stpr-Fl	ISLA-DEPS
LF	Stream-Deposition-Stream Processes-Fluvial	Stre-Deps-Stpr-Fl	STRE-DEPS
LF	Stream Terrace (Undif)-Deposition-Stream Processes-Fluvial	Stte-Deps-Stpr-Fl	STTE-DEPS
LF	Thalweg-Deposition-Stream Processes-Fluvial	Thal-Deps-Stpr-Fl	THAL-DEPS
Modifier	Erosion-Stream Processes-Fluvial	Eros-Stpr-Fl	EROS-STPR
LF	Channel-Erosion-Stream Processes-Fluvial	Chan-Eros-Stpr-Fl	CHAN-EROS
LF	Cutoff Channel-Erosion-Stream Processes-Fluvial	Cuch-Eros-Stpr-Fl	CUCH-EROS
LF	Erosional Stream Terrace-Erosion-Stream Processes-Fluvial	Erst-Eros-Stpr-Fl	ERST-EROS
LF	Stream-Erosion-Stream Processes-Fluvial	Stre-Eros-Stpr-Fl	STRE-EROS
LF	Thalweg-Erosion-Stream Processes-Fluvial	Thal-Eros-Stpr-Fl	THAL-EROS
Modifier	Terminal Deposition-Stream Processes-Fluvial	Tede-Stpr-Fl	TEDE-STPR
LF	Delta-Terminal Deposition-Stream Processes-Fluvial	Delt-Tede-Stpr-Fl	DELT-TEDE
ElemLF	Delta Plain-Delta-Terminal Deposition-Stream Processes-Fluvial	Depl-Delt-Tede-Stpr-Fl	DEPL-DELT-TEDE
Modifier	Transporting Stream Channel System-Stream Processes-Fluvial	Trsc-Stpr-Fl	TRSC-STPR

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Channel-Transporting Stream Channel System-Stream Processes-Fluvial	Chan-Trsc-Stpr-Fl	CHAN-TRSC
LF	Cutoff Channel-Transporting Stream Channel System-Stream Processes-Fluvial	Cuch-Trsc-Stpr-Fl	CUCH-TRSC
LF	Stream-Transporting Stream Channel System-Stream Processes-Fluvial	Stre-Trsc-Stpr-Fl	STRE-TRSC
LF	Thalweg-Transporting Stream Channel System-Stream Processes-Fluvial	Thal-Trsc-Stpr-Fl	THAL-TRSC
Modifier	Undiff Stream Channel System-Stream Processes-Fluvial	Unsc-Stpr-Fl	UNSC-STPR
LF	Bank-Undiff Stream Channel System-Stream Processes-Fluvial	Bank-Unsc-Stpr-Fl	BANK-UNSC
LF	Bar-Undiff Stream Channel System-Stream Processes-Fluvial	Bar-Unsc-Stpr-Fl	BAR-UNSC
ElemLF	Longitudinal Bar-Bar-Undiff Stream Channel System-Stream Processes-Fluvial	Loba-Bar-Unsc-Stpr-Fl	LOBA-BAR-UNSC
ElemLF	Point Bar-Bar-Undiff Stream Channel System-Stream Processes-Fluvial	Poba-Bar-Unsc-Stpr-Fl	POBA-BAR-UNSC
LF	Channel-Undiff Stream Channel System-Stream Processes-Fluvial	Chan-Unsc-Stpr-Fl	CHAN-UNSC
LF	Cutoff Channel-Undiff Stream Channel System-Stream Processes-Fluvial	Cuch-Unsc-Stpr-Fl	CUCH-UNSC
LF	Depositional Stream Terrace-Undiff Stream Channel System-Stream Processes-Fluvial	Dest-Unsc-Stpr-Fl	DEST-UNSC
LF	Erosional Stream Terrace-Undiff Stream Channel System-Stream Processes-Fluvial	Erte-Unsc-Stpr-Fl	ERTE-UNSC
LF	Flood Plain Playa-Undiff Stream Channel System-Stream Processes-Fluvial	Flpp-Unsc-Stpr-Fl	FLPP-UNSC
LF	Flood Plain Splay-Undiff Stream Channel System-Stream Processes-Fluvial	Flps-Unsc-Stpr-Fl	FLPS-UNSC
LF	Flood Plain-Undiff Stream Channel System-Stream Processes-Fluvial	Flpl-Unsc-Stpr-Fl	FLPL-UNSC
ElemLF	Alluvial Flat-Flood Plain-Undiff Stream Channel System-Stream Processes-Fluvial	Alfl-Flpl-Unsc-Stpr-Fl	ALFL-FLPL-UNSC

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Levee-Flood Plain-Undiff Stream Channel System-Stream Processes-Fluvial	Leve-Flpl-Unsc-Stpr-Fl	LEVE-FLPL-UNSC
ElemLF	Meander Scar-Flood Plain-Undiff Stream Channel System-Stream Processes-Fluvial	Mesr-Flpl-Unsc-Stpr-Fl	MESR-FLPL-UNSC
ElemLF	Meander Scroll-Flood Plain-Undiff Stream Channel System-Stream Processes-Fluvial	Mesc-Flpl-Unsc-Stpr-Fl	MESC-FLPL-UNSC
ElemLF	Oxbow-Flood Plain-Undiff Stream Channel System-Stream Processes-Fluvial	Oxbo-Flpl-Unsc-Stpr-Fl	OXBO-FLPL-UNSC
LF	Island-Undiff Stream Channel System-Stream Processes-Fluvial	Isla-Unsc-Stpr-Fl	ISLA-UNSC
LF	Stream Terrace-Undiff Stream Channel System-Stream Processes-Fluvial	Stte-Unsc-Stpr-Fl	STTE-UNSC
LF	Stream-Undiff Stream Channel System-Stream Processes-Fluvial	Stre-Unsc-Stpr-Fl	STRE-UNSC
LF	Thalweg-Undiff Stream Channel System-Stream Processes-Fluvial	Thal-Unsc-Stpr-Fl	THAL-UNSC

Glacial

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
Process	Glacial	Gl	GL
Subpr	Active Ice And Snow Process-Glacial	Aisp-Gl	AISP
Mod	Alpine Glaciation-Active Ice And Snow Process-Glacial	Alpi-Aisp-Gl	ALPI-AISP
LF	Glacier-Alpine Glaciation-Active Ice And Snow Process-Glacial	Glcr-Alpi-Aisp-Gl	GLCR-ALPI
ElemLF	Bergshrund-Glacier-Alpine Glaciation-Active Ice And Snow Process-Glacial	Berg-Glcr-Alpi-Aisp-Gl	BERG-GLCR-ALPI
ElemLF	Crevasse-Glacier-Alpine Glaciation-Active Ice And Snow Process-Glacial	Crev-Glcr-Alpi-Aisp-Gl	CREV-GLCR-ALPI
ElemLF	Drainage Channel (Undiff)-Glacier-Alpine Glaciation-Active Ice And Snow Process-Glacial	Drch-Glcr-Alpi-Aisp-Gl	DRCH-GLCR-ALPI
ElemLF	Fosse-Glacier-Alpine Glaciation-Active Ice And Snow Process-Glacial	Foss-Glcr-Alpi-Aisp-Gl	FOSS-GLCR-ALPI
ElemLF	Ice Apron-Glacier-Alpine Glaciation-Active Ice And Snow Process-Glacial	Icap-Glcr-Alpi-Aisp-Gl	ICAP-GLCR-ALPI
ElemLF	Moulin-Glacier-Alpine Glaciation-Active Ice And Snow Process-Glacial	Moul-Glcr-Alpi-Aisp-Gl	MOUL-GLCR-ALPI

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Pressure Ridge-Glacier-Alpine Glaciation-Active Ice And Snow Process-Glacial	Prri-Glcr-Alpi-Aisp-Gl	PRRI-GLCR-ALPI
ElemLF	Serac-Glacier-Alpine Glaciation-Active Ice And Snow Process-Glacial	Sera-Glcr-Alpi-Aisp-Gl	SERA-GLCR-ALPI
LF	Snowfield-Alpine Glaciation-Active Ice And Snow Process-Glacial	Snow-Alpi-Aisp-Gl	SNOW-ALPI
ElemLF	Nivation Hollow-Snowfield-Alpine Glaciation-Active Ice And Snow Process-Glacial	Niho-Snow-Alpi-Aisp-Gl	NIHO-SNOW-ALPI
ElemLF	Nivation Ridge-Snowfield-Alpine Glaciation-Active Ice And Snow Process-Glacial	Niri-Snow-Alpi-Aisp-Gl	NIRI-SNOW-ALPI
Mod	Continental Glaciation-Active Ice And Snow Process-Glacial	Cont-Aisp-Gl	CONT-AISP
LF	Glacier-Continental Glaciation-Active Ice And Snow Process-Glacial	Glcr-Cont-Aisp-Gl	GLCR-CONT
ElemLF	Bergshrund-Glacier-Continental Glaciation-Active Ice And Snow Process-Glacial	Berg-Glcr-Cont-Aisp-Gl	BERG-GLCR-CONT
ElemLF	Crevasse-Glacier-Continental Glaciation-Active Ice And Snow Process-Glacial	Crev-Glcr-Cont-Aisp-Gl	CREV-GLCR-CONT
ElemLF	Drainage Channel (Undiff)-Glacier-Continental Glaciation-Active Ice And Snow Process-Glacial	Drch-Glcr-Cont-Aisp-Gl	DRCH-GLCR-CONT
ElemLF	Fosse-Glacier-Continental Glaciation-Active Ice And Snow Process-Glacial	Foss-Glcr-Cont-Aisp-Gl	FOSS-GLCR-CONT
ElemLF	Ice Apron-Glacier-Continental Glaciation-Active Ice And Snow Process-Glacial	Icap-Glcr-Cont-Aisp-Gl	ICAP-GLCR-CONT
ElemLF	Moulin-Glacier-Continental Glaciation-Active Ice And Snow Process-Glacial	Moul-Glcr-Cont-Aisp-Gl	MOUL-GLCR-CONT
ElemLF	Pressure Ridge-Glacier-Continental Glaciation-Active Ice And Snow Process-Glacial	Prri-Glcr-Cont-Aisp-Gl	PRRI-GLCR-CONT
ElemLF	Serac-Glacier-Continental Glaciation-Active Ice And Snow Process-Glacial	Sera-Glcr-Cont-Aisp-Gl	SERA-GLCR-CONT
LF	Snowfield-Continental Glaciation-Active Ice And Snow Process-Glacial	Snow-Cont-Aisp-Gl	SNOW-CONT
ElemLF	Nivation Hollow-Snowfield- Continental Glaciation-Active Ice And Snow Process-Glacial	Niho-Snow-Cont-Aisp-Gl	NIHO-SNOW-CONT
ElemLF	Nivation Ridge-Snowfield-Continental Glaciation-Active Ice And Snow Process-Glacial	Niri-Snow-Cont-Aisp-Gl	NIRI-SNOW-CONT
Subpr	Ice Contact Deposition-Glacial	Icde-Gl	ICDE

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
Mod	Alpine Glaciation-Ice Contact Deposition-Glacial	Alpi-Icde-Gl	ALPI-ICDE
LF	Crag And Tail-Alpine Glaciation-Ice Contact Deposition-Glacial	Crta-Alpi-Icde-Gl	CRTA-ALPI
LF	Disintegration Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Dimo-Alpi-Icde-Gl	DIMO-ALPI
ElemLF	Kettle-Disintegration Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Kett-Dimo-Alpi-Icde-Gl	KETT-DIMO-ALPI
LF	Drumlin-Alpine Glaciation-Ice Contact Deposition-Glacial	Drum-Alpi-Icde-Gl	DRUM-ALPI
LF	End Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Enmo-Alpi-Icde-Gl	ENMO-ALPI
ElemLF	Kettle-End Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Kett-Enmo-Alpi-Icde-Gl	KETT-ENMO-ALPI
LF	Fluted Morain Surface-Alpine Glaciation-Ice Contact Deposition-Glacial	Flms-Alpi-Icde-Gl	FLMS-ALPI
LF	Ground Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Grmo-Alpi-Icde-Gl	GRMO-ALPI
ElemLF	Kettle-Ground Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Kett-Grmo-Alpi-Icde-Gl	KETT-GRMO-ALPI
LF	Interlobate Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Inmo-Alpi-Icde-Gl	INMO-ALPI
ElemLF	Kettle-Interlobate Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Kett-Inmo-Alpi-Icde-Gl	KETT-INMO-ALPI
LF	Kame Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Kamo-Alpi-Icde-Gl	KAMO-ALPI
ElemLF	Kettle-Kame Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Kett-Kamo-Alpi-Icde-Gl	KETT-KAMO-ALPI
LF	Lateral Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Lamo-Alpi-Icde-Gl	LAMO-ALPI
ElemLF	Kettle-Lateral Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Kett-Lamo-Alpi-Icde-Gl	KETT-LAMO-ALPI
LF	Medial Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Memo-Alpi-Icde-Gl	MEMO-ALPI
ElemLF	Kettle-Medial Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Kett-Memo-Alpi-Icde-Gl	KETT-MEMO-ALPI
LF	Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Mora-Alpi-Icde-Gl	MORA-ALPI
ElemLF	Kettle-Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Kett-Mora-Alpi-Icde-Gl	KETT-MORA-ALPI
LF	Recessional Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Remo-Alpi-Icde-Gl	REMO-ALPI

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Kettle-Recessional Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Kett-Remo-Alpi-Icde-Gl	KETT-REMO-ALPI
LF	Terminal Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Temo-Alpi-Icde-Gl	TEMO-ALPI
ElemLF	Kettle-Terminal Moraine-Alpine Glaciation-Ice Contact Deposition-Glacial	Kett-Temo-Alpi-Icde-Gl	KETT-TEMO-ALPI
Mod	Continental Glaciation-Ice Contact Deposition-Glacial	Cont-Icde-Gl	CONT-ICDE
LF	Crag And Tail-Continental Glaciation-Ice Contact Deposition-Glacial	Crta-Cont-Icde-Gl	CRTA-CONT
LF	Disintegration Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Dimo-Cont-Icde-Gl	DIMO-CONT
ElemLF	Kettle-Disintegration Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Kett-Dimo-Cont-Icde-Gl	KETT-DIMO-CONT
LF	Drumlin-Continental Glaciation-Ice Contact Deposition-Glacial	Drum-Cont-Icde-Gl	DRUM-CONT
LF	End Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Enmo-Cont-Icde-Gl	ENMO-CONT
ElemLF	Kettle-End Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Kett-Enmo-Cont-Icde-Gl	KETT-ENMO-CONT
LF	Fluted Moraine Surface-Continental Glaciation-Ice Contact Deposition-Glacial	Flms-Cont-Icde-Gl	FLMS-CONT
LF	Ground Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Grmo-Cont-Icde-Gl	GRMO-CONT
ElemLF	Kettle-Ground Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Kett-Grmo-Cont-Icde-Gl	KETT-GRMO-CONT
LF	Interlobate Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Inmo-Cont-Icde-Gl	INMO-CONT
ElemLF	Kettle-Interlobate Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Kett-Inmo-Cont-Icde-Gl	KETT-INMO-CONT
LF	Kame Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Kamo-Cont-Icde-Gl	Gl KAMO-CONT
ElemLF	Kettle-Kame Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Kett-Kamo-Cont-Icde-Gl	KETT-KAMO-CONT
LF	Lateral Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Lamo-Cont-Icde-Gl	LAMO-CONT
ElemLF	Kettle-Lateral Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Kett-Lamo-Cont-Icde-Gl	KETT-LAMO-CONT
LF	Medial Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Memo-Cont-Icde-Gl	MEMO-CONT
ElemLF	Kettle-Medial Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Kett-Memo-Cont-Icde-Gl	KETT-MEMO-CONT

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Mora-Cont-Icde-Gl	MORA-CONT
ElemLF	Kettle-Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Kett-Mora-Cont-Icde-Gl	KETT-MORA-CONT
LF	Recessional Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Remo-Cont-Icde-Gl	REMO-CONT
ElemLF	Kettle-Recessional Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Kett-Remo-Cont-Icde-Gl	KETT-REMO-CONT
LF	Terminal Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Temo-Cont-Icde-Gl	TEMO-CONT
ElemLF	Kettle-Terminal Moraine-Continental Glaciation-Ice Contact Deposition-Glacial	Kett-Temo-Cont-Icde-Gl	KETT-TEMO-CONT
Subpr	Ice Erosion-Glacial	Icer-Gl	ICER
Mod	Alpine Glaciation-Ice Erosion-Glacial	Alpi-Icer-Gl	ALPI-ICER
LF	Arete-Alpine Glaciation-Ice Erosion-Glacial	Aret-Alpi-Icer-Gl	ARET-ALPI
LF	Cirque-Alpine Glaciation-Ice Erosion-Glacial	Cirq-Alpi-Icer-Gl	CIRQ-ALPI
LF	Cirque Floor-Alpine Glaciation-Ice Erosion-Glacial	Cifl-Alpi-Icer-Gl	CIFL-ALPI
LF	Cirque Headwall-Alpine Glaciation-Ice Erosion-Glacial	Cihe-Alpi-Icer-Gl	CIHE-ALPI
LF	Col-Alpine Glaciation-Ice Erosion-Glacial	Col-Alpi-Icer-Gl	COL-ALPI
LF	Flute-Alpine Glaciation-Ice Erosion-Glacial	Flut-Alpi-Icer-Gl	FLUT-ALPI
LF	Glacial Quarry-Alpine Glaciation-Ice Erosion-Glacial	Glqu-Alpi-Icer-Gl	GLQU-ALPI
LF	Hanging Valley-Alpine Glaciation-Ice Erosion-Glacial	Hava-Alpi-Icer-Gl	HAVA-ALPI
LF	Horn-Alpine Glaciation-Ice Erosion-Glacial	Horn-Alpi-Icer-Gl	HORN-ALPI
LF	Nunatek-Alpine Glaciation-Ice Erosion-Glacial	Nuna-Alpi-Icer-Gl	NUNA-ALPI
LF	Riegel-Alpine Glaciation-Ice Erosion-Glacial	Rieg-Alpi-Icer-Gl	RIEG-ALPI
LF	Roche Mountonnee-Alpine Glaciation-Ice Erosion-Glacial	Romo-Alpi-Icer-Gl	ROMO-ALPI
LF	Scoured Basin-Alpine Glaciation-Ice Erosion-Glacial	Scba-Alpi-Icer-Gl	SCBA-ALPI
LF	Sidewall-Alpine Glaciation-Ice Erosion-Glacial	Side-Alpi-Icer-Gl	SIDE-ALPI
LF	Trough (Glacial Valley)-Alpine Glaciation-Ice Erosion-Glacial	Trou-Alpi-Icer-Gl	TROU-ALPI
LF	Trough Floor-Alpine Glaciation-Ice Erosion-Glacial	Trfl-Alpi-Icer-Gl	TRFL-ALPI

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Trough Wall-Alpine Glaciation-Ice Erosion-Glacial	Trwa-Alpi-Icer-Gl	TRWA-ALPI
Mod	Continental Glaciation-Ice Erosion-Glacial	Cont-Icer-Gl	CONT-ICER
LF	Arete-Continental Glaciation-Ice Erosion-Glacial	Aret-Cont-Icer-Gl	ARET-CONT
LF	Cirque-Continental Glaciation-Ice Erosion-Glacial	Cirq-Cont-Icer-Gl	CIRQ-CONT
LF	Cirque Floor-Continental Glaciation-Ice Erosion-Glacial	Cifl-Cont-Icer-Gl	CIFL-CONT
LF	Cirque Headwall-Continental Glaciation-Ice Erosion-Glacial	Cihe-Cont-Icer-Gl	CIHE-CONT
LF	Col-Continental Glaciation-Ice Erosion-Glacial	Col-Cont-Icer-Gl	COL-CONT
LF	Flute-Continental Glaciation-Ice Erosion-Glacial	Flut-Cont-Icer-Gl	FLUT-CONT
LF	Glacial Quarry-Continental Glaciation-Ice Erosion-Glacial	Glqu-Cont-Icer-Gl	GLQU-CONT
LF	Hanging Valley-Continental Glaciation-Ice Erosion-Glacial	Hava-Cont-Icer-Gl	HAVA-CONT
LF	Horn-Continental Glaciation-Ice Erosion-Glacial	Horn-Cont-Icer-Gl	HORN-CONT
LF	Nunatek-Continental Glaciation-Ice Erosion-Glacial	Nuna-Cont-Icer-Gl	NUNA-CONT
LF	Riegel-Continental Glaciation-Ice Erosion-Glacial	Rieg-Cont-Icer-Gl	RIEG-CONT
LF	Roche Mountonnee-Continental Glaciation-Ice Erosion-Glacial	Romo-Cont-Icer-Gl	ROMO-CONT
LF	Scoured Basin-Continental Glaciation-Ice Erosion-Glacial	Scba-Cont-Icer-Gl	SCBA-CONT
LF	Sidewall-Continental Glaciation-Ice Erosion-Glacial	Side-Cont-Icer-Gl	SIDE-CONT
LF	Trough (Glacial Valley)-Continental Glaciation-Ice Erosion-Glacial	Trou-Cont-Icer-Gl	TROU-CONT
LF	Trough Floor-Continental Glaciation-Ice Erosion-Glacial	Trfl-Cont-Icer-Gl	TRFL-CONT
LF	Trough Wall-Continental Glaciation-Ice Erosion-Glacial	Trwa-Cont-Icer-Gl	TRWA-CONT
Subpr	Meltwater Erosion-Glacial	Meer-Gl	MEER
Mod	Alpine Glaciation-Meltwater Erosion-Glacial	Alpi-Meer-Gl	ALPI-MEER
LF	Coulee-Alpine Glaciation-Meltwater Erosion-Glacial	Coul-Alpi-Meer-Gl	COUL-ALPI
LF	Ice Margin Channel-Alpine Glaciation-Meltwater Erosion-Glacial	Icmc-Alpi-Meer-Gl	ICMC-ALPI

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Spillway-Alpine Glaciation-Meltwater Erosion-Glacial	Spil-Alpi-Meer-Gl	SPIL-ALPI
LF	Tunnel Valley-Alpine Glaciation-Meltwater Erosion-Glacial	Tuva-Alpi-Meer-Gl	TUVA-ALPI
Mod	Continental Glaciation-Meltwater Erosion-Glacial	Cont-Meer-Gl	CONT-MEER
LF	Coulee-Continental Glaciation-Meltwater Erosion-Glacial	Coul-Cont-Meer-Gl	COUL-CONT
LF	Ice Margin Channel-Continental Glaciation-Meltwater Erosion-Glacial	Icmc-Cont-Meer-Gl	ICMC-CONT
LF	Spillway-Continental Glaciation-Meltwater Erosion-Glacial	Spil-Cont-Meer-Gl	SPIL-CONT
LF	Tunnel Valley-Continental Glaciation-Meltwater Erosion-Glacial	Tuva-Cont-Meer-Gl	TUVA-CONT
Subpr	Proglacial Deposition (Distal)-Glacial	Prde-Gl	PRDE
Mod	Alpine Glaciation-Proglacial Deposition (Distal)-Glacial	Alpi-Prde-Gl	ALPI-PRDE
LF	Kettled Outwash Plain (Kettled Sandur)-Alpine Glaciation-Proglacial Deposition (Distal)-Glacial	Keop-Alpi-Prde-Gl	KEOP-ALPI
LF	Outburst Floodplain-Alpine Glaciation-Proglacial Deposition (Distal)-Glacial	Oufl-Alpi-Prde-Gl	OUFL-ALPI
ElemLF	Giant Ripples-Outburst Floodplain-Alpine Glaciation-Proglacial Deposition (Distal)-Glacial	Giri-Oufl-Alpi-Prde-Gl	GIRI-OUFL-ALPI
LF	Outwash Fan-Alpine Glaciation-Proglacial Deposition (Distal)-Glacial	Oufa-Alpi-Prde-Gl	OUFA-ALPI
LF	Outwash Plain (Plain Sandur)-Alpine Glaciation-Proglacial Deposition (Distal)-Glacial	Oupl-Alpi-Prde-Gl	OUPL-ALPI
LF	Outwash Terrace-Alpine Glaciation-Proglacial Deposition (Distal)-Glacial	Oute-Alpi-Prde-Gl	OUTE-ALPI
LF	Valley Train (Valley Sandur)-Alpine Glaciation-Proglacial Deposition (Distal)-Glacial	Vatr-Alpi-Prde-Gl	VATR-ALPI
Mod	Continental Glaciation-Proglacial Deposition (Distal)-Glacial	Cont-Prde-Gl	CONT-PRDE
LF	Kettled Outwash Plain (Kettled Sandur)-Continental Glaciation-Proglacial Deposition Deposition (Distal)-Glacial	Keop-Cont-Prde-Gl	KEOP-CONT
LF	Outburst Floodplain-Continental Glaciation-Proglacial Deposition (Distal)-Glacial	Oufl-Cont-Prde-Gl	OUFL-CONT

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Giant Ripples-Outburst Floodplain-Continental Glaciation-Proglacial Deposition (Distal)-Glacial	Giri-Oufl-Cont-Prde-Gl	GIRI-OUFL-CONT
LF	Outwash Fan-Continental Glaciation-Proglacial Deposition (Distal)-Glacial	Oufa-Cont-Prde-Gl	OUFA-CONT
LF	Outwash Plain (Plain Sandur)-Continental Glaciation-Proglacial Deposition (Distal)-Glacial	Oupl-Cont-Prde-Gl	OUPL-CONT
LF	Outwash Terrace-Continental Glaciation-Proglacial Deposition (Distal)-Glacial	Oute-Cont-Prde-Gl	OUTE-CONT
LF	Valley Train-Continental Glaciation-Proglacial Deposition (Distal)-Glacial	Vatr-Cont-Prde-Gl	VATR-CONT
Subpr	Water Deposition (Proximal)-Glacial	Wade-Gl	WADE
Mod	Alpine Glaciation-Water Deposition (Proximal)-Glacial	Alpi-Wade-Gl	ALPI-WADE
LF	Collapsed Ice-Floored Lakebed-Alpine Glaciation-Water Deposition (Proximal)-Glacial	Coil-Alpi-Wade-Gl	COIL-ALPI
LF	Collapsed Ice-Walled Lakebed-Alpine Glaciation-Water Deposition (Proximal)-Glacial	Ciwl-Alpi-Wade-Gl	CIWL-ALPI
LF	Crevasse Filling-Alpine Glaciation-Water Deposition (Proximal)-Glacial	Crfi-Alpi-Wade-Gl	CRFI-ALPI
LF	Esker-Alpine Glaciation-Water Deposition (Proximal)-Glacial	Eske-Alpi-Wade-Gl	ESKE-ALPI
LF	Kame-Alpine Glaciation-Water Deposition (Proximal)-Glacial	Kame-Alpi-Wade-Gl	KAME-ALPI
LF	Kame Terrace-Alpine Glaciation-Water Deposition (Proximal)-Glacial	Kate-Alpi-Wade-Gl	KATE-ALPI
Mod	Continental Glaciation-Water Deposition (Proximal)-Glacial	Cont-Wade-Gl	CONT-WADE
LF	Collapsed Ice-Floored Lakebed-Continental Glaciation-Water Deposition (Proximal)-Glacial	Coil-Cont-Wade-Gl	COIL-CONT
LF	Collapsed Ice-Walled Lakebed-Continental Glaciation-Water Deposition (Proximal)-Glacial	Ciwl-Cont-Wade-Gl	CIWL-CONT
LF	Crevasse Filling-Continental Glaciation-Water Deposition (Proximal)-Glacial	Crfi-Cont-Wade-Gl	CRFI-CONT
LF	Esker-Continental Glaciation-Water Deposition (Proximal)-Glacial	Eske-Cont-Wade-Gl	ESKE-CONT
LF	Kame-Continental Glaciation-Water Deposition (Proximal)-Glacial	Kame-Cont-Wade-Gl	KAME-CONT

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Kame Terrace-Continental Glaciation-Water Deposition (Proximal)-Glacial	Kate-Cont-Wade-Gl	KATE-CONT

Periglacial

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
Process	Periglacial	Pe	PE
Subpr	Frost Action-Periglacial	Frac-Pe	FRAC
LF	Patterned Ground (Undiff)-Frost Action-Periglacial	Pgun-Frac-Pe	PGUN-FRAC
LF	Patterned Ground-Frost Action-Periglacial	Pagr-Frac-Pe	PAGR-FRAC
ElemLF	Circles-Patterned Ground-Frost Action-	Circ-Pagr-Frac-Periglacial	CIRC-PAGR-Pe FRAC
ElemLF	Nets-Patterned Ground-Frost Action-Periglacial	Nets-Pagr-Frac-Pe	NETS-PAGR-FRAC
ElemLF	Polygons-Patterned Ground-Frost Action-Periglacial	Poly-Pagr-Frac-Pe	POLY-PAGR-FRAC
ElemLF	Steps-Patterned Ground-Frost Action-Periglacial	Step-Pagr-Frac-Pe	STEP-PAGR-FRAC
ElemLF	Stripes-Patterned Ground-Frost Action-Periglacial	Stri-Pagr-Frac-Pe	STRI-PAGR-FRAC
Subpr	Permafrost-Periglacial	Perm-Pe	PERM
LF	Block (Rock) Field-Permafrost-Periglacial	Blfi-Perm-Pe	BLFI-PERM
LF	Palsa-Permafrost-Periglacial	Pals-Perm-Pe	PALS-PERM
LF	Pingo-Permafrost-Periglacial	Ping-Perm-Pe	PING-PERM
LF	Tor-Permafrost-Periglacial	Tor-Perm-Pe	TOR-PERM
LF	Thermokarst-Permafrost-Periglacial	Ther-Perm-Pe	THER-PERM
ElemLF	Alas-Thermokarst-Permafrost-Periglacial	Alas-Ther-Perm-Pe	ALAS-THER-PERM

Lacustrine

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
Process	Lacustrine	La	LA
Subpr	Anthropogenic-Lacustrine	Anth-La	ANTH
LF	Beach-Anthropogenic-Lacustrine	Beac-Anth-La	BEAC-ANTH
ElemLF	Backshore Terrace-Beach-Anthropogenic-Lacustrine	Bate-Beac-Anth-La	BATE-BEAC-ANTH
ElemLF	Beach Plain-Beach-Anthropogenic-Lacustrine	Bepl-Beac-Anth-La	BEPL-BEAC-ANTH

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Beach Ridge-Beach-Anthropogenic-Lacustrine	Beri-Beac-Anth-La	BERI-BEAC-ANTH
LF	Island-Anthropogenic-Lacustrine	Isla-Anth-La	ISLA-ANTH
LF	Lake-Anthropogenic-Lacustrine	Lake-Anth-La	LAKE-ANTH
LF	Lake Bed-Anthropogenic-Lacustrine	Labe-Anth-La	LABE-ANTH
LF	Lake Plain-Anthropogenic-Lacustrine	Lapl-Anth-La	LAPL-ANTH
LF	Lake Terrace-Anthropogenic-Lacustrine	Late-Anth-La	LATE-ANTH
LF	Shoreline-Anthropogenic-Lacustrine	Shor-Anth-La	SHOR-ANTH
Subpr	Beaver-Lacustrine	Beav-La	BEAV
LF	Beach-Beaver-Lacustrine	Beac-Beav-La	BEAC-BEAV
ElemLF	Backshore Terrace-Beach-Beaver-Lacustrine	Bate-Beac-Beav-La	BATE-BEAC-BEAV
ElemLF	Beach Plain-Beach-Beaver-Lacustrine	Bepl-Beac-Beav-La	BEPL-BEAC-BEAV
ElemLF	Beach Ridge-Beach-Beaver-Lacustrine	Beri-Beac-Beav-La	BERI-BEAC-BEAV
LF	Island-Beaver-Lacustrine	Isla-Beav-La	ISLA-BEAV
LF	Lake-Beaver-Lacustrine	Lake-Beav-La	LAKE-BEAV
LF	Lake Bed-Beaver-Lacustrine	Labe-Beav-La	LABE-BEAV
LF	Lake Plain-Beaver-Lacustrine	Lapl-Beav-La	LAPL-BEAV
LF	Lake Terrace-Beaver-Lacustrine	Late-Beav-La	LATE-BEAV
LF	Shoreline-Beaver-Lacustrine	Shor-Beav-La	SHOR-BEAV
Subpr	Eolian-Lacustrine	Eoli-La	EOLI
LF	Beach-Eolian-Lacustrine	Beac-Eoli-La	BEAC-EOLI
ElemLF	Backshore Terrace-Beach-Eolian-Lacustrine	Bate-Beac-Eoli-La	BATE-BEAC-EOLI
ElemLF	Beach Plain-Beach-Eolian-Lacustrine	Bepl-Beac-Eoli-La	BEPL-BEAC-EOLI
ElemLF	Beach Ridge-Beach-Eolian-Lacustrine	Beri-Beac-Eoli-La	BERI-BEAC-EOLI
LF	Island-Eolian-Lacustrine	Isla-Eoli-La	ISLA-EOLI
LF	Lake-Eolian-Lacustrine	Lake-Eoli-La	LAKE-EOLI
LF	Lake Bed-Eolian-Lacustrine	Labe-Eoli-La	LABE-EOLI
LF	Lake Plain-Eolian-Lacustrine	Lapl-Eoli-La	LAPL-EOLI
LF	Lake Terrace-Eolian-Lacustrine	Late-Eoli-La	LATE-EOLI
LF	Shoreline-Eolian-Lacustrine	Shor-Eoli-La	SHOR-EOLI
Subpr	Fluvatile-Lacustrine	Flut-La	FLUT
LF	Beach-Fluvatile-Lacustrine	Beac-Flut-La	BEAC-FLUT

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Backshore Terrace-Beach-Fluvatile-Lacustrine	Bate-Beac-Flut-La	BATE-BEAC-FLUT
ElemLF	Beach Plain-Beach-Fluvatile-Lacustrine	Bepl-Beac-Flut-La	BEPL-BEAC-FLUT
ElemLF	Beach Ridge-Beach-Fluvatile-Lacustrine	Beri-Beac-Flut-La	BERI-BEAC-FLUT
LF	Island-Fluvatile-Lacustrine	Isla-Flut-La	ISLA-FLUT
LF	Lake-Fluvatile-Lacustrine	Lake-Flut-La	LAKE-FLUT
LF	Lake Bed-Fluvatile-Lacustrine	Labe-Flut-La	LABE-FLUT
LF	Lake Plain-Fluvatile-Lacustrine	Lapl-Flut-La	LAPL-FLUT
LF	Lake Terrace-Fluvatile-Lacustrine	Late-Flut-La	LATE-FLUT
LF	Oxbow Lake-Fluvatile-Lacustrine	Oxla-Flut-La	OXLA-FLUT
LF	Shoreline-Fluvatile-Lacustrine	Shor-Flut-La	SHOR-FLUT
Subpr	Glacial-Lacustrine	Glac-La	GLAC
LF	Beach-Glacial-Lacustrine	Beac-Glac-La	BEAC-GLAC
ElemLF	Backshore Terrace-Beach-Glacial-Lacustrine	Bate-Beac-Glac-La	BATE-BEAC-GLAC
ElemLF	Beach Plain-Beach-Glacial-Lacustrine	Bepl-Beac-Glac-La	BEPL-BEAC-GLAC
ElemLF	Beach Ridge-Beach-Glacial-Lacustrine	Beri-Beac-Glac-La	BERI-BEAC-GLAC
LF	Island-Glacial-Lacustrine	Isla-Glac-La	ISLA-GLAC
LF	Lake-Glacial-Lacustrine	Lake-Glac-La	LAKE-GLAC
LF	Lake Bed-Glacial-Lacustrine	Labe-Glac-La	LABE-GLAC
LF	Lake Plain-Glacial-Lacustrine	Lapl-Glac-La	LAPL-GLAC
LF	Lake Terrace-Glacial-Lacustrine	Late-Glac-La	LATE-GLAC
LF	Paternoster Lakes-Glacial-Lacustrine	Pala-Glac-La	PALA-GLAC
LF	Shoreline-Glacial-Lacustrine	Shor-Glac-La	SHOR-GLAC
LF	Tarn-Glacial-Lacustrine	Tarn-Glac-La	TARN-GLAC
Subpr	Lacustrine (Undiff)-Lacustrine	Lacu-La	LACU
LF	Beach-Lacustrine (Undiff)-Lacustrine	Beac-Lacu-La	BEAC-LACU
ElemLF	Backshore Terrace-Beach-Lacustrine (Undiff)-Lacustrine	Bate-Beac-Lacu-La	BATE-BEAC-LACU
ElemLF	Beach Plain-Beach-Lacustrine (Undiff)-Lacustrine	Bepl-Beac-Lacu-La	BEPL-BEAC-LACU
ElemLF	Beach Ridge-Beach-Lacustrine (Undiff)-Lacustrine	Beri-Beac-Lacu-La	BERI-BEAC-LACU
LF	Island-Lacustrine (Undiff)-Lacustrine	Isla-Lacu-La	ISLA-LACU
LF	Lake-Lacustrine (Undiff)-Lacustrine	Lake-Lacu-La	LAKE-LACU

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Lake Bed-Lacustrine (Undiff)-Lacustrine	Labe-Lacu-La	LABE-LACU
LF	Lake Plain-Lacustrine (Undiff)-Lacustrine	Lapl-Lacu-La	LAPL-LACU
LF	Lake Terrace-Lacustrine (Undiff)-Lacustrine	Late-Lacu-La	LATE-LACU
LF	Shoreline-Lacustrine (Undiff)-Lacustrine	Shor-Lacu-La	SHOR-LACU
Subpr	Landslide-Lacustrine	Land-La	LAND
LF	Beach-Landslide-Lacustrine	Beac-Land-La	BEAC-LAND
ElemLF	Backshore Terrace-Beach-Landslide-Lacustrine	Bate-Beac-Land-La	BATE-BEAC-LAND
ElemLF	Beach Plain-Beach-Landslide-Lacustrine	Bepl-Beac-Land-La	BEPL-BEAC-LAND
ElemLF	Beach Ridge-Beach-Landslide-Lacustrine	Beri-Beac-Land-La	BERI-BEAC-LAND
LF	Island-Landslide-Lacustrine	Isla-Land-La	ISLA-LAND
LF	Lake-Landslide-Lacustrine	Lake-Land-La	LAKE-LAND
LF	Lake Bed-Landslide-Lacustrine	Labe-Land-La	LABE-LAND
LF	Lake Plain-Landslide-Lacustrine	Lapl-Land-La	LAPL-LAND
LF	Lake Terrace-Landslide-Lacustrine	Late-Land-La	LATE-LAND
LF	Shoreline-Landslide-Lacustrine	Shor-Land-La	SHOR-LAND
LF	Slump Pond-Landslide-Lacustrine	Slpo-Land-La	SLPO-LAND
Subpr	Meteoric-Lacustrine	Mete-La	METE
LF	Beach-Meteoric-Lacustrine	Beac-Mete-La	BEAC-METE
ElemLF	Backshore Terrace-Beach-Meteoric-Lacustrine	Bate-Beac-Mete-La	BATE-BEAC-METE
ElemLF	Beach Plain-Beach-Meteoric-Lacustrine	Bepl-Beac-Mete-La	BEPL-BEAC-METE
ElemLF	Beach Ridge-Beach-Meteoric-Lacustrine	Beri-Beac-Mete-La	BERI-BEAC-METE
LF	Island-Meteoric-Lacustrine	Isla-Mete-La	ISLA-METE
LF	Lake-Meteoric-Lacustrine	Lake-Mete-La	LAKE-METE
LF	Lake Bed-Meteoric-Lacustrine	Labe-Mete-La	LABE-METE
LF	Lake Plain-Meteoric-Lacustrine	Lapl-Mete-La	LAPL-METE
LF	Lake Terrace-Meteoric-Lacustrine	Late-Mete-La	LATE-METE
LF	Shoreline-Meteoric-Lacustrine	Shor-Mete-La	SHOR-METE
Subpr	Organic-Lacustrine	Orga-La	ORGA
LF	Beach-Organic-Lacustrine	Beac-Orga-La	BEAC-ORGA
ElemLF	Backshore Terrace-Beach-Organic-Lacustrine	Bate-Beac-Orga-La	BATE-BEAC-ORGA

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Beach Plain-Beach-Organic-Lacustrine	Bepl-Beac-Orga-La	BEPL-BEAC-ORGA
ElemLF	Beach Ridge-Beach-Organic-Lacustrine	Beri-Beac-Orga-La	BERI-BEAC-ORGA
LF	Island-Organic-Lacustrine	Isla-Orga-La	ISLA-ORGA
LF	Lake-Organic-Lacustrine	Lake-Orga-La	LAKE-ORGA
LF	Lake Bed-Organic-Lacustrine	Labe-Orga-La	LABE-ORGA
LF	Lake Plain-Organic-Lacustrine	Lapl-Orga-La	LAPL-ORGA
LF	Lake Terrace-Organic-Lacustrine	Late-Orga-La	LATE-ORGA
LF	Shoreline-Organic-Lacustrine	Shor-Orga-La	SHOR-ORGA
Subpr	Shoreline-Lacustrine	Shor-La	SHOR
LF	Beach-Shoreline-Lacustrine	Beac-Shor-La	BEAC-SHOR
ElemLF	Backshore Terrace-Beach-Shoreline-Lacustrine	Bate-Beac-Shor-La	BATE-BEAC-SHOR
ElemLF	Beach Plain-Beach-Shoreline-Lacustrine	Bepl-Beac-Shor-La	BEPL-BEAC-SHOR
ElemLF	Beach Ridge-Beach-Solution-Lacustrine	Beri-Beac-Solu-La	BERI-BEAC-SOLU
LF	Island-Shoreline-Lacustrine	Isla-Shor-La	ISLA-SHOR
LF	Lake-Shoreline-Lacustrine	Lake-Shor-La	LAKE-SHOR
LF	Lake Bed-Shoreline-Lacustrine	Labe-Shor-La	LABE-SHOR
LF	Lake Plain-Shoreline-Lacustrine	Lapl-Shor-La	LAPL-SHOR
LF	Lake Terrace-Shoreline-Lacustrine	Late-Shor-La	LATE-SHOR
LF	Shoreline-Shoreline-Lacustrine	Shor-Shor-La	SHOR-SHOR
Subpr	Solution-Lacustrine	Solu-La	SOLU
LF	Beach-Solution-Lacustrine	Beac-Solu-La	BEAC-SOLU
ElemLF	Backshore Terrace-Beach-Solution-Lacustrine	Bate-Beac-Solu-La	BATE-BEAC-SOLU
ElemLF	Beach Plain-Beach-Solution-Lacustrine	Bepl-Beac-Solu-La	BEPL-BEAC-SOLU
ElemLF	Beach Ridge-Beach-Shoreline-Lacustrine	Beri-Beac-Shor-La	BERI-BEAC-SHOR
LF	Island-Solution-Lacustrine	Isla-Solu-La	ISLA-SOLU
LF	Lake-Solution-Lacustrine	Lake-Solu-La	LAKE-SOLU
LF	Lake Bed-Solution-Lacustrine	Labe-Solu-La	LABE-SOLU
LF	Lake Plain-Solution-Lacustrine	Lapl-Solu-La	LAPL-SOLU
LF	Lake Terrace-Solution-Lacustrine	Late-Solu-La	LATE-SOLU
LF	Shoreline-Solution-Lacustrine	Shor-Solu-La	SHOR-SOLU

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
Subpr	Tectonic-Lacustrine	Tect-La	TECT
LF	Beach-Tectonic-Lacustrine	Beac-Tect-La	BEAC-TECT
ElemLF	Backshore Terrace-Beach-Tectonic-Lacustrine	Bate-Beac-Tect-La	BATE-BEAC-TECT
ElemLF	Beach Plain-Beach-Tectonic-Lacustrine	Bepl-Beac-Tect-La	BEPL-BEAC-TECT
ElemLF	Beach Ridge-Beach-Tectonic-Lacustrine	Beri-Beac-Tect-La	BERI-BEAC-TECT
LF	Island-Tectonic-Lacustrine	Isla-Tect-La	ISLA-TECT
LF	Lake-Tectonic-Lacustrine	Lake-Tect-La	LAKE-TECT
LF	Lake Bed-Tectonic-Lacustrine	Labe-Tect-La	LABE-TECT
LF	Lake Plain-Tectonic-Lacustrine	Lapl-Tect-La	LAPL-TECT
LF	Lake Terrace-Tectonic-Lacustrine	Lapl-Tect-La	LATE-TECT
LF	Sag Pond-Tectonic-Lacustrine	Sapo-Tect-La	SAPO-TECT
LF	Shoreline-Tectonic-Lacustrine	Shor-Tect-La	SHOR-TECT
Subpr	Volcanic-Lacustrine	Volc-La	VOLC
LF	Beach-Volcanic-Lacustrine	Beac-Volc-La	BEAC-VOLC
ElemLF	Backshore Terrace-Beach-Volcanic-Lacustrine	Bate-Beac-Volc-La	BATE-BEAC-VOLC
ElemLF	Beach Plain-Beach-Volcanic-Lacustrine	Bepl-Beac-Volc-La	BEPL-BEAC-VOLC
ElemLF	Beach Ridge-Beach-Volcanic-Lacustrine	Beri-Beac-Volc-La	BERI-BEAC-VOLC
LF	Island-Volcanic-Lacustrine	Isla-Volc-La	ISLA-VOLC
LF	Lake-Volcanic-Lacustrine	Lake-Volc-La	LAKE-VOLC
LF	Lake Bed-Volcanic-Lacustrine	Labe-Volc-La	LABE-VOLC
LF	Lake Plain-Volcanic-Lacustrine	Lapl-Volc-La	LAPL-VOLC
LF	Lake Terrace-Volcanic-Lacustrine	Late-Volc-La	LATE-VOLC
LF	Shoreline-Volcanic-Lacustrine	Shor-Volc-La	SHOR-VOLC

Tectonic

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
Process	Tectonic	Te	TE
Subpr	Faulting-Tectonic	Faul-Te	FAUL
LF	Compound Fault Scarps-Faulting-Tectonic	Cofs-Faul-Te	COFS-FAUL
LF	Fault Scarp-Faulting-Tectonic	Fasc-Faul-Te	FASC-FAUL
LF	Fault Terrace-Faulting-Tectonic	Fate-Faul-Te	FATE-FAUL

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Fault Trace-Faulting-Tectonic	Fatr-Faul-Te	FATR-FAUL
LF	Fissure-Faulting-Tectonic	Fiss-Faul-Te	FISS-FAUL
LF	Graben-Faulting-Tectonic	Grab-Faul-Te	GRAB-FAUL
LF	Horst-Faulting-Tectonic	Hors-Faul-Te	HORS-FAUL
LF	Scarp Slope-Faulting-Tectonic	Scsl-Faul-Te	SCSL-FAUL
LF	Shutter Ridge-Faulting-Tectonic	Shri-Faul-Te	SHRI-FAUL
LF	Tilt Block-Faulting-Tectonic	Tibl-Faul-Te	TIBL-FAUL
Subpr	Folding-Tectonic	Fold-Te	FOLD
LF	Anticline-Folding-Tectonic	Anti-Fold-Te	ANTI-FOLD
LF	Dome-Folding-Tectonic	Dome-Fold-Te	DOME-FOLD
LF	Folds-Folding-Tectonic	Flds-Fold-Te	FLDS-FOLD
LF	Homocline-Folding-Tectonic	Homo-Fold-Te	HOMO-FOLD
LF	Laccolith-Structural-Tectonic	Lacc-Stru-Te	LACC-STRU
LF	Monocline-Folding-Tectonic	Mono-Fold-Te	MONO-FOLD
LF	Syncline-Folding-Tectonic	Sync-Fold-Te	SYNC-FOLD
LF	Synform-Folding-Tectonic	Synf-Fold-Te	SYNF-FOLD
Subpr	Structural-Tectonic	Stru-Te	STRU
LF	Batholith-Structural-Tectonic	Bath-Stru-Te	BATH-STRU
LF	Diapirs-Structural-Tectonic	Diap-Stru-Te	DIAP-STRU
LF	Stock-Structural-Tectonic	Stoc-Stru-Te	STOC-STRU
LF	Structural Basin-Structural-Tectonic	Stba-Stru-Te	STBA-STRU
LF	Structural Domes (Undiff)-Structural-Tectonic	Stdo-Stru-Te	STDO-STRU

Volcanic

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
Process	Volcanic	Vo	VO
Subpr	Constructional-Volcanic	Cons-Vo	CONS
LF	Aa Flow-Constructional-Volcanic	Aafl-Cons-Vo	AAFL-CONS
ElemLF	Pressure Ridge-Aa Flow-Constructional-Volcanic	Prri-Aafl-Cons-Vo	PRRI-AAFL-CONS
ElemLF	Spatter Cone-Aa Flow-Constructional-Volcanic	Spco-Aafl-Cons-Vo	SPCO-AAFL-CONS
ElemLF	Trench-Aa Flow-Constructional-Volcanic	Tren-Aafl-Cons-Vo	TREN-AAFL-CONS
LF	Ash-Fall Tephra Field-Constructional-Volcanic	Aftf-Cons-Vo	AFTF-CONS
LF	Block Flow-Constructional-Volcanic	Blfl-Cons-Vo	BLFL-CONS

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Pressure Ridge-Block Flow-Constructional-Volcanic	Prri-Blfl-Cons-Vo	PRRI-BLFL-CONS
ElemLF	Spatter Cone-Block Flow-Constructional-Volcanic	Spco-Blfl-Cons-Vo	SPCO-BLFL-CONS
ElemLF	Trench-Block Flow-Constructional-Volcanic	Tren-Blfl-Cons-Vo	TREN-BLFL-CONS
LF	Cinder Cone-Constructional-Volcanic	Cico-Cons-Vo	CICO-CONS
LF	Composite Cone (Stratovolcano)-Constructional-Volcanic	Stra-Cons-Vo	STRA-CONS
LF	Exogenous Dome-Constructional-Volcanic	Exdo-Cons-Vo	EXDO-CONS
LF	Fissure Vent-Constructional-Volcanic	Five-Cons-Vo	FIVE-CONS
LF	Fumarole Field-Constructional-Volcanic	Fufi-Cons-Vo	FUFI-CONS
LF	Intrusive Dome-Constructional-Volcanic	Indo-Cons-Vo	INDO-CONS
LF	Lahar-Constructional-Volcanic	Laha-Cons-Vo	LAHA-CONS
LF	Lava Flow (Undiff)-Constructional-Volcanic	Lafl-Cons-Vo	LAFL-CONS
ElemLF	Pressure Ridge-Lava Flow (Undiff)-Constructional-Volcanic	Prri-Lafl- Cons-Vo	PRRI-LAFL-CONS
ElemLF	Spatter Cone-Lava Flow (Undiff)-Constructional-Volcanic	Spco-Lafl-Cons-Vo	SPCO-LAFL-CONS
ElemLF	Trench-Lava Flow (Undiff)-Constructional-Volcanic	Tren-Lafl-Cons-Vo	TREN-LAFL-CONS
LF	Mud Pot Field-Constructional-Volcanic	Mupf-Cons-Vo	MUPF-CONS
LF	Mud Volcano-Constructional-Volcanic	Muvo-Cons-Vo	MUVO-CONS
LF	Pahoehoe Flow-Constructional-Volcanic	Pafl-Cons-Vo	PAFL-CONS
ElemLF	Pressure Ridge-Pahoehoe Flow-Constructional-Volcanic	Prri-Pafl- Cons-Vo	PRRI-PAFL-CONS
ElemLF	Splatter Cone-Pahoehoe Flow-Constructional-Volcanic	Spco-Pafl-Cons-Vo	SPCO-PAFL-CONS
ElemLF	Trench-Pahoehoe Flow-Constructional-Volcanic	Tren-Pafl-Cons-Vo	TREN-PAFL-CONS
LF	Parasitic Cone-Constructional-Volcanic	Paco-Cons-Vo	PACO-CONS
LF	Pelean Dome-Constructional-Volcanic	Pado-Cons-Vo	PADO-CONS
LF	Plug Dome-Constructional-Volcanic	Pldo-Cons-Vo	PLDO-CONS
LF	Pumice Cone-Constructional-Volcanic	Puco-Cons-Vo	PUCO-CONS
LF	Pyroclastic Cone (Undiff)-Constructional-Volcanic	Pyco-Cons-Vo	PYCO-CONS
LF	Pyroclastic Flow (Ash Flow)-Constructional-Volcanic	Pyfl-Cons-Vo	PYFL-CONS
LF	Shield Volcano-Constructional-Volcanic	Shvo-Cons-Vo	SHVO-CONS
LF	Steptoe-Constructional-Volcanic	Step-Cons-Vo	STEP-CONS

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Upheaved Dome-Constructional-Volcanic	Updo-Cons-Vo	UPDO-CONS
LF	Volcanic Cone (Undiff)-Constructional-Volcanic	Voco-Cons-Vo	VOCO-CONS
LF	Volcanic Dome (Undiff)-Constructional-Volcanic	Vodo-Cons-Vo	VODO-CONS
Subpr	Destructional-Volcanic	Dest-Vo	DEST
LF	Caldera-Destructional-Volcanic	Cald-Dest-Vo	CALD-DEST
LF	Collapse Caldera-Destructional-Volcanic	Coca-Dest-Vo	COCA-DEST
LF	Crater-Destructional-Volcanic	Crat-Dest-Vo	CRAT-DEST
LF	Explosion Caldera-Destructional-Volcanic	Exca-Dest-Vo	EXCA-DEST
LF	Maar-Destructional-Volcanic	Maar-Dest-Vo	MAAR-DEST

Mass Wasting

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
Process	Mass Wasting	Mw	MW
Subpr	Complex-Mass Wasting	Comp-Mw	COMP
LF	Valley Inner Gorge-Complex-Mass Wasting	Vaig-Comp-Mw	VAIG-COMP
LF	Debris Slide Basin-Complex-Mass Wasting	Desb-Comp-Mw	DESB-COMP
LF	Internested/Multiple Rotation-Translation Slides-Complex-Mass	Wasting Irts-Comp-Mw	IRTS-COMP
LF	Rock Fall Avalanche-Complex-Mass Wasting	Rofa-Comp-Mw	ROFA-COMP
ElemLF	Source Area-Rock Fall Avalanche-Complex-Mass Wasting	Soar-Rofa-Comp-Mw	SOAR-ROFA-COMP
ElemLF	Transport Zone-Rock Fall Avalanche-Complex-Mass Wasting	Trzo-Rofa-Comp-Mw	TRZO-ROFA-COMP
ElemLF	Deposit-Rock Fall Avalanche-Complex-Mass Wasting	Depo-Rofa-Comp-Mw	DEPO-ROFA-COMP
LF	Rock Slide-Rock Fall-Complex-Mass Wasting	Rsrf-Comp-Mw	RSRF-COMP
ElemLF	Source Area-Rock Slide-Rock Fall-Complex-Mass Wasting	Soar-Rsrf-Comp-Mw	SOAR-RSRF-COMP
ElemLF	Transport Zone-Rock Slide-Rock Fall-Complex-Mass Wasting	Trzo-Rsrf-Comp-Mw	TRZO-RSRF-COMP
ElemLF	Deposit-Rock Slide-Rock Fall-Complex-Mass Wasting	Depo-Rsrf-Comp-Mw	DEPO-RSRF-COMP
LF	Slump And Topple-Prone Slope-Complex-Mass Wasting	Stps-Comp-Mw	STPS-COMP
ElemLF	Source Area-Slump And Topple-Prone Slope-Complex-Mass Wasting	Soar-Stps-Comp-Mw	SOAR-STPS-COMP
ElemLF	Transport Zone-Slump And Topple-Prone Slope-Complex-Mass Wasting	Trzo-Stps-Comp-Mw	TRZO-STPS-COMP

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Deposit-Slump And Topple-Prone Slope-Complex-Mass Wasting	Depo-Stps-Comp-Mw	DEPO-STPS-COMP
LF	Slump-Earth Flow-Complex-Mass Wasting	Slef-Comp-Mw	SLEF-COMP
ElemLF	Main Scarp (Undiff)-Slump-Earth Flow-Complex-Mass Wasting	Masc-Slef-Comp-Mw	MASC-SLEF-COMP
ElemLF	DS-Prone Main Scarp-Slump-Earth Flow-Complex-Mass Wasting	Dspm-Slef-Comp-Mw	DSPM-SLEF-COMP
ElemLF	Nested Main Scarp-Slump-Earth Flow-Complex-Mass Wasting	Nems-Slef-Comp-Mw	NEMS-SLEF-COMP
ElemLF	Secondary Scarp (Undiff)-Slump-Earth Flow-Complex-Mass Wasting	Sesc-Slef-Comp-Mw	SESC-SLEF-COMP
ElemLF	DS-Prone Secondary Scarp-Slump-Earth Flow-Complex-Mass Wasting	Dsps-Slef-Comp-Mw	DSPS-SLEF-COMP
ElemLF	Nested Secondary Scarp-Slump-Earth Flow-Complex-Mass Wasting	Ness-Slef-Comp-Mw	NESS-SLEF-COMP
ElemLF	Lateral Scarp (Undiff)-Slump-Earth Flow-Complex-Mass Wasting	Lasc-Slef-Comp-Mw	LASC-SLEF-COMP
ElemLF	Nested Lateral Scarp-Slump-Earth Flow-Complex-Mass Wasting	Nels-Slef-Comp-Mw	NELS-SLEF-COMP
ElemLF	DS-Prone Lateral Scarp-Slump-Earth Flow-Complex-Mass Wasting	Dspl-Slef-Comp-Mw	DSPL-SLEF-COMP
ElemLF	Bench (Undiff)-Slump-Earth Flow-Complex-Mass Wasting	Benc-Slef-Comp-Mw	BENC-SLEF-COMP
ElemLF	Eroded Bench-Slump-Earth Flow-Complex-Mass Wasting	Erbe-Slef-Comp-Mw	ERBE-SLEF-COMP
ElemLF	Nested Bench-Slump-Earth Flow-Complex-Mass Wasting	Nebe-Slef-Comp-Mw	NEBE-SLEF-COMP
ElemLF	Toe Zone (Undiff)-Slump-Earth Flow-Complex-Mass Wasting	Tozo-Slef-Comp-Mw	TOZO-SLEF-COMP
ElemLF	Nested Toe Zone-Slump-Earth Flow-Complex-Mass Wasting	Netz-Slef-Comp-Mw	NETZ-SLEF-COMP
ElemLF	Debris Slide Prone Toe Zone-Slump-Earth Flow-Complex-Mass Wasting	Dspt-Slef-Comp-Mw	DSPT-SLEF-COMP
Subpr	Fall-Mass Wasting	Fall-Mw	FALL
LF	Fall-Prone Slope-Fall-Mass Wasting	Faps-Fall-Mw	FAPS-FALL
ElemLF	Source Area-Fall-Prone Slope-Fall-Mass Wasting	Soar-Faps-Fall-Mw	SOAR-FAPS-FALL
ElemLF	Deposit (Talus)-Fall-Prone Slope-Fall-Mass Wasting	Depo-Faps-Fall-Mw	DEPO-FAPS-FALL
Subpr	Flow-Mass Wasting	Flow-Mw	FLOW
LF	Debris Avalanche-Flow-Mass Wasting	Deav-Flow-Mw	DEAV-FLOW

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Source Area-Debris Avalanche-Flow-Mass Wasting	Soar-Deav-Flow-Mw	SOAR-DEAV-FLOW
ElemLF	Transport Zone-Debris Avalanche-Flow-MassWasting	Trzo-Deav-Flow-Mw	TRZO-DEAV-FLOW
ElemLF	Deposit-Debris Avalanche-Flow-Mass Wasting	Depo-Deav-Flow-Mw	DEPO-DEAV-FLOW
LF	Debris Flow-Flow-Mass Wasting	Defl-Flow-Mw	DEFL-FLOW
ElemLF	Source Area-Debris Flow-Flow-Mass Wasting	Soar-Defl-Flow-Mw	SOAR-DEFL-FLOW
ElemLF	Transport Zone-Debris Flow-Flow-Mass Wasting	Trzo-Defl-Flow-Mw	TRZO-DEFL-FLOW
ElemLF	Deposit-Debris Flow-Flow-Mass Wasting	Depo-Defl-Flow-Mw	DEPO-DEFL-FLOW
LF	Earth Flow-Flow-Mass Wasting	Eafl-Flow-Mw	EAFL-FLOW
ElemLF	Main Scarp-Earth Flow-Flow-Mass Wasting	Masc-Eafl-Flow-Mw	MASC-EAFL-FLOW
ElemLF	Secondary Scarp-Earth Flow-Flow-Mass Wasting	Sesc-Eafl-Flow-Mw	SESC-EAFL-FLOW
ElemLF	Bench-Earth Flow-Flow-Mass Wasting	Benc-Eafl-Flow-Mw	BENC-EAFL-FLOW
ElemLF	Eroded Bench-Earth Flow-Flow-Mass Wasting	Erbe-Eafl-Flow-Mw	ERBE-EAFL-FLOW
ElemLF	Toe Zone-Earth Flow-Flow-Mass Wasting	Tozo-Eafl-Flow-Mw	TOZO-EAFL-FLOW
LF	Dry Sand Flow-Flow-Mass Wasting	Drsf-Flow-Mw	DRSF-FLOW
ElemLF	Ravel Cone-Dry Sand Flow-Flow-Mass Wasting	Raco-Drsf-Flow-Mw	RACO-DRSF-FLOW
LF	Loess Flow-Flow-Mass Wasting	Lofl-Flow-Mw	LOFL-FLOW
LF	Frost Creep Slope-Flow-Mass Wasting	Frcs-Flow-Mw	FRCS-FLOW
LF	Soil Creep Slope-Flow-Mass Wasting	Socs-Flow-Mw	SOCS-FLOW
ElemLF	Ridgetop Bedrock Outcrop (Source)-Soil Creep Slope-Flow-Mass Wasting	Ribo-Socs-Flow-Mw	RIBO-SOCS-FLOW
ElemLF	Hillslope Bedrock Outcrop (Source)-Soil Creep Slope-Flow-Mass Wasting	Hibo-Socs-Flow-Mw	HIBO-SOCS-FLOW
ElemLF	Colluvial Shoulder-Soil Creep Slope-Flow-Mass Wasting	Cosh-Socs-Flow-Mw	COSH-SOCS-FLOW
ElemLF	Colluvial Slopes-Soil Creep Slope-Flow-Mass Wasting	Cosl-Socs-Flow-Mw	COSL-SOCS-FLOW
LF	Periglacial Flows (Undiff)-Flow-Mass Wasting	Pefl-Flow-Mw	PEFL-FLOW
LF	Rock Glaciers-Flow-Mass Wasting	Rogl-Flow-Mw	ROGL-FLOW

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Rock Stream-Flow-Mass Wasting	Rost-Flow-Mw	ROST-FLOW
LF	Solifluction Lobe-Flow-Mass Wasting	Solo-Flow-Mw	SOLO-FLOW
LF	Solifluction Sheet-Flow-Mass Wasting	Sosh-Flow-Mw	SOSH-FLOW
LF	Solifluction Terrace-Flow-Mass Wasting	Sote-Flow-Mw	SOTE-FLOW
LF	Snow Avalanche Slope-Flow-Mass Wasting	Snas-Flow-Mw	SNAS-FLOW
ElemLF	Source Area-Snow Avalanche Slope-Flow-Mass Wasting	Soar-Snas-Flow-Mw	SOAR-SNAS-FLOW
ElemLF	Transport Zone (Chute)-Snow Avalanche Slope-Flow-Mass Wasting	Trzo-Snas-Flow-Mw	TRZO-SNAS-FLOW
ElemLF	Runout Zone-Snow Avalanche Slope-Flow-Mass Wasting	Ruzo-Snas-Flow-Mw	RUZO-SNAS-FLOW
ElemLF	Avalanche Talus-Snow Avalanche Slope-Flow-Mass Wasting	Avta-Snas-Flow-Mw	AVTA-SNAS-FLOW
Subpr	Lateral Spread-Mass Wasting	Lasp-Mw	LASP
LF	Earth Lateral Spread-Lateral Spread-Mass Wasting	Eals-Lasp-Mw	EALS-LASP
LF	Rock Spread-Lateral Spread-Mass Wasting	Rosp-Lasp-Mw	ROSP-LASP
Subpr	Slide-Mass Wasting	Slid-Mw	SLID
LF	Rotational Slide-Slide-Mass Wasting	Rosl-Slid-Mw	ROSL-SLID
ElemLF	Main Scarp (Undiff)-Rotational Slide-Slide-Mass Wasting	Masc-Rosl-Slid-Mw	MASC-ROSL-SLID
ElemLF	DS-Prone Main Scarp-Rotational Slide-Slide-Mass Wasting	Dspm-Rosl-Slid-Mw	DSPM-ROSL-SLID
ElemLF	Nested Main Scarp-Rotational Slide-Slide-Mass Wasting	Nems-Rosl-Slid-Mw	NEMS-ROSL-SLID
ElemLF	Secondary Scarp (Undiff)-Rotational Slide-Slide-Mass Wasting	Sesc-Rosl-Slid-Mw	SESC-ROSL-SLID
ElemLF	DS-Prone Secondary Scarp-Rotational Slide-Slide-Mass Wasting	Dsps-Rosl-Slid-Mw	DSPS-ROSL-SLID
ElemLF	Nested Secondary Scarp-Rotational Slide-Slide-Slide-Mass Wasting	Ness-Rosl-Slid-Mw	NESS-ROSL-SLID
ElemLF	Bench (Undiff)-Rotational Slide-Slide-Mass Wasting	Benc-Rosl-Slid-Mw	BENC-ROSL-SLID
ElemLF	Eroded Bench-Rotational Slide-Slide-Mass Wasting	Erbe-Rosl-Slid-Mw	ERBE-ROSL-SLID
ElemLF	Nested Bench-Rotational Slide-Slide-Mass Wasting	Nebe-Rosl-Slid-Mw	NEBE-ROSL-SLID
ElemLF	Debris Slide Prone Toe Zone-Rotational Slide-Slide-Mass Wasting	Dspt-Rosl-Slid-Mw	DSPT-ROSL-SLID
ElemLF	Toe Zone (Undiff)-Rotational Slide-Slide-Mass Wasting	Tozo-Rosl-Slid-Mw	TOZO-ROSL-SLID

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Nested Toe Zone-Rotational Slide-Slide-Mass Wasting	Netz-Rosl-Slid-Mw	NETZ-ROSL-SLID
LF	Rotational-Translational Slide-Slide-Mass Wasting	Rots-Slid-Mw	ROTS-SLID
ElemLF	Main Scarp (Undiff)-Rotational-Translational Slide-Slide-Mass Wasting	Masc-Rots-Slid-Mw	MASC-ROTS-SLID
ElemLF	DS-Prone Main Scarp-Rotational-Translational Slide-Slide-Mass Wasting	Dspm-Rots-Slid-Mw	DSPM-ROTS-SLID
ElemLF	Nested Main Scarp-Rotational-Translational Slide-Slide-Mass Wasting	Nems-Rots-Slid-Mw	NEMS-ROTS-SLID
ElemLF	Secondary Scarp (Undiff)-Rotational-Translational Slide-Slide-Mass Wasting	Sesc-Rots-Slid-Mw	SESC-ROTS-SLID
ElemLF	DS-Prone Secondary Scarp-Rotational-Translational Slide-Slide-Mass Wasting	Dsps-Rots-Slid-Mw	DSPS-ROTS-SLID
ElemLF	Nested Secondary Scarp-Rotational-Translational Slide-Slide-Mass Wasting	Ness-Rots-Slid-Mw	NESS-ROTS-SLID
ElemLF	Bench (Undiff)-Rotational-Translational Slide-Slide-Mass Wasting	Benc-Rots-Slid-Mw	BENC-ROTS-SLID
ElemLF	Eroded Bench-Rotational-Translational Slide-Slide-Mass Wasting	Erbe-Rots-Slid-Mw	ERBE-ROTS-SLID
ElemLF	Nested Bench-Rotational-Translational Slide-Slide-Mass Wasting	Nebe-Rots-Slid-Mw	NEBE-ROTS-SLID
ElemLF	Toe Zone (Undiff)-Rotational-Translational Slide-Slide-Mass Wasting	Tozo-Rots-Slid-Mw	TOZO-ROTS-SLID
ElemLF	Nested Toe Zone-Rotational-Translational Slide-Slide-Mass Wasting	Netz-Rots-Slid-Mw	NETZ-ROTS-SLID
ElemLF	Debris Slide Prone Toe Zone-Rotational-Translational Slide-Slide-Mass Wasting	Dspt-Rots-Slid-Mw	DSPT-ROTS-SLID
LF	Translational - Block Slide-Slide-Mass Wasting	Trbs-Slid-Mw	TRBS-SLID
ElemLF	Main Scarp (Undiff)-Translational-Masc-Block Slide-Slide-Mass Wasting	Trbs-Slid-Mw	MASC-TRBS-SLID
ElemLF	DS-Prone Main Scarp-Translational - Block Slide-Slide-Mass Wasting	Dspm-Trbs-Slid-Mw	DSPM-TRBS-SLID
ElemLF	Nested Main Scarp-Translational - Block Slide-Slide-Mass Wasting	Nems-Trbs-Slid-Mw	NEMS-TRBS-SLID
ElemLF	Secondary Scarp (Undiff)-Translational - Block Slide-Slide-Mass Wasting	Sesc-Trbs-Slid-Mw	SESC-TRBS-SLID
ElemLF	DS-Prone Secondary Scarp-Translational - Block Slide-Slide-Mass Wasting	Dsps-Trbs-Slid-Mw	DSPS-TRBS-SLID
ElemLF	Nested Secondary Scarp-Translational- Block Slide-Slide-Mass Wasting	Ness-Trbs-Slid-Mw	NESS-TRBS-SLID

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
ElemLF	Bench (Undiff)-Translational - Block Slide-Slide-Mass Wasting	Benc-Trbs-Slid-Mw	BENC-TRBS-SLID
ElemLF	Eroded Bench-Translational - Block Slide-Slide-Mass Wasting	Erbe-Trbs-Slid-Mw	ERBE-TRBS-SLID
ElemLF	Nested Bench-Translational - Block Slide-Slide-Mass Wasting	Nebe-Trbs-Slid-Mw	NEBE-TRBS-SLID
ElemLF	Toe Zone (Undiff)-Translational - Block Slide-Slide-Mass Wasting	Tozo-Trbs-Slid-Mw	TOZO-TRBS-SLID
ElemLF	Nested Toe Zone-Translational - Block Slide-Slide-Mass Wasting	Netz-Trbs-Slid-Mw	NETZ-TRBS-SLID
ElemLF	Debris Slide Prone Toe Zone-Translational - Block Slide-Slide- Mass Wasting	Dspt-Trbs-Slid-Mw	DSPT-TRBS-SLID
LF	Translational - Debris Slide-Slide-Mass Wasting	Trds-Slid-Mw	TRDS-SLID
ElemLF	Main Scarp-Translational - Debris Slide-Slide-Mass Wasting	Masc-Trds-Slid-Mw	MASC-TRDS-SLID
ElemLF	Secondary Scarp-Translational - Debris Slide-Slide-Mass Wasting	Sesc-Trds-Slid-Mw	SESC-TRDS-SLID
ElemLF	Bench-Translational - Debris Slide-Slide-Mass Wasting	Benc-Trds-Slid-Mw	BENC-TRDS-SLID
ElemLF	Eroded Bench-Translational - Debris Slide-Slide-Mass Wasting	Erbe-Trds-Slid-Mw	ERBE-TRDS-SLID
ElemLF	Toe Zone-Translational - Debris Slide-Slide-Mass Wasting	Tozo-Trds-Slid-Mw	TOZO-TRDS-SLID
LF	Undifferentiated Slide-Slide-Mass Wasting	Undi-Slid-Mw	UNDI-SLID
ElemLF	Main Scarp-Undifferentiated Slide-Slide-Mass Wasting	Masc-Undi-Slid-Mw	MASC-UNDI-SLID
ElemLF	Secondary Scarp-Undifferentiated Slide-Slide-Mass Wasting	Sesc-Undi-Slid-Mw	SESC-UNDI-SLID
ElemLF	Bench-Undifferentiated Slide-Slide-Mass Wasting	Benc-Undi-Slid-Mw	BENC-UNDI-SLID
ElemLF	Eroded Bench-Undifferentiated Slide-Slide-Mass Wasting	Erbe-Undi-Slid-Mw	ERBE-UNDI-SLID
ElemLF	Toe Zone-Undifferentiated Slide-Slide-Mass Wasting	Tozo-Undi-Slid-Mw	TOZO-UNDI-SLID
Subpr	Topple-Mass Wasting Topp-Mw TOPP		
LF	Topple-Prone Slope-Topple-Mass Wasting	Tops-Topp-Mw	TOPS-TOPP
ElemLF	Source Area-Topple-Prone Slope-Topple-Mass Wasting	Soar-Tops-Topp-Mw	SOAR-TOPS-TOPP
ElemLF	Deposit (Talus)-Topple-Prone Slope-Topple-Mass Wasting	Depo-Tops-Topp-Mw	DEPO-TOPS-TOPP

Coastal Marine

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
Process	Coastal Marine	Cm	CM
Subpr	Backshore/Backbeach-Coastal Marine	Babp-Cm	BABP
LF	Backwater-Backshore/Backbeach-Coastal Marine	Back-Babp-Cm	BACK-BABP
LF	Estuary-Backshore/Backbeach-Coastal Marine	Estu-Babp-Cm	ESTU-BABP
LF	Lagoon-Backshore/Backbeach-Coastal Marine	Lago-Babp-Cm	LAGO-BABP
LF	Mud Flat-Backshore/Backbeach-Coastal Marine	Mufl-Babp-Cm	MUFL-BABP
Subpr	Emergence-Coastal Marine	Emer-Cm	EMER
LF	Carolina Bay-Emergence-Coastal Marine	Caba-Emer-Cm	CABA-EMER
LF	Chenier Plain-Emergence-Coastal Marine	Chpl-Emer-Cm	CHPL-EMER
LF	Chenier-Emergence-Coastal Marine	Chen-Emer-Cm	CHEN-EMER
LF	Coastal Plain-Emergence-Coastal Marine	Copl-Emer-Cm	COPL-EMER
LF	Marine Terrace (Undiff)-Emergence-Coastal Marine	Mate-Emer-Cm	MATE-EMER
LF	Raised Beach-Emergence-Coastal Marine	Rabe-Emer-Cm	RABE-EMER
ElemLF	Raised Beach Ridge-Raised Beach-Emergence-Coastal Marine	Rabr-Rabe-Emer-Cm	RABR-RABE-EMER
ElemLF	Raised Inner Beach-Raised Beach-Emergence-Coastal Marine	Raib-Rabe-Emer-Cm	RAIB-RABE-EMER
LF	Raised Estuary-Emergence-Coastal Marine	Raes-Emer-Cm	RAES-EMER
LF	Raised Tidal Flat-Emergence-Coastal Marine	Ratf-Emer-Cm	RATF-EMER
LF	Relict Coastline-Emergence-Coastal Marine	Reco-Emer-Cm	RECO-EMER
LF	Strand Plain-Emergence-Coastal Marine	Stpl-Emer-Cm	STPL-EMER
LF	Wave Built Terrace-Emergence-Coastal Marine	Wabt-Emer-Cm	WABT-EMER
LF	Wave Cut Platform-Emergence-Coastal Marine	Wacp-Emer-Cm	WACP-EMER
Subpr	Shoreline Process-Coastal Marine	Shpr-Cm	SHPR
LF	Barrier Island-Shoreline Process-Coastal Marine	Bais-Shpr-Cm	BAIS-SHPR
ElemLF	Barrier Beach-Barrier Island-Shoreline Process-Coastal Marine	Babe-Bais-Shpr-Cm	BABE-BAIS-SHPR
ElemLF	Barrier Flat-Barrier Island-Shoreline Process-Coastal Marine	Bafl-Bais-Shpr-Cm	BAFL-BAIS-SHPR
LF	Barrier Reef-Shoreline Process-Coastal	Marine Bare-Shpr-Cm	BARE-SHPR

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Beach-Shoreline Process-Coastal Marine	Beac-Shpr-Cm	BEAC-SHPR
ElemLF	Backshore Terrace (Berm)-Beach-Shoreline Process-Coastal Marine	Bate-Beac-Shpr-Cm	BATE-BEAC-SHPR
ElemLF	Beach Plain-Beach-Shoreline Process-Coastal Marine	Bepl-Beac-Shpr-Cm	BEPL-BEAC-SHPR
ElemLF	Beach Ridge-Beach-Shoreline Process-Coastal Marine	Beri-Beac-Shpr-Cm	BERI-BEAC-SHPR
LF	Corral Pinnacle-Shoreline Process-Coastal Marine	Copi-Shpr-Cm	COPI-SHPR
LF	Dunes-Shoreline Process-Coastal Marine	Dune-Shpr-Cm	DUNE-SHPR
LF	Faros-Shoreline Process-Coastal Marine	Faro-Shpr-Cm	FARO-SHPR
LF	Fringing Reef-Shoreline Process-Coastal Marine	Frre-Shpr-Cm	FRRE-SHPR
LF	Headland-Shoreline Process-Coastal Marine	Hedl-Shpr-Cm	HEDL-SHPR
LF	Island-Shoreline Process-Coastal Marine	Isla-Shpr-Cm	ISLA-SHPR
LF	Longshore Bar-Shoreline Process-Coastal Marine	Loba-Shpr-Cm	LOBA-SHPR
LF	Oceanic Atoll-Shoreline Process-Coastal Marine	Ocat-Shpr-Cm	OCAT-SHPR
LF	Organic Reef (Undiff)-Shoreline Process-Coastal Marine	Orre-Shpr-Cm	ORRE-SHPR
LF	Patch Reef-Shoreline Process-Coastal Marine	Pare-Shpr-Cm	PARE-SHPR
LF	Platform Reef-Shoreline Process-Coastal Marine	Plre-Shpr-Cm	PLRE-SHPR
LF	Sea Cliff-Shoreline Process-Coastal Marine	Secl-Shpr-Cm	SECL-SHPR
LF	Shelf Atoll-Shoreline Process-Coastal Marine	Shat-Shpr-Cm	SHAT-SHPR
LF	Spit-Shoreline Process-Coastal Marine	Spit-Shpr-Cm	SPIT-SHPR
LF	Stack-Shoreline Process-Coastal Marine	Stac-Shpr-Cm	STAC-SHPR
LF	Storm Berm-Shoreline Process-Coastal Marine	Stbe-Shpr-Cm	STBE-SHPR
LF	Tidal Flat-Shoreline Process-Coastal Marine	Tifl-Shpr-Cm	TIFL-SHPR
LF	Tombolo-Shoreline Process-Coastal Marine	Tomb-Shpr-Cm	TOMB-SHPR
LF	Washover Fan-Shoreline Process-Coastal Marine	Wafn-Shpr-Cm	WAFN-SHPR

Solution

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
Process	Solution	So	SO
Subpr	General Chemical Weathering-Solution	Gecw-So	GECW

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Chemically Denuding Surface-General Chemical Weathering-Solution	Chds-Gecw-So	CHDS-GECW
Subpr	Karstification-Solution	Kars-So	KARS
LF	Blind Valley-Karstification-Solution	Blva-Kars-So	BLVA-KARS
LF	Cockpits-Karstification-Solution	Cock-Kars-So	COCK-KARS
LF	Collapse Sinkhole-Karstification-Solution	Cosi-Kars-So	COSI-KARS
LF	Karst Tower-Karstification-Solution	Kato-Kars-So	KATO-KARS
LF	Karst Window-Karstification-Solution	Kawi-Kars-So	KAWI-KARS
LF	Kegel Karst-Karstification-Solution	Kege-Kars-So	KEGE-KARS
LF	Poljes-Karstification-Solution	Polj-Kars-So	POLJ-KARS
LF	Sinkhole (Undiff)-Karstification-Solution	Sink-Kars-So	SINK-KARS
LF	Solution Sinkhole-Karstification-Solution	Sosi-Kars-So	SOSI-KARS
LF	Subjacent Karst Collapse Sinkhole-Karstification-Solution	Skcs-Kars-So	SKCS-KARS
LF	Subsidence Sinkhole-Karstification-Solution	Susi-Kars-So	SUSI-KARS
LF	Tower Karst-Karstification-Solution	Toka-Kars-So	TOKA-KARS
LF	Uvalas (Karst Valley)-Karstification-Solution	Uval-Kars-So	UVAL-KARS

Eolian

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
Process	Eolian	Eo	EO
Subpr	Deposition-Eolian	Deps-Eo	DEPS
LF	Barchan Dune-Deposition-Eolian	Badu-Deps-Eo	BADU-DEPS
LF	Barchanoid Ridge-Deposition-Eolian	Bari-Deps-Eo	BARI-DEPS
LF	Blowout Dune-Deposition-Eolian	Bldu-Deps-Eo	BLDU-DEPS
LF	Dune (Undiff)-Deposition-Eolian	Duun-Deps-Eo	DUUN-DEPS
LF	Dune Field-Deposition-Eolian	Dufi-Deps-Eo	DUFI-DEPS
LF	Foredune-Deposition-Eolian	Fodu-Deps-Eo	FODU-DEPS
LF	Interdune Flat-Deposition-Eolian	Infl-Deps-Eo	INFL-DEPS
LF	Loess Deposit (Undiff)-Deposition-Eolian	Lode-Deps-Eo	LODE-DEPS
LF	Paha-Deposition-Eolian	Paha-Deps-Eo	PAHA-DEPS
LF	Parabolic Dune-Deposition-Eolian	Padu-Deps-Eo	PADU-DEPS
LF	Parna Dune-Deposition-Eolian	Prdu-Deps-Eo	PRDU-DEPS
LF	Reversing Dune-Deposition-Eolian	Redu-Deps-Eo	REDU-DEPS
LF	Sand Ramp-Deposition-Eolian	Sara-Deps-Eo	SARA-DEPS

Geomorph Level	Class_Name	Class_Short _Name	Class_Code
LF	Sand Seas-Deposition-Eolian	Sase-Deps-Eo	SASE-DEPS
LF	Sand Sheet-Deposition-Eolian	Sash-Deps-Eo	SASH-DEPS
LF	Seif Dune-Deposition-Eolian	Sedu-Deps-Eo	SEDU-DEPS
LF	Star Dune-Deposition-Eolian	Stdu-Deps-Eo	STDU-DEPS
LF	Transverse Dune-Deposition-Eolian	Trdu-Deps-Eo	TRDU-DEPS
Subpr	Erosion-Eolian	Eros-Eo	EROS
LF	Yardang Trough-Erosion-Eolian	Yatr-Eros-Eo	YATR-EROS
LF	Yardang-Erosion-Eolian	Yard-Eros-Eo	YARD-EROS
LF	Deflation Basin-Erosion-Eolian	Deba-Eros-Eo	DEBA-EROS
ElemLF	Desert Pavement-Deflation Basin-Erosion-Eolian	Depa-Deba-Eros-Eo	DEPA-DEBA-EROS

Landscape Terms

Class_Name	Class_Short_Name	Class_Code
Badlands (Lf)	Badlands	BADL
Bajada (Lf)	Bajada	BAJA
Barrier Islands (Singular Lf)	Barrier Islands	BAIS
Basin (Lf)	Basin	BASI
Basin And Range	Basin And Range	BAAR
Basin Floor	Basin Floor	BAFL
Bolson (Lf)	Bolson	BOLS
Bottomland	Bottomland	BOTT
Breaks	Breaks	BREA
Canyon	Canyon	CANY
Canyonland	Canyonland	CALA
Coast	Coast	COAS
Coastal Plain (Lf)	Coastal Plain	COPL
Delta	Delta	DELT
Drumlin Field	Drumlin Field	DRFI
Dune Field	Dune Field	DUFI
Fan Piedmont (Lf)	Fan Piedmont	FAPI
Flatlands	Flatlands	FLLA
Foothills	Foothills	FOOT
Front	Front	FRON
Glaciated Uplands	Glaciated Uplands	GLUP
Highland	High	HIGH
Hills	Hills	HILL
Intermontane Basin	Intermontane Basin	INBA
Island	Island	ISLA

Class_Name	Class_Short_Name	Class_Code
Karst	Karst	KRST
Lava Plain	Lava Plain	LAPA
Lava Plateau	Lava Plateau	LAPL
Lowlands	Lowlands	LOWL
Meander Belt	Meander Belt	MEBE
Mountains	Mountains	MTNS
Outwash Plain (LF)	Outwash Plain	OUPL
Peninsula	Peninsula	PENI
Piedmont	Piedmont	PIED
Plains	Plains	PLAI
Plateau	Plateau	PLAT
Range	Range	RANG
Ridge And Valley	Ridge And Valley	RIAV
Rift Valley	Rift Valley	RIVA
Sandhills	Sandhills	SAND
Scabland	Scabland	SCAB
Semi-Bolson (Lf)	Semi-Bolson	SEBO
Tableland	Tableland	TABL
Thermokarst	Thermokarst	THER
Till Plain	Till Plain	TIPL
Upland	Upland	UPLA
Valleys	Valleys	VALL
Volcanic Mountains	Volcanic Mountains	VOMO

Common Landforms

Class_Name	Class_Short_Name	Class_Code
Arch	Arch	ARCH
Arroyo	Arroyo	ARRO
Bald	Bald	BALD
Ballon	Ballon	BALO
Bay	Bay	BAY
Bench	Bench	BNCH
Blowout	Blow	BLOW
Bluff	Bluff	BLUF
Breaks	Breaks	BREA
Channel	Channel	CHAN
Cliff	Cliff	CLIF
Depression	Depression	DEPR
Divide	Divide	DIVI
Drainage	Drainage	DRAI
Draw	Draw	DRAW

Class_Name	Class_Short_Name	Class_Code
Escarpment	Escarpment	ESCA
Faceted Spur	Faceted Spur	FASP
Flat	Flat	FLAT
Floor	Floor	FLOO
Fluve	Fluve	FLUV
Free Face	Free Face	FRFA
Gap	Gap	GAP
Gorge	Gorge	GORG
Gulch	Gulch	GULC
Gully	Gull	GULL
Headwall	Headwall	HEWA
Hill	Hill	HILL
Hillslope	Hillslope	HISL
Hummock	Hummock	HUMM
Interfluve	Interfluve	INTE
Knob	Knob	KNOB
Ledge	Ledge	LEDG
Mound	Mound	MOUN
Mountain	Mountain	MTNS
Mountain Slope	Mountain slope	MOSL
Mountain Valley	Mountain Valley	MOVA
Noseslope	Nose	NOSE
Notch	Notch	NOTC
Outwash Plain (LF)	Outwash Plain (LF)	OUPL
Peak	Peak	PEAK
Pinnacle	Pinnacle	PINN
Pothole	Pothole	POTH
Ravine	Ravine	RAVI
Ridge	Ridge	RIDG
Rim	Rim	RIM
Rise	Rise	RISE
Riser	Riser	RISR
Saddle	Saddle	SADD
Scarp	Scar	SCAR
Scour	Scour	SCOU
Seep	Seep	SEEP
Shoal	Shoal	SHOA
Slough	Slough	SLOU
Splay	Splay	SPLA
Spur	Spur	SPUR
Step	Step	STP

Class_Name	Class_Short_Name	Class_Code
Swale	Swale	SWAL
Talus Slope	Talus Slope	TASL
Terracettes	Terracettes	TERR
Tread	Tread	TRED
Trench	Trench	TRNC
V-Notch	V-Notch	VNOT
Wash	Wash	WASH

Microfeatures

Class_Name	Class_Short_Name	Class_Code
Bar	Bar	BAR
Bar and Channel	Bar and Channel	BACH
Channel	Channel	CHAN
Circle	Circle	CIRC
Earth Pillar	Earth Pillar	EAPI
Earth Hummock	Earth Hummock	EAHU
Frost Boil	Frost Boil	FRBO
Frost Mound	Frost Mound	FRMO
Gilgai	Gilgai	GILG
Ice Wedge	Ice Wedge	ICWE
Lava Blister	Lava Blister	LABL
Mima Mound	Mima Mound	MIMO
Net	Net	NET
Nonsorted Circle	Nonsorted Circle	NOSC
Patterned Ground	Patterned Ground	PAGR
Pedestal	Pedestal	PEDE
Polygon	Polygon	POLY
Rill	Rill	RILL
Ripple Mark	Ripple Mark	RIMA
Sand Boil	Sand Boil	SABO
Shrub-coppice Dune	Shrub-coppice Dune	SHCD
Sorted Circle	Sorted Circle	SOCI
Step	Step	STEP
Stone Stripe	Stone Stripe	STST
Stripe	Stripe	STRI
Terracette	Terracette	TERR
Tree-tip Mound	Tree-tip Mound	TRTM
Tree-tip Pit	Tree-tip Pit	TRTP
Turf Hummock	Turf Hummock	TUHU

Slope Terms

Slope Position

Code	Meaning
SU	Summit
SH	Shoulder
BS	Backslope
FS	Footslope
TS	Toeslope

Slope Shape

Code	Meaning
BR	Broken
CC	Concave
CV	Convex
FL	Flat
LI	Linear or planar
PA	Patterned
UN	Undulating
XX	Unable to assess

Slope Complexity

Code	Meaning
C	Complex
CB	Complex, broken
CP	Complex, patterned
CU	Complex, undulating
S	Simple
SCV	Simple concave
SCX	Simple convex
SL	Simple linear/planar

Dissection

Dissection Frequency Class

Code	Meaning
U	Undissected (0 channels/mile)
S	Slightly dissected (1–3 channels/mile)
M	Moderately dissected (3–10 channels/mile)
H	Highly dissected (> 10 channels/mile)

Dissection Depth Class

Code	Meaning
S	Shallowly incised (0–50 ft)
M	Moderately incised (50–100 ft)
D	Deeply incised (100–500 ft)
VD	Very deeply incised (500–1,000 ft)
ED	Extremely incised (> 1,000 ft)

Appendix E. Soil Pedon Description

Soil Pedon Description Form

Site ID #	Map Unit SYMBOL	Date (mm-dd-yyyy)		Examiner:	
Soil Classification:				Family or Series	Modal ________
Erosion A. Kind_________ B. Class_________	Water Table A. Kind _____________ B. Depth ___________	Depth to Lithic Contact Depth to Paralithic Contact________ Root Restrict Layer Type___________ Depth_____	Surface Runoff Class ____________	Soil Temp ________ Depth ___________	Diagnostic Horizons: Surface: _________________________ Subsurface 1: _____________________ Subsurface 2: _____________________
Box Sampled ____	Lab Sampled ______	Particle Size Control Section: Depth _______ Avg. Clay ____ Avg. RF ___			Drainage Class

Hor. Seq.	Horizon	Depth Low High	Boun-dary	Color	Mois-ture State	Color Cond.	Texture class %s - %c	Struc-ture	Consist-ence Dry Moist Wet D M W	Clay Films	% Rock Fragments GR ST CB BY	Roots Pores	Effer. Class	Field pH	Special Features and Notes
1															
2															
3															
4															

Hor. Seq.	Horizon.	Depth Low High	Boun- dary	Color	Mois- ture State	Color Cond	Texture		Struc- ture	Consist- ence Dry Moist Wet			clay Films	% Rock Fragments		Roots	Effer. Class	Field pH	Special Features and Notes
							class							GR	ST	Pores			
							%s -	%c		D	M	W		CB	BY				
5																			
6																			
7																			
8																			
9																			
10																			

Soil Pedon Description Form Instructions

Soil Pedon Description Form

Field Name	Description and Action To Be Taken
Site ID	Record the identifier that is unique within a specific project or inventory area.
Map Unit Symbol	Enter the map unit symbol (if known), typically a two- or three-digit number, in which the site occurs.
Date	Enter the date the profile was described in MMDDYYYY. Example: 07081997.
Examiner	Enter the name of the person(s) describing the site.
Soil Classification	Use the most recent edition of *Keys to Soil Taxonomy* (USDA NRCS 2003a) and enter the soil classification. Example: loamy-skeletal, mixed Typic Cryalfs.
Family or Series	Enter the family name or series name. Indicate the latter by drawing a circle around the word(s) "Family" or "Series," respectively.
Taxonomic Modal	Enter Yes or No if this is the modal pedon description for the taxonomic unit (ecological type).
Erosion	**A.** **Kind:** Wind – Deflation by wind. Water: **S** – sheet. Even soil loss, no channels. **R** – rill. Small channels. **G** – gully. Big channels. **T** – tunnel. Subsurface voids within soil that enlarge by running water (i.e., piping). **B.** **Degree class.** Estimated % loss of the original A & E horizons or the estimated loss of the upper 20 cm (if original, combined A & E horizons were < 20 cm thick). **Class 0:** 0% **Class 1:** > 0 up to 25% **Class 2:** 25 up to 75% **Class 3:** 75 up to 100% **Class 4:** > 75% and total removal of A (Schoeneberger et al. 2002, 1–23)
Water Table	Measure or estimate the depth from the ground surface to the stabilized contact with free-standing water in an open bore hole or well. **a.** **Kind: AP** – apparent. Level of stabilized water in a fresh, unlined borehole. **PE** – perched. A water table that lies above an unsaturated zone. The water table will fall if the borehole is extended.

Field Name	Description and Action To Be Taken
	b. Depth: Measurement in cm of the depth to water table. **(**Schoeneberger et al. 2002, 1-14)
Depth to Lithic or Paralithic Contact	**Lithic Contact.** The boundary between soil and a coherent underlying material. Except in Ruptic-Lithic subgroups, the underlying material must be virtually continuous within the limits of the pedon. Cracks that can be penetrated by roots are few, and their horizontal spacing is 10 cm or more. The underlying material must be sufficiently coherent when moist to make hand digging with a spade impractical, although the material may be chipped or scraped with a spade (USDA NRCS 2003a). **Paralithic Contact.** A paralithic contact is a contact between soil and paralithic materials in which the paralithic materials have no cracks or the spacing of the cracks that roots can enter is 10 cm or more. Paralithic materials are relatively unaltered materials that have an extremely weakly cemented to moderately cemented rupture-resistance (USDA NRCS 2003a). **Root Restricting Depth.** The root restricting depth is where root penetration would be strongly inhibited because of physical and/or chemical characteristics. (Soil Survey Division Staff 1993). Restriction kinds include: ABR Abrupt textural change CALC Petrocalcic CTEX Strongly contrasting textural stratification DENS Dense material DUR Duripan FE Petroferric FPAN Fragipan IRON Plinthite LITH Bedrock (lithic) NATR Natric ORST Ortstein PARA Bedrock (paralithic) PERM Permafrost PGYP Petrogypsic PLAC Placic SAL Salic SULF Sulfuric
Surface Runoff Class	**Surface Runoff**. The flow of water from an area that occurs over the surface to the soil. Surface runoff differs from internal flow or throughflow that results when infiltrated water moves laterally or vertically

Field Name	Description and Action To Be Taken
	within a soil, above the water table. The **Index Surface Runoff Classes** are relative estimates of surface runoff based on slope gradient and saturated hydraulic conductivity. This index is specific to the following conditions: • The soil surface is assumed to be bare. • The soil is free of ice. • Retention of water by ground surface irregularities is negligible or low. • Infiltration is assumed to be at the steady ponded infiltration stage. • Water is added to the soil by precipitation or snowmelt that yields 50 mm in 24 hours with no more than 25 mm in any 1-hour period. • Antecedent soil water state is assumed to be very moist or wet to: (a) the base of the solum, (b) a depth of 1 m, or (c) through the horizon that has the minimum Ksat within the top 1 meter; whichever is the least depth. Use table E.1 and the above conditions to estimate the Index Surface Runoff Class for the site. If seasonal or permanent, internal free water occurs at a depth of < or = 50 cm (very shallow and shallow internal free water classes), use a Ksat of Very Low. If seasonal or permanent, internal free water is deeper than 50 cm, use the appropriate Ksat from the table **(**Schoeneberger et al. 2002, 1-24).

Index of Surface Runoff Classes						
	Saturated Hydraulic Conductivity (Ksat) Class					
Slope Gradient Percent	**Very High**	**High**	**Mod. High**	**Mod. Low**	**Low**	**Very Low**
cm/hour	> 36	3.6 – < 36	0.36 – < 3.6	0.036 – < 0.36	0.0036 – < 0.036	< 0.0036
Concave[a]	N	N	N	N	N	N
< 1	N	N	N	L	M	H
1–5	N	LV	L	M	H	HV
5–10	LV	L	M	H	HV	HV
10–20	LV	L	M	H	HV	HV
> 20	LV	L	M	H	HV	HV

Table E.1. *Index Surface Runoff Classes based on slope gradient and saturated hydaulic conductivity (adapted from Schoeneberger et al. 2002, 1–24).*
Negligible – N; Very Low – LV; Low – L; Medium – M; High – H; Very High – HV
[a] *Areas from which little or no water escapes by flow over the ground surface.*

Field Name	Description and Action To Be Taken
Soil Temperature	Measure the soil temperature at 50 cm and enter the degrees F. If a restrictive layer is encountered above 50 cm, record the depth and temperature at the maximum depth possible. Soil temperature should be read as soon as the soil pit is excavated.
Diagnostic Horizons	**a. Surface.** Use the current edition of *Keys to Soil Taxonomy* (USDA NRCS 2003a) to determine the surface diagnostic horizon. **b. Subsurface.** Use the current edition of *Keys to Soil Taxonomy* (USDA NRCS 2003a) to determine the subsurface diagnostic horizons.
Box Sampled	Enter Yes or No if a box sample of the pedon was collected.
Lab Sampled	Enter Yes or No if a lab sample was collected.
Particle Size Control Section	**a. Depth.** Enter the depth range for the particle size control section. Example: 20–40 inches. **b. Avg. Clay and Avg. RF Content.** Enter the weighted average rock fragments by volume and the weighted average clay by weight. The weighted average is calculated by multiplying the percentage of rock fragments or clay in each horizon by the thickness of the horizon, then adding the total percentage and dividing by the total thickness of the control section.
Drainage Class	Use the following definitions (USDA NRCS 1993, 98-99) to determine the drainage class: **ED—***Excessively Drained.* Water is removed very rapidly. The occurrence of internal free water commonly is very rare or very deep. The soils are commonly coarse-textured and have **very high-saturated hydraulic conductivity** or are very shallow. **SE—***Somewhat Excessively Drained.* Water is removed from the soil rapidly. Internal free water occurrence commonly is very rare or very deep. The soils are commonly coarse-textured and have **high-saturated hydraulic conductivity** or are very shallow. **WD—***Well Drained.* Water is removed from the soil readily but not rapidly. Internal free water occurrence commonly is deep or very deep; annual duration is not specified. Water is available to plants throughout most of the growing season in humid regions. Wetness does not inhibit growth of roots for significant periods during most growing seasons. The soils are mainly free of the deep to redoximorphic features that are related to wetness. **MW—***Moderately Well Drained.* Water is removed from the soil somewhat slowly during some periods of the year. Internal free occurrence commonly is moderately deep and transitory through permanent. The soils are wet for only a short time within the rooting depth during the growing season, but long enough that most mesophytic crops are affected. They commonly have a **moderately low or lower saturated hydraulic conductivity** in a layer within the upper 1 m, periodically receive high rainfall, or both.

Field Name	Description and Action To Be Taken
	SP—*Somewhat Poorly Drained.* Water is removed slowly so that the soil is wet at a shallow depth for significant periods during the growing season. The occurrence of internal free water commonly is shallow to moderately deep and transitory to permanent. Wetness markedly restricts the growth of mesophytic crops, unless artificial drainage is provided. The soils commonly have one or more of the following characteristics: **low or very low saturated hydraulic conductivity**, a high water table, additional water from seepage, or nearly continuous rainfall. **PD—***Poorly Drained.* Water is removed so slowly that the soil is wet at shallow depths periodically during the growing seasons or remains wet for long periods. The occurrence of internal free water is shallow or very shallow and common or persistent. Free water is commonly at or near the surface long enough during the growing season so that most mesophytic crops cannot be grown, unless the soil is artificially drained. The soil, however, is not continuously wet directly below plow-depth. Free water at shallow depth is usually present. This water table is commonly the result of **low or very low saturated hydraulic conductivity** or nearly continuous rainfall, or of a combination of these. **VP—***Very Poorly Drained.* Water is removed from the soil so slowly that free water remains at or very near the ground surface during much of the growing season. The occurrence of internal free water is very shallow and persistent or permanent. Unless the soil is artificially drained, most mesophytic crops cannot be grown. The soils are commonly level or depressed and frequently ponded. If rainfall is high or nearly continuous, slope gradients may be greater.

Horizon

Field Name	Description and Action To Be Taken
Hor. Seq. #	The horizon sequence number used when entering the data in a database. The number 1 implies the 1st horizon.
Horizon Designation	Using the current edition of *Keys to Soil Taxonomy* (USDA NRCS 2003a), enter the appropriate symbol and suffix(es) for each horizon.
Depth	Enter the thickness of each layer in cm, using the surface of the mineral soil as the base from which to measure. Example: 0–8 cm; 8–18 cm; 18–40 cm; 40–60 cm. Duff layers recorded in reverse depths. Example: 2–0.
Boundary	A surface or transitional layer between two adjoining horizons or layers. Most boundaries are zones of transition rather than sharp lines of division. Boundaries vary in distinctness and in topography.

Distinctness

Code	Meaning	Description
V	Very abrupt	< 0.5 cm
A	Abrupt	0.5 to 2 cm thick
C	Clear	2 to 5 cm thick
G	Gradual	5 to 15 cm thick
D	Diffuse	More than 15 cm thick

Table E.2. *Boundary distinctness codes.*

Topography

Code	Meaning	Description
S	Smooth	The boundary is a plane with few or no irregularities.
W	Wavy	The boundary has undulations in which the depressions are wider than they are deep.
I	Irregular	The boundary has pockets that are deeper than they are wide.
B	Broken	One or both of the horizons or layers separated by the boundary are discontinuous and the boundary is interrupted.

Table E.3. *Boundary topography codes.*

Soil Color

Field Name	Description and Action To Be Taken
Soil Color and Mottles	The *Soil Survey Manual* (USDA NRCS 1993) states that the elements of soil descriptions are "the color name, the Munsell notation, the water state, and the physical state: brown (10YR 5/3), dry, crushed and smoothed." Physical state is recorded as broken, rubbed, crushed, or crushed and smoothed. The term "crushed" usually applies to dry samples and "rubbed" to moist samples. If unspecified, the surface is broken. The color of the soil is recorded for a surface broken through a ped if a ped can be broken as a unit. The color value of most soil material becomes lower after moistening. Consequently, the water state of a sample is always given. The water state is either moist or dry. The dry state for color determinations is air-dry and should be made at the site where the color does not change with additional drying. Color in the moist state is determined on moderately moist or very moist soil material and should be made at the point where the soil color does not change with additional moistening.

Field Name	Description and Action To Be Taken
	Mottling refers to repetitive color changes that cannot be associated with compositional properties of the soil. Redoximorphic features are a type of mottling that is associated with wetness. A color pattern that can be related to proximity to a ped surface or other organizational or compositional feature is not mottling. Mottling description follows the dominant color. Mottles are described by quantity, size, contrast, color, and other attributes, in that order.

Redoximorphic Features

Type of feature	Code	Meaning
Redox features	CLD	Clay depletions
Redox features	F2M	Masses of reduced iron (Fe+2) accumulation
Redox features	F3M	Masses of oxidized iron (Fe+3) accumulation
Redox features	FED	Iron depletions
Redox features	FEF	Ferriargillan coats (Fe+3 stained clay films)
Redox features	FMC	Iron-manganese concretions
Redox features	FMM	Masses of iron-manganese accumulation
Redox features	FMN	Iron-manganese nodules
Redox features	FSN	Ironstone nodules
Redox features	MNF	Manganese surface coats/films or hypocoats
Redox features	MNM	Masses of manganese accumulation
Redox features	PLN	Plinthite nodules
Redox features	RC	Redoximorphic concentrations (undifferentiated)
Redox features	RD	Redoximorphic depletions (undifferentiated)
Redox features	RMX	Reduced matrix

Table E.4. *Redox feature codes.*

Quantity and Size Classes

Code	Meaning	Description
F	Few	Less than 2 percent
C	Common	2 to 20 percent
M	Many	More than 20 percent

Tabe E.5. *Quantity classes.*

Code	Meaning	Description
F	Fine	Smaller than 5 mm
M	Medium	5 to 15 mm
C	Coarse	Larger than 15 mm

Table E.6. *Size classes.*

Contrast

Contrast refers to the degree of visual distinction evident between associated colors.

Code	Meaning	Description
F	Faint	Evident only on close examination. Faint mottles commonly have the same hue as the color to which they are compared, and differ by no more than 1 unit of chroma or 2 units of value. Some faint mottles of similar but low chroma and value differ by 2.5 units (1 card) of hue.
D	Distinct	Readily seen, but contrast only moderately with the color to which they are compared. Distinct mottles commonly have the same hue as the color to which they are compared, but differ by 2 to 4 units of chroma or 3 to 4 units of value; or differ from the color to which they are compared by 2.5 units (1 card) of hue, but by no more than 1 unit of chroma or 2 units of value.
P	Prominent	Contrast strongly with the color to which they are compared. Prominent mottles are commonly the most obvious color feature of the section described. Prominent mottles that have medium chroma and value commonly differ from the color to which they are compared by at least 5 units (2 pages) of hue if chroma and value are the same; at least 4 units of value or chroma if the hue is the same; or at least 1 unit of chroma or 2 units of value if hue differs by 2.5 units (1 card).

Table E.7. *Contrast codes.*

Location of Redoximorphic and Mottles.

Code	Meaning	Description
Redox features	CRK	Cracks
Redox features	BRF	On bottom of rock fragments
Redox features	BPF	Between peds
Redox features	MPO	Infused into the matrix adjacent to pores (hypocoating)
Redox features	MAT	Matrix adjacent to pores
Redox features	MAC	Matrix surrounding redox concentrations
Redox features	MAD	Matrix surrounding redox depletions
Redox features	MPF	Matrix
Redox features	APF	Ped faces
Redox features	HPF	Ped horizontal faces
Redox features	VPF	Ped vertical faces
Redox features	LPO	Pore lining
Redox features	ARF	Around rock fragments
Redox features	SPO	On surface along pores
Redox features	TOT	Throughout
Redox features	TOH	Top of horizon
Redox features	PEPO	Ped faces and pores

Code	Meaning	Description
Mottles	BRF	On bottom of rock fragments
Mottles	MPF	Matrix
Mottles	ARF	Around rock fragments

Table E.8. *Redox feature and mottle location codes.*

Texture

Field Name	Description and Action To Be Taken
Texture	The *Soil Survey Manual* (Soil Survey Division Staff 1993) directs researchers to hand texture each horizon, enter the texture, texture modifier, and estimated % clay and % sand.

Code	Meaning	Code	Meaning
C	Clay	S	Sand
CL	Clay loam	SC	Sandy clay
COS	Coarse sand	SCL	Sandy clay loam
COSL	Coarse sandy loam	SI	Silt
FS	Fine sand	SIC	Silty clay
FSL	Fine sandy loam	SICL	Silty clay coam
L	Loam	SIL	Silt loam
LCOS	Loamy coarse sand	SL	Sandy loam
LFS	Loamy fine sand	VFS	Very fine sand
LS	Loamy sand	VFSL	Very fine sandy loam
LVFS	Loamy very fine sand		

Table E.9. *Texture classes.*

Rock Fragments

Spherical, cubelike, or equiaxial

Shape and size	Noun	Adjective	Code
2–75 mm diameter	Pebbles	Gravelly	GR
2–5 mm diameter	Fine	Fine gravelly	GRF
5–20 mm diameter	Medium	Medium gravelly	GRM
20–75 mm diameter	Coarse	Coarse gravelly	GRC
75–250 mm diameter	Cobbles	Cobbly	CB
250–600 mm diameter	Stones	Stony	ST
> 600 mm diameter	Boulders	Bouldery	BY

Flat

Shape and size	Noun	Adjective	Code
2–150 mm long	Channers	Channery	CN
150–380 mm long	Flagstones	Flaggy	FL
380–600 mm long	Stones	Stony	ST
>600 mm long	Boulders	Bouldery	BY

Table E.10. *Rock fragment terms.*

Texture Modifier Classes

- *Less than 15 percent.* No terms are used for contrast with soils having less than 15 percent pebbles, cobbles, or flagstones. The adjective "slightly" may be used, however, to recognize those soils used for special purposes.
- *15 to < 35 percent*. The adjectival term of the dominant kind of rock fragment is used as a modifier of the textural term: "gravelly loam (GRL)," "channery loam (CNL)," "cobbly loam (CBL)."
- *35 to < 60 percent.* The adjectival term of the dominant kind of rock fragment is used with the word "very (V)" as a modifier of the textural term: "very gravelly loam (GRVL)," "very flaggy loam (FLV)."
- *60 to < 90 percent.* If enough fine earth is present to determine the textural class (approximately 10 percent or more by volume) the adjectival term of the dominant kind of rock fragment is used with the word "extremely (X)" as a modifier of the textural term: "extremely gravelly loam (GRXL)," "extremely bouldery loam (BYXL)." If there is too little fine earth to determine the textural class (less than 10 percent by volume), the term "gravel," "cobbles," "stones," or "boulders" is used as appropriate.

Code	Meaning	Code	Meaning
BY	Bouldery	PBY	Parabouldery
BYV	Very Bouldery	PBYV	Very parabouldery
BYX	Extremely bouldery	PBYX	Extremely parabouldery
CB	Cobbly	PCB	Paracobbly
CBV	Very cobbly	PCBV	Very paracobbly
CBX	Extremely paracobbly	PCBX	Extremely paracobbly
CN	Channery	PCN	Parachannery
CNV	Very channery	PCNV	Very parachannery
CNX	Extremely channery	PCNX	Extremely parachannery
FL	Flaggy	PFL	Paraflaggy
FLV	Very flaggy	PFLV	Very paraflaggy
FLX	Extremely flaggy	PFLX	Extremely paraflaggy
GR	Gravelly	PGR	Paragravelly
GRC	Coarse gravelly	PGRV	Very paragravelly
GRF	Fine gravelly	PGRX	Extremely paragravelly
GRM	Medium gravelly	PST	Parastony
GRV	Very gravelly	PSTV	Very parastony
GRX	Extremely gravelly	PSTX	Extremely parastony
		ST	Stony
		STV	Very stony
		STX	Extremely stony

Table E.11. *Texture modifiers.*

Compositional Texture Modifier

Code	Meaning	Code	Meaning
ASHY	Ashy	MEDL	Medial
COP	Coprogenous	MK	Mucky
DIA	Diatomaceous	MR	Marly
GS	Grassy	MS	Mossy
GYP	Gypsiferous	PF	Permanently frozen
HB	Herbaceous	PT	Peaty
HYDR	Hydrous	WD	Woody

Table E.12. *Compositional texture modifiers.*

Terms Used in Lieu of Texture

Terms used in lieu of texture are substitute terms applied to materials that do not fit into a texture class because of organic matter content, size, rupture resistance, solubility, or another reason. Examples include muck, duripan, gravel, and bedrock.

Code	Meaning	Code	Meaning
BR	Bedrock	PC	Petrocalcic
BY	Boulders	PCB	Paracobbles
CB	Cobbles	PCN	Parachanners
CN	Channers	PEAT	Peat
DUR	Duripan	PF	Petroferric
FL	Flagstones	PFL	Paraflagstones
GR	Gravel	PG	Paragravel
HPM	Highly decomposed plant material	PGP	Petrogypsic
MAT	Material	PL	Placic
MPM	Moderately decomposed plant material	PST	Parastones
MPT	Mucky peat	SPM	Slightly decomposed
MUCK	Muck	ST	Stones
OR	Ortstein	W	Water
PBY	Paraboulders		
	plant material		

Table E.13. *Terms used in lieu of texture.*

Structure

Field Name	Description and Action To Be Taken
Structure (Shape, size, and grade)	Soil structure refers to units composed of primary particles. The cohesion within these units is greater than the adhesion among units. As a consequence, under stress, the soil mass tends to rupture along predetermined planes or zones. Some soils lack structure and are referred to as structureless. In structureless layers or horizons, no units are observable in place or after the soil has been gently disturbed, such as by tapping a spade containing a slice of soil against a hard surface or dropping a large fragment on the ground. (USDA NRCS 1993, 157-163). In soils that have structure, the shape, size, and grade (distinctness) of the units are described. Field terminology for soil structure consists of separate sets of terms designating each of the three properties, which by combination form the names for structure.

Field Name	Description and Action To Be Taken
	Shape. Several basic shapes of structural units are recognized in soils. Supplemental statements about the variations in shape of individual peds are needed in detailed descriptions of some soils. The following terms describe the basic shapes and related arrangements: ***Platy.*** The units are flat and platelike. They are generally oriented horizontally. A special form, lenticular platy structure, is recognized for plates that are thickest in the middle and thin toward the edges. ***Prismatic.*** The individual units are bounded by flat to rounded vertical faces. Units are distinctly longer vertically, and the faces are typically casts or molds of adjoining units. Vertices are angular or subrounded; the tops of the prisms are somewhat indistinct and normally flat. ***Columnar.*** The units are similar to prisms and are bounded by flat or slightly rounded vertical faces. The tops of the columns, in contrast to those of prisms, are very distinct and normally rounded. ***Blocky.*** The units are blocklike or polyhedral. They are bounded by flat or slightly rounded surfaces that are casts of the faces of surrounding peds. Typically, blocky structural units are nearly equidimensional but grade to prisms and to plates. The structure is described as angular blocky if the faces intersect at relatively sharp angles; it is described as subangular blocky if the faces are a mixture of rounded and plane faces and the corners are mostly rounded.

Code	Description	Code	Description
ABK	Angular blocky	PL	Platy
CDY	Cloddy	PR	Prismatic
COL	Columnar	SGR	Single grain
GR	Granular	SBK	Subangular blocky
LP	Lenticular platy	WEG	Wedged shaped aggregates
MA	Massive		

Table E.14. *Structure shape codes.*

Size. Five classes are employed: very fine, fine, medium, coarse, and very coarse. The size limits of the classes differ according to the shape of the units. The size limits refer to the smallest dimension of the plates, prisms, and columns. If the units are more than twice the minimum size of "very coarse," the actual size is given: "prisms 30 to 40 cm across." In describing plates, "thin" is used instead of "fine" and "thick" instead of "coarse."

Size Classes	Platy	Prismatic and Columnar	Blocky	Granular
Very fine	< 1 mm	< 10 mm	< 5 mm	< 1 mm
Fine	1–2 mm	10–20 mm	5–10 mm	1–2 mm
Medium	2–5 mm	20–50 mm	10–20 mm	2–5 mm
Coarse	5–10 mm	50–100 mm	20–50 mm	5–10 mm
Very coarse	> 10 mm	> 100 mm	> 50 mm	> 10 mm

Table E.15. *Structural size classes.*

Code	Description	Code	Description	Code	Description
VN	Very thin	F	Fine	VC	Very coarse
TN	Thin	M	Medium	VF	Very fine
TK	Thick	C	Coarse	EC	Extremely coarse
VK	Very thick				

Table E.16. *Size codes.*

Grade. Grade describes the distinctness of the units. Criteria are the ease of separation into discrete units and the proportion of the units that hold together when the soil is handled. Three classes are used:

1. ***Weak.*** The units are barely observable in place. When gently disturbed, the soil material parts into a mixture of whole and broken units and much material that exhibits no planes of weakness. Faces that indicate persistence through wet-dry cycles are evident if the soil is handled carefully. Distinguishing structurelessness from weak structure is sometimes difficult. Weakly expressed structural units in virtually all soil materials have surfaces that differ in some way from the interiors.

2. ***Moderate.*** The units are well formed and evident in undisturbed soil. When disturbed, the soil material parts into a mixture of mostly whole units, some broken units, and material that is not in units. Peds part from adjoining peds to reveal nearly entire faces that have properties distinct from those of fractured surfaces.

3. ***Strong.*** The units are distinct in undisturbed soil. They separate cleanly when the soil is disturbed. When removed, the soil material separates mainly into whole units. Peds have distinctive surface properties.

Code	Description
1	Weak
2	Moderate
3	Strong
0	Structureless

Table E.17. *Grade codes.*

Compound structure occurs when smaller units may be held together to form larger units. Grade, size, and shape are given for both and the relationship of one set to the other is indicated: "strong medium blocks within moderate coarse prisms," or "moderate coarse prismatic structure parting to strong medium blocky."

Consistence

Field Name	Description and Action To Be Taken
Consistence	Soil consistence (USDA NRCS 1993, 172-183) refers to "attributes of soil material as expressed in degree of cohesion and adhesion or in resistance to deformation on rupture." As employed here, consistence includes: (1) resistance of soil material to rupture, (2) resistance to penetration, (3) plasticity, toughness and stickiness of puddled soil material, and (4) the manner in which the soil material behaves when subject to compression. Consistency is highly dependent on the soil-water state and the description has little meaning unless the water state class is specified or is implied by the test. Previously class sets were given for "dry" and "moist" consistence of the soil material as observed in the field. "Wet" consistence was evaluated for puddled soil material. Here the terms used for "moist" consistence previously are applied to the wet state as well. Stickiness, plasticity, and toughness of the puddled soil material are independent tests.

Classes			Test Description
Moderately dry and very dry	Slightly dry and wetter	Air dried, submerged	Operation.
Loose	Loose	Not applicable	Specimen not obtainable.
Soft	Very friable	Noncemented	Fails under very slight force applied slowly between thumb and forefinger.
Slightly hard	Friable	Extremely weakly Cemented	Fails under slight force applied slowly between thumb and forefinger.
Moderately hard	Firm	Very weakly cemented	Fails under moderate force applied slowly between thumb and forefinger.
Hard	Very firm	Weakly cemented	Fails under strong force applied slowly between thumb and forefinger.
Very hard	Extremely firm	Moderately cemented	Cannot be failed between thumb and forefinger but can be between both hands or by placing on a nonresilent surface and applying gentle force underfoot.

Classes			Test Description
Extremely hard	Slightly rigid	Strongly cemented	Cannot be failed in hands but can be underfoot by full body weight applied slowly.
Rigid	Rigid	Very strongly cemented	Cannot be failed underfoot by full body weight but can be by < 3 Joules blow.*
Very rigid	Very rigid	Indurated	Cannot be failed by a blow > 3 Joules.

Table E.18. R*upture resistance for blocklike specimens.*
**One joule is the energy delivered by dropping a 1 kg weight 10 cm.*

Code	Description	Code	Description	Code	Description
EH	Extremely hard	MH	Moderately hard	S	Soft
HA	Hard	R	Rigid	VH	Very hard
L	Loose	SH	Slightly hard	VR	Very rigid

Table E.19. *Moderately dry and very dry blocklike specimens.*

Code	Description	Code	Description	Code	Description
EFI	Extremely firm	L	Loose	VFI	Very firm
FI	Firm	R	Rigid	VFR	Very friable
FR	Friable	SR	Slightly rigid	VR	Very rigid

Table E.20. *Slightly dry and wetter blocklike specimens.*

Code	Description	Code	Description
EW	Extremely weakly cemented	S	Strongly cemented
I	Indurated	VS	Very strongly cemented
M	Moderately cemented	VW	Very weakly cemented
NA	Nonapplicable	W	Weakly cemented
N	Noncemented		

Table E.21. *Air dried, submerged blocklike specimens.*

Stickiness

Stickiness refers to the capacity of a soil to adhere to other objects. The determination is made on puddled < 2 mm soil material at the water content at which the material is most sticky. The sample is crushed in the hand; water is applied while manipulation is contained between thumb and forefinger until maximum stickiness is reached. The classes in the table below are used to describe stickiness.

Code	Classes	Test Description
SO	Nonsticky	After release of pressure, practically no soil material adheres to thumb or forefinger.
SS	Slightly sticky	After release of pressure, soil material adheres perceptibly to both digits. As the digits are separated, the material tends to come off one or the other rather cleanly. The material does not stretch appreciably on separation of the digits.
MS	Moderately sticky	After release of pressure, soil material adheres to both digits and tends to stretch slightly rather than pull completely free from either digit.
VS	Very sticky	After release of pressure, soil material adheres so strongly to both digits that it stretches decidedly when the digits are separated. Soil material remains on both digits.

Table E.22. *Stickiness codes.*

Plasticity

Plasticity is the degree to which a puddled soil material is permanently deformed without rupturing by force applied continuously in any direction. Plasticity is determined on material smaller than 2 mm.

The determination is made on thoroughly puddled soil material at a water content where maximum plasticity is expressed. This water content is above the plastic limit, but it is less than the water content at which maximum stickiness is expressed. The water content is adjusted by adding water or removing it during manipulation. The closely related plastic limit, used in engineering classifications, is the water content for < 0.4 mm material at which a roll of 3 mm in diameter which had been formed at a higher water content breaks apart.

Code	Classes	Test Description
PO	Nonplastic	A roll 4 cm long and 6 mm thick that supports its own weight held on end cannot be formed.
SP	Slightly plastic	A roll 4 cm long and 6 mm thick can be formed and, if held on end, will support its own weight. A roll 4 mm thick will not support its own weight.
MP	Moderately	A roll 4 cm long and 4 mm thick can be formed and will support plastic its own weight, but a roll 2 mm thick will not support its own weight.
VP	Very plastic	A roll 4 cm long and 2 mm thick can be formed and will support its own weight.

Table E.23. *Plasticity codes.*

Code	Classes	Test Description
Brittleness		Press a 3 cm block between thumb and forefinger).
B	Brittle	Ruptures abruptly (“pops” or shatters).
SD	Semi-deformable	Rupture occurs after compression to > or = to ? original thickness.
D	Deformable	Rupture occurs after compression to > or = to ? original thickness.
Fluidity		Squeeze a palmful of soil in hand.
NF	Nonfluid	No soil flows through fingers with full compression.
SF	Slightly fluid	Some soil flows through fingers, most remains in the palm, after full pressure.
MF	Moderately fluid	Most soil flows through fingers, some remains in palm, after full pressure.
VF	Very fluid	Most soil flows through fingers, very little remains in palm, after gentle pressure.
Smeariness[1]		Press a 3 cm block between thumb and forefinger.
NS	Nonsmeary	At failure, the sample does not change abruptly to fluid, fingers do not skid, no smearing occurs.
WS	Weakly smeary	At failure, the sample changes abruptly to fluid, fingers skid, soil smears, little or no water remains on fingers.
MS	Moderately smeary	At failure, the sample changes abruptly to fluid, fingers skid, soil smears, some water remains on fingers.
SS	Strongly smeary	At failure, the sample changes abruptly to fluid, fingers skid, soil smears and is slippery, water easily seen on fingers.

[1] *Smeary failure classes are used dominantly with Andic materials, but may also be used with some spodic materials.*

Special Features

Field Name	Description and Action To Be Taken
Special Features	***Films.*** The kinds of special surface features are clay films (or clay skins), clay bridges, sand or silt coats, other coats, stress surfaces (pressure faces), and slickensides. The various surface features may be on some or all structural units, channels, pores, primary particles or grains, soil fragments, rock fragments, nodules, or concretions. The kind and orientation of surface on which features are observed is always given. For example, if clay films are on vertical but not horizontal faces of peds, this fact should be recorded.

Feature	Code	Description
Surface features	BRF	Clay bridging
Surface features	CAF	Carbonate coats
Surface features	CLF	Clay films
Surface features	CT	Coats (undifferentiated)
Surface features	CTOX	Oxide coats
Surface features	FEF	Iron stains
Surface features	GBF	Gibbsite coats
Surface features	MNF	Manganese stains
Surface features	NNS	Nonintersecting slickenslides
Surface features	OAF	Organoargillians
Surface features	OSF	Organic stains
Surface features	PRF	Pressure faces
Surface features	SAF	Skeletans on argillans
Surface features	SIF	Silica (silans, opal)
Surface features	SKF	Skeletans (sand or silt)
Surface features	SLF	Silt coats
Surface features	SNF	Sand coats
Surface features	SS	Slickensides (pedogenic)
Surface features	SSG	Slickensides (geogenic)
Surface features	STIR	Iron-manganese stains
Surface features	STSB	Black stains

Table E.24. *Ped surface feature kinds.*

Amount

The amount, or percentage, of the total surface area of the kind of surface considered occupied by a particular surface feature over the extent of the horizon or layer is described.

Code	Meaning	Description
VF	Very few	Occupies < 5 percent
F	Few	Occupies 5 to 25 percent
C	Common	Occupies 25 to 50 percent
M	Many	Occupies > 50 percent

Table E.25. *Surface features abundance codes.*

Distinctness

Distinctness refers to the ease and degree of certainty with which a surface feature can be identified.

Code	Meaning	Description
F	Faint	Evident only on close examination with 10X magnification and cannot be identified positively in all places without greater magnification. The contrast with the adjacent material in color, texture, and other properties is small.
D	Distinct	Can be detected without magnification, although magnification or tests may be needed for positive identification. The feature contrasts enough with the adjacent material to make a difference in color, texture, or other properties evident.
P	Prominent	Conspicuous without magnification when compared with a surface broken through the soil. Color, texture, or some other property or combination of properties contrasts sharply with properties of the adjacent material or the feature is thick enough to be conspicuous.

Table E.26. *Distinctness class codes.*

Location of Surface Features

Type of feature	Code	Meaning
Surface features	SC	Root channels
Surface features	PLB	Plate bottoms
Surface features	BG	Between sand grains
Surface features	VF	Ped vertical faces
Surface features	CC	Concretions
Surface features	PF	All ped faces
Surface features	PEPO	Peds and pores
Surface features	HF	Ped horizontal faces
Surface features	BF	Ped lower surface (bottom faces)
Surface features	BR	Rock lower surface
Surface features	NO	Nodules
Surface features	RF	Rock fragments
Surface features	SGR	Sand and gravel
Surface features	TC	Column tops
Surface features	TF	On top faces of peds
Surface features	TR	Rock upper surface
Surface features	SP	On surfaces along pores

Table E.27. *Surface feature location codes.*

The order of the description of surface features is usually amount, distinctness, color, kind, and location. For example: “few distinct grayish brown (10YR 5/2) clay films/clay skins on vertical faces of peds”; “many distinct brown clay bridges between mineral grains.”

Rock Fragments and Roots

Field Name	Description and Action To Be Taken
Rock Fragments	Using the ocular method and/or line intercept method, determine the percent of gravels (GR), cobbles (CB), stones (ST), and boulders (BY) for each horizon.
Roots	Quantity, size, and location of roots in each layer are recorded (USDA NRCS 1993, 184-188). Using features of the roots (length, flattening, nodulation and lesions), the relationships to special soil attributes or to structure may be recorded as notes. Quantity of roots is described in terms of numbers of each size per unit area. The class placement for quantity of roots pertains to an area in a horizontal plane unless otherwise stated. This unit area changes with root size as follows: 1 cm^2 for very fine and fine, 1 dm^2 for medium and coarse and 1 m^2 for very coarse. The quantity classes given in table E.28.

Code	Meaning	Description
F	Few	< 1 per unit area
C	Common	1–5 per unit area
M	Many	> 5 per unit area

Table E.28. *Quantity of roots codes.*

Roots are described in terms of a specified diameter size.

Code	Meaning	Description
VF	Very fine	< 1 mm
F	Fine	1–2 mm
M	Medium	2–5 mm
C	Coarse	5–10 mm
VC	Very coarse	> 10 mm

Table E.29. *Size of roots codes.*

Pores

Field Name	Description and Action To Be Taken
Pores	Pore space is a general term for voids in the soil material (USDA NRCS 1993, 186-190). The term includes matrix, nonmatrix, and interstructural pore space. Matrix pores are formed by the agencies that control the packing of the primary soil particles. These pores are usually smaller than nonmatrix pores. In addition, their aggregate volume and size would change markedly with water state for soil horizons or layers with high extensibility. Nonmatrix pores are relatively large voids that are expected to be present when the soil is moderately moist or wetter, as well as under drier states. The voids are not bounded by the planes that delimit structural units. Interstructural pores, in turn, are delimited by structural units. Inferences as to the interstructural porosity may be obtained from the structure description. Commonly, interstructural pores are at least crudely planar. Nonmatrix pores may be formed by roots, animals, action of compressed air, and other agents. Most nonmatrix pores are either vesicular (approximately spherical or elliptical) or tubular (approximately cylindrical and elongated). Some are irregularly shaped. Nonmatrix pores are described by quantity, size, shape, and vertical continuity—generally in that order. Some examples of descriptions of pores are "many fine tubular pores," "few fine tubular pores and many medium tubular pores with moderate vertical continuity," and "many medium vesicular pores in a horizontal band about 1-cm wide at the bottom of the horizon."

Quantity classes pertain to numbers per unit area: 1 cm^2 for very fine and fine pores, 1 dm^2 for medium and coarse pores, and 1 m^2 for very coarse.

Code	Meaning	Description
F	Few	< 1 per unit area
C	Common	1–5 per unit area
M	Many	> 5 per unit area

Table E.30. *Quantity of pores codes.*

Pores are described in five classes relative to a specified diameter size.

Code	Meaning	Description
VF	Very fine	< 0.5 mm
F	Fine	0.5–2.0 mm
M	Medium	2.0–5.0 mm
C	Coarse	5.0–10.0 mm
VC	Very coarse	> 10.0 mm

Table E.31. *Size of pores codes.*

Pores are described in five classes relative to their shape.

Code	Meaning	Description
VE	Vesicular	Approximately spherical or elliptical
DT	Dendritic Tubular	Cylindrical, elongated, branching voids
TU	Tubular	Approximately cylindrical and elongated
IR	Interstitial	Irregularly shaped
IG	Irregular	Nonconnected cavities, chambers

Table E.32. *Shape of pores codes.*

Effervescence

Field Name	Description and Action To Be Taken
Effervescence Class	Cold 2.87N (about 1:10 dilution of concentrated HCL) hydrochloric acid is used to test for carbonates in the field. The amount and expression of effervescence is affected by size distribution and mineralogy as well as the amount of carbonates. Consequently, effervescence cannot be used to estimate the amount of carbonate.

Code	Meaning	Description
NE	Noneffervescent	No reaction.
VS	Very slightly effervescent	Few bubbles seen.
SL	Slightly effervescent	Bubbles readily seen.
ST	Strongly effervescent	Bubbles form low foam.
VE	Violently effervescent	Thick foam forms quickly.

Table E.33. *Effervescence class codes.*

Water State

Field Name	Description and Action To Be Taken
PH	Enter the pH value. List reagent or method used in notes section.
Water State Class	Three classes defined below are used in this field. See discussion on pages 90 to 98 of the *Soil Survey Manual* (USDA NRCS 1993) for further definitions of classes.

Code	Meaning
D	Dry
M	Moist
W	Wet

Table E.34. *Water state class codes.*

Accessory Properties

Masses, plinthite, nodules, concretions, crystals, ironstone, pressure faces, and slickensides (USDA NRCS 1993, 169-172) are accessory properties of soils. These features are identifiable bodies within the soil that were formed by pedogenesis. Some of these bodies are thin and sheetlike, some are nearly equidimensional, and others have irregular shapes. They may contrast sharply with the surrounding material in strength, composition, or internal organization. Alternatively, the differences from the surrounding material may be slight. Soft rock fragments, which have rock structure but are weakly cemented or noncemented, are not considered concentrations. They are excluded based on inference as to a geological as opposed to pedological origin.

Masses are noncemented concentrations of substances that commonly cannot be removed from the soil as a discrete unit. Most accumulations consist of calcium carbonate, fine crystals of gypsum or more soluble salts, or iron and manganese oxides. Except for very unusual conditions, masses have formed in place.

Plinthite consists of reddish, iron-enriched bodies that are low in organic matter and are coherent enough to be separated readily from the surrounding soil. Plinthite commonly occurs within and above reticulately mottled horizons. Soil layers that contain plinthite rarely become dry in the natural setting. The bodies are commonly about 5 to 20 mm across their smallest dimension. Plinthite bodies are firm or very firm when moist, hard, or very hard when air dry, and become moderately cemented on repetitive wetting and drying.

Nodules and concretions are cemented bodies that can be removed from the soil intact. Composition ranges from material dominantly like that of the surrounding soil to nearly pure chemical substances entirely different from the surrounding material. Their form is apparently not governed by crystal forms based on examination at a magnification of 10X, as is the case for crystals and clusters of crystals. It is impossible to be sure if some nodules and concretions formed where they are observed or were transported.

Type of feature	Code	Meaning
Concentrations	BAM	Barite masses
Concentrations	BAX	Barite crystals
Concentrations	BC	Biological concentrations (undifferentiated)
Concentrations	CAC	Carbonate concretions
Concentrations	CAM	Carbonate masses
Concentrations	CAN	Carbonate nodules
Concentrations	CAX	Calcite crystals
Concentrations	CBM	Clay bodies
Concentrations	CCD	Dark concretions

Type of feature	Code	Meaning
Concentrations	CCIM	Iron-manganese concretions
Concentrations	CCIR	Iron concretions
Concentrations	CCMN	Manganese concretions
Concentrations	CO	Concentrations (undifferentiated)
Concentrations	COLI	Lime concretions
Concentrations	CR	Crystals (undifferentiated)
Concentrations	DIB	Diatoms
Concentrations	DM	Finely disseminated materials (undifferentiated)
Concentrations	DNN	Durinodes
Concentrations	DPC	Clay depletions
Concentrations	DPIR	Iron depletions
Concentrations	FDC	Finely disseminated carbonates
Concentrations	FDS	Finely disseminated salts
Concentrations	FPB	Fecal pellets
Concentrations	GBC	Gibbsite concretions
Concentrations	GBN	Gibbsite nodules
Concentrations	GLI	Glauconite pellets
Concentrations	GNM	Nests of gypsum
Concentrations	GYM	Masses of gypsum
Concentrations	GYX	Gypsum crystals
Concentrations	HACR	Halite crystals
Concentrations	ICB	Insect casts
Concentrations	MA	Masses (undifferentiated)
Concentrations	MIC	Mica flakes
Concentrations	MSD	Masses of dark accumulations
Concentrations	MSIM	Masses of iron-manganese
Concentrations	MSIR	Masses of iron
Concentrations	MSL	Masses of lime
Concentrations	MSMN	Masses of manganese
Concentrations	MSOX	Masses of oxides
Concentrations	NO	Nodules (undifferentiated)
Concentrations	NOD	Dark nodules
Concentrations	NOIM	Iron-manganese nodules
Concentrations	NOIR	Ironstone nodules
Concentrations	NOLI	Lime nodules
Concentrations	NOMN	Manganese nodules
Concentrations	OPN	Opal
Concentrations	PPB	Plant phytoliths
Concentrations	RSB	Root sheaths
Concentrations	SAM	Masses of salt

Type of feature	Code	Meaning
Concentrations	SAX	Salt crystals
Concentrations	SFB	Shell fragments
Concentrations	SGPT	Plinthite segregations
Concentrations	SHMG	Magnetic shot
Concentrations	SHNMG	Nonmagnetic shot
Concentrations	SIC	Silica concretions
Concentrations	SIM	Masses of silica
Concentrations	SSB	Sponge spicules
Concentrations	THCB	Carbonate threads
Concentrations	THGP	Gypsum threads
Concentrations	TIC	Titanium oxide
Concentrations	WCB	Worm casts
Concentrations	WNO	Worm nodules

Table E.35. *Concentration kind codes.*

Soft Masses and Concretions

Code	Meaning	Description
F	Few	Less than 2 percent of the surface area
C	Common	2 to 20 percent of the surface area
M	Many	More than 20 percent of the surface area

Table E.36. Abundance codes.

Code	Meaning	Description
F	Fine	< 2 mm
M	Medium	2–5 mm
C	Coarse	5–20 mm
VC	Very coarse	20–76 mm
EC	Extremely coarse	> 76 mm

Table E.37. *Size codes.*

Code	Meaning	Description
R	Rounded	Generally rounded or slightly oblong.
C	Cylindrical	Cylindrical or tubular; one dimension is much greater than the other two.
P	Platelike	Shaped crudely like a plate; one dimension is very much smaller than the other two.
I	Irregular	Characterized by branching, convoluted, or mycelial form.

Table E.38. *Shape codes.*

Type of feature	Code	Meaning
Concentrations	ARF	Around rock fragments
Concentrations	TOH	Top of horizon
Concentrations	CRK	Cracks
Concentrations	MPF	Matrix
Concentrations	DIA	Diatoms
Concentrations	MAT	Matrix adjacent to pores
Concentrations	ALS	Along lamina or strata surfaces
Concentrations	RPO	On surfaces along root channels
Concentrations	SSS	On slickensides
Concentrations	MAC	Matrix surrounding concentrations
Concentrations	MAD	Matrix surrounding depletions
Concentrations	LPO	Pore lining
Concentrations	APF	Ped faces
Concentrations	HPF	Ped horizontal faces
Concentrations	PFPO	Ped faces and pores
Concentrations	VPF	Ped vertical faces
Concentrations	TOT	Throughout
Concentrations	BPF	Between peds
Concentrations	BRF	On bottom of rock fragments
Concentrations	SPO	On surface along pores
Concentrations	MPO	Infused into the matrix adjacent to pores (hypocoats)

Table E.39. *Concentration location codes.*

Excavation Difficulty

Field Name	Description and Action To Be Taken
Excavation Difficulty	Enter the appropriate code from table E.40 for excavation difficulty.

Code	Classes	Test Description
LO	Low	Can be excavated with a spade using arm-applied pressure only. Neither application of impact energy nor application of pressure with the foot to a spade is necessary.
MO	Moderate	Arm-applied pressure to a spade is insufficient. Excavation can be accomplished quite easily by application of impact energy with a spade or by foot pressure on a spade.
HI	High	Excavation with a spade can be accomplished, but with difficulty. Excavation is easily possible with a full length pick using an over-the-head swing.

Code	Classes	Test Description
VH	Very high	Excavation with a full-length pick using an over-the-head swing is moderately to markedly difficult. Excavation is possible in a reasonable period of time with a backhoe mounted on a 40 to 60 kW (50 to 80 hp) tractor.
EH	Extremely high	Excavation is nearly impossible with a full-length pick using an over-the-head arm swing. Excavation cannot be accomplished in a reasonable time period with a backhoe mounted on a 40 to 60 kW (50 to 80 hp) tractor.

Table E.40. *Excavation difficulty codes.*

Appendix F. TEUI Documentation

The following examples were adapted from the *Bridger-East Ecological Unit Inventory* (Svalberg et al. 1997).

Ecological Type Description

PIAL/VASC, Ivywild Family Ecological Type

Whitebark pine/grouse whortleberry, Ivywild Family Ecological Type

Concept and Distribution

This ecological type (ET) consists of the PIAL/VASC Plant Association (p.a.) on soils of the Ivywild Family. The PIAL/VASC p.a. includes plant communities in which whitebark pine is the projected climax dominant tree and the understory is characterized by grouse whortleberry. Soils of the Ivywild Family are 20 to 40 inches deep, well drained, and have a loamy-skeletal subsoil layer.

This ET occurs dominantly from Doubletop Mountain south to Big Sandy Opening within the Subsummit Uplands Subsection. It is a component of map units 2345, 2601, and 2602. The geographic extent of this ET is approximately 53,480 acres. Within this area, it occupies about 9,590 acres.

Geomorphology

Landscape: Mountains.

Landforms: Roche Mountonee-Alpine Glaciation – Ice Erosion-Glacial.

Common Landforms: Bench and Freeface.

Landscape Position: Backslopes and sideslopes.

Surficial/Parent Materials

Primary Lithology: Unconsolidated.

Secondary Lithology: Glacial till desposit, colluvium, and residuum. Colluvium, residuum, and glacial till are derived from Early to Late Archean granite, granite gneiss, and granodiorite.

Colluvium occurs predominantly as slopewash, with some areas of talus and scree deposits. Glacial till is dominantly Late Wisconsin (Pinedale) age. Higher elevations may have Holocene (Neoglacial) till present.

Parent/Surficial Material Size Class: Bouldery.

Bedrock

Primary Lithology: Igneous Intrusive, Metamorphic.

Secondary Lithology: Granite, granodiorite, gneiss. Bedrock includes some areas of diorite, quartz diorite, amphibolite, and/or quartzite.

Climate: Cryic temperature regime and ustic moisture regime. Estimated mean annual precipitation ranges from 21 to 46 inches.

Elevation: Full Range: 9,000 to 10,800 feet. Typical Range: 9,000 to 10,500 feet.

Slope: 5 to 50 percent, on all aspects.

Potential Natural Vegetation: The potential natural vegetation of this ET is the PIAL/VASC p.a. (Steele et al. 1983).

In mature stands, total tree canopy cover ranges from 10 to 30 percent. Whitebark pine is the projected climax dominant tree. Lodgepole pine is the major early seral species. At lower elevations, lodgepole pine may persist for long periods of time and act as a codominant (Steele et al. 1983).

Shrub cover ranges from 10 to 30 percent. Grouse whortleberry is the climax dominant. It forms a low, somewhat open mat approximately 6 inches high. Planeleaf willow may be found on sites transitional to wetter areas.

Herbaceous cover is usually sparse and ranges from 5 to 30 percent. The most common graminoids are Wheeler's bluegrass, Ross' sedge, and spike trisetum. Common forbs include pussytoes, heartleaf arnica, and varileaf cinquefoil. Herbs that increase with disturbance are fireweed, pussytoes, western yarrow, and common dandelion.

Soil Description: Soils of this ET are 20 to 40 inches deep, well drained, and have a permeability of 2.0 to 6.0 inches per hour. Available water capacity to a depth of bedrock ranges from 1.5 to 2.4 inches.

Soil Name: Ivywild Family.

Taxonomic Classification: Loamy-skeletal, mixed, superactive Typic Dystrocryepts.

Location of Typical Pedon: Horseshoe Lake quadrangle, SW 1/4 of NW 1/4 Section 03, T. 34 N., R. 107 W., 1 mile east of Belford Lake, Pinedale Ranger District, Sublette County, Wyoming. Latitude 42 56’ 39” N., Longitude 109 37’ 16” W. Map unit 2602. Reference pedon: L1804B.

Horizon Description

A 0 to 5 inches; dark grayish brown (10YR 4/2) very bouldery sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft, very friable, nonsticky and nonplastic; 5 percent gravel, 5 percent cobbles, 5 percent stones, 20 percent boulders; many very fine, few fine, many medium, few coarse roots; many very fine and fine, common medium interstitial pores; pH 6.0; clear smooth boundary.

Bw1 5 to 12 inches; yellowish brown (10YR 5/4) very bouldery sandy loam, dark yellowish brown (10YR 4/4) moist; weak fine and medium subangular blocky structure; soft, very friable, nonsticky and nonplastic; 20 percent gravel, 15 percent cobbles, 10 percent stones, 10 percent boulders; many very fine, few fine, many medium roots; common very fine, few fine interstitial pores; pH 6.0; gradual smooth boundary.

Bw2 12 to 30 inches; yellowish brown (10YR 5/4) very stony sandy loam, dark yellowish brown (10YR 4/4) moist; weak fine subangular blocky structure; soft, friable, nonsticky and nonplastic; 20 percent gravel, 15 percent cobbles, 10 percent stones, 5 percent boulders; few very fine roots; common very fine and fine interstitial pores; pH 6.0; abrupt wavy boundary.

R 30 inches; granitic bedrock.

Observed Characteristics: Depth to hard bedrock ranges from 22 to 36 inches. Rooting depth ranges from 12 to 31 inches. Texture of the A horizon is very bouldery sandy loam, very stony sandy loam, or cobbly loam. The A horizon is 5 to 10 percent gravel, 2 to 15 percent cobbles, 3 to 20 percent stones, and 5 to 20 percent boulders. The pH of the A horizon ranges from 5.0 to 6.0. Texture of the Bw horizons is very bouldery sandy loam, very stony sandy loam, or very cobbly sandy loam. The Bw horizons are 15 to 20 percent gravel, 10 to 15 percent cobbles, 5 to 20 percent stones, and 5 to 10 percent boulders. The pH of the Bw horizons ranges from 4.5 to 6.0. A C horizon with a texture of very stony sandy loam, extremely bouldery sandy loam, or very gravelly sandy loam is present in some pedons.

Plant Community Composition (n=5)

Common Name	Code	Const.	Cover	Const.	Cover	Ecological Role
			Overstory			
Trees						
Whitebark pine	PIAL	100	6	100	18	Major climax dominant
Tall lodgepole pine	PICOL	20	2	20	8	Incidental to minor seral
			Understory			
Shrubs:						
Grouse whortleberry	VASC	80	18			Major climax increaser, resprouts after fire
Alpine prickly currant	RIMO2	20	3			Minor climax increaser
Perennial grasses						
Wheeler's bluegrass	PONE	100	5			Minor climax decreaser, rhizomatous
Spike trisetum	TRSP2	60	2			Minor climax decreaser
Slender bluegrass	POGR	20	1			Minor climax
Sandberg bluegrass	POSEI	20	1			Minor climax
Sedges and rushes						
Ross' sedge	CARO5	40	4			Minor climax, increases fire, grazing, or mechanical disturbance
Parry's rush	JUPA	40	3			Minor climax increaser
Sedge	CAREX	20	1			Minor climax
Rush	JUNCU	20	1			Minor climax
Perennial forbs						
Pussytoes	ANTEN	100	1			Minor climax, increases on bared soil
Heartleaf arnica	ARCO9	80	2			Minor climax increaser, rhizomatous
Varileaf cinquefoil	PODI2	60	1			Minor climax increaser
Aster	ASTER	40	2			Minor climax increaser, often rhizomatous
Western yarrow	ACMIL3	40	1			Minor climax increaser
Fireweed	EPAN2	40	1			Seral, increases after fire
Lupine	LUPIN	20	6			Seral increaser

Common Name	Code	Const.	Cover	Const.	Cover	Ecological Role
Pale agoseris	AGGL	20	3			Minor climax decreaser
Rydberg's arnica	ARRY	20	3			Minor climax increaser, rhizomatous
Manyray goldenrod	SOMUS	20	2			Minor climax increaser
Sulphur buckwheat	ERUM	20	1			Minor climax, increases on bared soil
Fleabane	ERIGE2	20	1			Minor climax increaser
Ballhead sandwort	ARCO5	20	1			Minor climax, increases on bared soil

Const. = Constancy, the percentage of plots in which a species is present.

Cover = The mean cover of a species for the plots in which it is present.

Similar Ecological Types

The PIAL/VASC, Ivywild Family ET is similar to other ETs on Ivywild Family soils. No other ETs have been defined with the PIAL/VASC p.a. Other ETs on Ivywild Family soils differ from the PIAL/VASC, Ivywild Family ET as follows:

> The ABLA-PIEN/VASC, Ivywild Family has (1) Subalpine fir or Engelmann spruce as the climax dominant tree, and (2) no lodgepole pine.
>
> The ABLA/ARCO9, Ivywild Family has (1) Subalpine fir as the climax dominant tree, (2) lower elevations, and (3) an understory represented by heartleag arnica.
>
> The ABLA/VASC, Ivywild Family has (1) subalpine fir as the climax dominant tree, and (2) lower elevations.

Associated Ecological Types

The PIAL/VASC, Ivywild Family ET is associated primarily with ETs within the ABLA/VASC p.a. and the ABLA/PIEN/VASC group with well drained, loamy-skeletal soils. It is also an association with rock outcrop. The table below lists the ETs that occur as map unit components within the geographic extent of this ET and the area in which each is associated with this ET.

Associated Ecological Types	Acres	Percent Co-occurrence
Rock Outcrop	44,696	84%
ABLA/VASC, Jeru Family ET	30,820	58%
ABLA-PIEN/VASC, Ivywild Family ET	13,876	26%
ABLA-PIEN/VASC, Boze Family ET	8,784	16%
DECE, Oxyaquic Cryumbrepts, C-L Family, D, MW ET	8,784	16%

Map Unit Description

MAP UNIT: 2345

Subsummit Moraines, Spruce/Fir – Whitebark Pine – Meadow Complex

MAP UNIT COMPOSITION

This map unit is a mosaic of coniferous forests and meadows on benches, roche moutonnées, ground moraines, and benches. The ABLA-PIEN/VASC, Boze Family ET occurs on benches and roche moutonnées andmountain slopes. The PIAL/VASC, Ivywild Family ET occurs on similar landforms with southerly aspects. The DECE, Oxyaquic Dystrocryepts, C-L Family, D, MW ET occurs on lower backslopes, footslopes, and toeslopes of ground moraines.

35 Percent – ABLA-PIEN/VASC (subalpine fir – Engelmann spruce/grouse whortleberry), Boze Family ET

25 Percent – PIAL/VASC (whitebark pine/grouse whortleberry), Ivywild Family ET

25 Percent – DECE (tufted hairgrass), Oxyaquic Dystrocryepts, C-L Family, D, MW ET

15 Percent – Minor Components

SETTING

Hierarchy of Ecological Units: The Subsummit Uplands Subsection.
General Location: Sandpoint Lake south to Poston Lake.

Elevation:	Full Range: 9,500 to 10,800 feet 80 Percent Range: 9,600 to 10,400 feet	**Annual Precipitation:** **Areal Extent:**	29 to 36 inches 8,800 acres
Slope:	0 to 25 percent		
Aspect:	Dominantly southwest, minor east, northwest, and flat		

COMPONENT DESCRIPTIONS

ABLA-PIEN/VASC, Boze Family ET Component

Potential Natural Vegetation: ABLA-PIEN/VASC group. This includes plant communities in which either subalpine fir or Engelmann spruce dominate at climax and the understory is dominated by grouse whortleberry. The ABLA-PIEN/VASC group is not expected to occur below 9,700 feet. Below this elevation, the ABLA/VASC.p.a. is expected to occur.

Landform: Roche moutonnées, benches, and ground moraines on glacial mountain slopes.

Primary Lithology: Unconsolidated.

Secondary Lithology: Glacial till desposit, colluvium, and residuum. Colluvium, residuum, and glacial till are derived from Early to Late Archean granite, granite gneiss, and granodiorite.

Colluvium occurs predominantly as slopewash, with some areas of talus and scree deposits. Glacial till is dominantly Late Wisconsin (Pinedale) age. Higher elevations may have Holocene (Neoglacial) till present.

Parent/Surficial Material Size Class: Bouldery.

Bedrock

Primary Lithology: Igneous Intrusive, Metamorphic

Secondary Lithology: Granite, granodiorite, gneiss. Bedrock includes some areas of diorite, quartz diorite, amphibolite, and/or quartzite.

Soil Name: Boze Family.

Classification: Coarse-loamy, mixed, superactive Oxyaquic Dystrocryepts.

Landform Position: bench.

Depth: 28 inches to a dense layer, and more than 40 inches to bedrock.

Drainage Class: Well drained.

Permeability: 0.6 to 2.0 inches per hour.

Available Water Capacity (AWC): 2.6 inches to dense layer.

Reference Pedon: O2302B.

PIAL/VASC, Ivywild Family ET Component

Potential Natural Vegetation: PIAL/VASC p.a. This includes plant communities in which whitebark pine is the climax dominant tree and the understory is dominated by grouse whortleberry.

Landform: Roche moutonnées, benches, and ground moraines on glacial mountain slopes.

Primary Lithology: Unconsolidated.

Secondary Lithology: Glacial till desposit, colluvium, and residuum. Colluvium, residuum, and glacial till are derived from Early to Late Archean granite, granite gneiss, and granodiorite.

Colluvium occurs predominantly as slopewash, with some areas of talus and scree deposits. Glacial till is dominantly Late Wisconsin (Pinedale) age. Higher elevations may have Holocene (Neoglacial) till present.

Parent/Surficial Material Size Class: Bouldery

Bedrock

Primary Lithology: Igneous Intrusive, Metamorphic.

Secondary Lithology: Granite, granodiorite, gneiss. Bedrock includes some areas of diorite, quartz diorite, amphibolite, and/or quartzite.

Soil Name: Ivywild Family.

Classification: Loamy-skeletal, mixed, superactive Typic Dystrocryepts.

Landscape Position: Narrow bench.

Depth: 31 inches.

Drainage Class: Well drained.

Permeability: 2.0 to 6.0 inches per hour.

Available Water Capacity (AWC): 1.6 inches.

Reference Pedon: O2109B.

DECE, Oxyaquic Dystrocryepts, C-L Family, D, MW ET Component

Potential Natural Vegetation: DECE community type (c.t.) This includes herbaceous riparian communities characterized by tufted hairgrass.

Landform: Roche moutonnées, benches, and ground moraines on glacial mountain slopes.

Primary Lithology: Unconsolidated.

Secondary Lithology: Glacial till desposit, colluvium, and residuum. Colluvium, residuum, and glacial till are derived from Early to Late Archean granite, granite gneiss, and granodiorite.

Colluvium occurs predominantly as slopewash, with some areas of talus and scree deposits. Glacial till is dominantly Late Wisconsin (Pinedale) age. Higher elevations may have Holocene (Neoglacial) till present.

Parent/Surficial Material Size Class: Bouldery.

Bedrock

Primary Lithology: Igneous Intrusive, Metamorphic.

Secondary Lithology: Granite, granodiorite, gneiss. Bedrock includes some areas of diorite, quartz diorite, amphibolite, and/or quartzite.

Soil Name: Oxyaquic Dystrocryepts, C-L Family, D, MW.

Classification: Coarse-loamy, mixed, superactive Oxyaquic Cryumbrepts.

Landscape Position: Toeslope.

Depth: More than 40 inches.

Drainage Class: Moderately well drained.

Permeability: 2.0 to 6.0 inches per hour.

Available Water Capacity (AWC): 3.3 inches.

Depth to Seasonal High Water Table: 21 inches.

Reference Pedon: Q2309B.

Minor Components

Rock outcrop.

The ABLA-PIEN/VASC (subalpine fir-Engelmann spruce/grouse whortleberry) group on soils similar to the Boze Family, except with a greater percentage of rock fragments in the subsoil.

The PIAL/VASC (whitebark pine/grouse whortleberry) p.a. on soils similar to the Ivywild Family, except with a thicker and/or darker surface layer.

The DECE (tufted hairgrass) c.t. on soils that are less than 40 inches deep to bedrock or a dense layer.

Areas of sedges on wet soils.

Appendix G. List of Reviewers

The following individuals contributed significant comments and edits:

Region 1

John Lane, Soil Scientist, Custer National Forest (NF), Billings, MT
Jeff Dibenedetto, Ecologist, Custer NF, Billings, MT
Mary Manning, Regional Ecologist, Missoula, MT
John Nesser, Regional Soil Scientist (retired), Missoula, MT
Henry Shovic, Soil Scientist, Gallatin NF, Bozeman, MT
Mark Jensen, Regional Planning Analyst, Missoula, MT

Region 2

John Rawinski, Soil Scientist, Rio Grande NF, Mone Vista, CO
Ron Wright, Soil Scientist, Rocky Mountain Region, Lakewood, CO
Angela Parker, Zone Silviculturist, Pike and San Isabel NF, Salida, CO

Region 3

Wayne Robbie, Supervisory Soil Scientist, Albuquerque, NM
Steve Strenger, Soil Scientist, Albuquerque, NM
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Region 4

Don Fallon, NRIS Terra Module Coordinator, Ogden, UT
Dave Tart, Ecologist, Ogden, UT
Clint Williams, Timber Planning Analyst, Ogden, UT
Jeff Bruggink, Regional Soil Scientist, Ogden, UT
Darlene Koerner, Ashley NF Soil Scientist, Vernal, UT
Sherel Goodrich, Ashley NF Ecologist, Vernal, UT

Region 5

Alan Gallegos, Assistant Province Geologist, Clovis, CA
John Chatoian, Regional Geologist, Vallejo, CA
Sydney Smith, Ecologist, Modoc/Lassen/Plumas NFs, Sonora, CA
Don Potter, Ecologist, Stanislaus NF, Sonara, CA
Denise Downie, Soil Scientist/Operations Hydrologist, Region 5, Lake Tahoe Basin Management Unit, Lake Tahoe, CA
Max Creasy, Ecologist, Happy Camp R.D., Klamath NF, Yreka, CA

Region 6

Tom DeMeo, Ecologist, Portland, OR

Duane Lammers, Assistant Regional Soil Scientists, Corvallis, OR

Jim Dorr, Soil Scientist, Winema NF, Lakeview, OR

Carl Davis, Soil Scientist, Okanogan and Wenatchee NF, Wenatchee, WA

Region 8

Tom Arnold, Soil Scientist (retired), Atlanta, GA

Wayne Owen, Regional Plant Ecologist, Atlanta, GA

David Meriwether, Ecosystem Management Coordinator, Atlanta, GA

James D. Brown, Forester, Francis Marion & Sumter NFs, Columbia, SC

Region 9

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Larry Laing, Regional Soil Scientist, Milwaukee, WI

Eunice Padley, Regional Ecologist, Milwaukee, WI

Region 10

Terry Brock, Regional Soil Scientist (retired)

Patti Krosse, Tongass Ecology and Botany Program Manager, Ketchikan, AK

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John Haglund, Ecologist, NRIS Terra, Sandy, OR

Martin Ferwerda, Soil Scientist, NRIS Terra, Sandy, OR

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Sheila Logan, NRIS Terra Resource Group Leader, Sandy, OR

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Paul Maus, Remote Sensing Specialist, Remote Sensing Applications Center, Salt Lake City, UT

Michael Williamson, Remote Sensing Specialist, Remote Sensing Applications Center, Salt Lake City, UT

Haans Fisk, Remote Sensing Specialist, Remote Sensing Applications Center, Salt Lake City, UT

Davis, Randy L., Soil Scientist, Watershed, Fish, and Wildlife Staff, Washington, DC

Keys, Jim, National Coordinator for Integrated Inventories, Ecosystem Management Coordination Staff, Washington, DC

Research

Dave Cleland, Ecologist, North Central Research Station, Rhinelander, WI

Agencies

The National Soil Survey Center, Natural Resources Conservation Service, Lincoln, NE

Appendix H. Field Equipment

Equipment List

Clinometer	Spade
Compass	Camera
Diameter tape	Backpack
Hand lense	Global Positioning System
Increment bore	Densitometer
Munsell soil color chart	First Aid kit
Notebook (write in rain)	Flagging
PH kit	Auger
Plant press	Soil thermometer
Prisim	Hard hat
Sieve	Tatums (clipboards)
Soil boxes	Stereoscope
Soil knife	Shovel
Soil sample bags	Field vest

Supply Sources

Suppliers

Forestry Suppliers, Inc.
Box 8397
205 West Rankin St.
Jackson, MS 39284–8397

Ben Meadows Company
http://www.benmeadows.com
A Division of Lab Safety Supply Inc.
P.O. Box 5277
Janesville WI 53547–5277
1–800–241–6401

Soiltest Products Division
ELE International
P.O. Box 8004
86 Albrecht Drive
Lake Bluff, IL 60044–8004

Magellan Systems Corporation
260 East Huntington Drive
Monrovia, CA 91016
John Michaels 818–358–2363

Trimble Navigation, Ltd.
645 North Mary Avenue
P.O. Box 3642
Sunnyvale, CA 94088–3642
408–730–2900

The sources indicated herein are in no way endorsed by the Government as being the preferred vendor of choice. Proposed acquisitions by the Government shall be in accordance with the applicable Federal Acquisition Regulations and in full compliance with the Competition and Contracting Act and Procurement Integrity Act.

Appendix I. Personnel Requirements

Terrestrial Ecological Unit Inventory Specialist Job Description

Ecologist, GS-408-11
Soil Scientist, GS-470-11
Geologist, GS-880-11

Introduction

This position is located at a Terrestrial Ecological Unit Inventory (TEUI) Center. The incumbent serves as a technical expert in soils, ecology, geology, and related disciplines for the Inventory Center, and develops the TEUI on one to four national forests. Incumbent will also ensure that the development of the TEUI is consistent with the *TEUI Technical Guide*. Incumbent works with the forest(s) in developing management interpretations and applications for the TEUI information.

Major Duties

1. Supplies all land surface (soils, geology, potential natural vegetation, and landform) information to the TEUI, including both photo interpreting and field verifying information on landform, soil, potential natural vegetation, and geology/parent material.

2. Conducts ecological inventory of soil, vegetation, and other environmental components of TEUI from which an ecological classification and mapping system is developed to produce useful land management and planning information. This activity requires intensive field sampling, mapping, and computerized analysis. The classifications of the TEUI and mapping information are used for indexing ecological information, inventory, data storage, and retrieval. Provides technical expertise in managing and analyzing this information, including entering and managing digital data in a Geographic Information System (GIS) environment.

3. Keeps abreast of the latest information relative to soil taxonomy, ecological classifications (including plant associations and integrated landform classifications), models, and evaluation methods to ensure adoption and application of new technology and theories.

4. Ensures consistency and quality of the TEUI. Focuses on the timeline of the inventory, ensuring completion of the workplan. Takes corrective action to ensure that policies,

plans, and prescribed budget are followed within predetermined flexibility limitations. Participates in quality control reviews as well as general management reviews of the inventory.

5. Works to integrate aquatic information and existing vegetation into inventory design and, where possible, polygon structure or appropriate modeling techniques. Establishes and maintains an atmosphere of complete cooperation with forest and District soil, ecology, and geology specialists. Cooperates with the Regional Office in the further refinement of inventory procedures. Formulates and recommends changes to the *TEUI Technical Guide*. Coordinates with other Inventory Centers around the Region to assure consistency and quality be maintained on a Regionwide basis.

6. Responsible for working with forest and District specialists to develop interpretations and applications of the TEUI information for land management planning and ecosystem management.

Factor 1. Knowledge Required by the Position

Professional knowledge and experience in soil classification, soil mapping, soil correlation, development of report interpretations, and report writing, which are used in completing soil resource inventories.

Professional knowledge and experience in plant association classification, and potential natural vegetation mapping and modeling. Development of report interpretations and report writing, which are used in completing plant association classification and resource inventories.

Mastery of advance concepts, principles, and practices of natural resources, databases, and the GIS environment sufficient to conduct an inventory based on the integration of ecosystem elements. Good working knowledge of related fields, such as hydrology, forestry, engineering, wildlife, fisheries, and ecology to coordinate ecological relationships.

Initiative and creativity in developing new approaches, methodologies, and techniques to meet target demands with limited funding and personnel ceilings.

Factor 2. Supervisory Controls

The Inventory Center leader will be the immediate supervisor and will provide administrative leadership and guidance in significant policy matters and coordination on a Regionwide basis. Functions with independence in reaching decisions. The incumbent clears with the supervisor approaches that have potential policy impacts. Results are reviewed by the supervisor and the Regional Office TEUI Coordinator. Performance is determined by these results.

Factor 3. Guidelines

The basic guides are the broad policies and objectives of the Forest Service and the broad policies of the National Cooperative Soil Survey as contained in the *National Soil Survey Handbook* (USDA NRCS 2003b) and the *Soil Survey Manual* (USDA NRCS 1993). Regional Guides, forest plans, applicable regulations, recognized standards, and administrative knowledge and training act as day-to-day guidelines.

Sound professional judgment, ingenuity, and resourcefulness are required. The incumbent will follow the *TEUI Technical Guide*. Many different situations will be encountered. Incumbent is expected to assist in developing new methods and procedures, to identify the latest technical concepts and practices, and to incorporate them in the inventory procedures.

Factor 4. Complexity

The assignment requires sound professional knowledge of plant and soil interactions, soil series, and plant associations. Must have a basic understanding of geology, geomorphology, climate, and vegetative characteristics. The assignment includes analysis of an extremely complex interaction of abiotic factors and flora along with cooperating with the Districts, forests, Regional Office, and other Inventory Centers.

The work assignment will require the incumbent to relate new work situations to precedent situations, to extend or modify existing techniques, and to adequately solve problems. Incumbent will work with the forests to develop management interpretations and applications for the information. Occasionally, the assignments require substantial effort to overcome resistance to change when it is necessary to modify an accepted method or approach.

Factor 5. Scope and Effect

The work associated with this position is primarily to carry out the complete classification and inventory of landforms, soils, potential natural vegetation, and geology/parent material on one to four national forests. The results of this work will have a significant effect on preparing the forests for a GIS and ecosystem management.

Factor 6. Personal Contacts

Contacts help develop new ideas and procedures, validate existing procedures, and complete the development, testing, and implementation of the TEUI on one to four forests and within the Region.

Factor 7. Purpose of Contacts

Contacts help develop new ideas and procedures, validate existing procedures, and complete the development, testing, and implementation of the TEUI on one to four forests and within the Region.

Factor 8. Physical Demands

Demands range from sedentary work seated in an office using stereoscopes to the rigorous physical exertion of walking in rugged terrain and streams. Physical exertion will include hiking, climbing, riding horses, and driving all-wheel vehicles over unimproved roads.

Factor 9. Work Environment

Routine office work is performed in a normal office setting. Work requires exposure to some risks involved in logging operations, firefighting, and walking or riding in isolated country, sometimes in adverse weather conditions. Safety precautions are required and the employee must wear protective equipment while making on-the-ground inspections.