Chapter 6

Developing the LANDFIRE Vegetation and Biophysical Settings Map Unit Classifications for the LANDFIRE Prototype Project

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Introduction

The Landscape Fire and Resource Management Planning Tools Prototype Project, or LANDFIRE Prototype Project, required a system for classifying vegetation composition, biophysical settings, and vegetation structure to facilitate the mapping of vegetation and wildland fuel characteristics and the simulation of vegetation dynamics using landscape modeling. We developed three separate, fully integrated vegetation and biophysical settings map unit classifications that quantified, categorized, and described vegetation and environmental conditions; these include: cover type (CT), potential vegetation type (PVT) and structural stage (SS). We used a rule-based approach to implement these map unit classifications in the LANDFIRE reference database (LFRDB), which is a field-based database comprised of existing field data from the prototype mapping zones (Caratti, Ch. 4). We used the LFRDB to create training databases to develop maps of CT, PVT, and SS (Frescino and Rollins, Ch. 7; Zhu and others, Ch. 8). These vegetation-based maps formed the foundation for the mapping of fire regime condition class (FRCC), fire behavior fuel models, fuel loading models, fuel characteristic classes, and canopy fuel characteristics (Pratt and others, Ch. 10; Holsinger and others, Ch. 11; Keane and others, Ch. 12). The map unit classifications also formed the building blocks for the development of succession pathway models for simulating historical fire regimes (Long and others, Ch. 9).

In this chapter, we refer to our process of categorizing the biophysical settings, vegetation composition, and vegetation structure as a "classification" process. Several design criteria were developed to ensure that the LANDFIRE map unit classifications were sufficient for successfully completing the LANDFIRE vegetation, wildland fuel, and fire regime products. We refer to the complete list of units in each classification as a "map legend." We call the results of each classification a "map unit" or refer to them by the appropriate mapping classification topic such as "cover type" or "potential vegetation type" or "structural stage."

The biophysical and vegetation map unit classifications provided guidelines for many of the LANDFIRE Prototype mapping and modeling tasks. The CT classification describes existing vegetation composition and was used to describe the dominant species within vegetation communities that are differentiated by unique species compositions. The PVT classification is a biophysical classification that uses indicator plant species to identify the unique biophysical characteristics of a site. A biophysical classification describes environmental conditions such as water availability, nutrient status, and average annual temperature. The SS classification describes important stages of canopy development, and the classes are often referred to as *stand structure types*. These classifications defined the specific map classes that were quantified in LANDFIRE vegetation mapping.

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Research has shown that the integration of a biophysical classification (PVT) with stand structure (SS) and species composition (CT) classifications can uniquely describe other ecological characteristics, such as wildland fuel characteristics, fire regimes, and wildlife habitat (Keane and others 1998). In addition, such integration facilitates the modeling of vegetation succession needed to simulate the historical landscape composition that may be used for determining departure from historical conditions (Hardy and others 1998; Keane and others 1998).

We designed the LANDFIRE vegetation map unit classifications to contain a comprehensive list of consistently categorized vegetation characteristics that may be used beyond the scope of the prototype study areas across the entire nation. All lands, federal and non-federal, and all vegetative communities, forest, shrubland, and herbaceous, within the LANDFIRE Prototype Project study areas were classified with the same level of detail and consideration.

Each individual CT, PVT, and SS map unit had to meet the following LANDFIRE guidelines:

- **Identifiable** – The CT, PVT, and SS classes must be able to be identified in the field and from existing field databases (such as the Forest Inventory and Analysis [FIA]). Additionally, all classes must be able to be identified by nationally standard terminology used in vegetation classifications and descriptions of vegetation map units.
- **Scalable** – The CT, PVT, and SS classes must be hierarchical with regard to floristic and spatial scale. The aggregation and disaggregation of classes must be straightforward.
- **Mappable** – The CT, PVT, and SS classes must be able to be delineated accurately on a map using standardized remote sensing techniques combined with biophysical gradient modeling.
- **Model-able** – The CT, PVT, and SS classes must fit into the framework of the landscape simulation models critical for producing several of the LANDFIRE products, including maps of historical fire regimes, departure from historical conditions (Holsinger and others, Ch. 11), fire behavior fuel models, and fire effects fuel models (Keane, Ch. 12).

We used established vegetation classifications, biophysical classifications, extensive literature review, vegetation modeling science, classifications from other fuel and fire regime mapping projects, and reference data contained in the LFRDB (Caratti, Ch. 4) in the development of LANDFIRE Prototype Project map unit classifications and to guide the development of the multi-level hierarchy in which we embedded our classes. Multiple levels of CT and PVT allowed us to aggregate or disaggregate the classes to support multiple LANDFIRE tasks using a single classification scheme. Multiple levels also allowed linkage between the LANDFIRE map classifications and existing classifications such as the Society of American Foresters (SAF) classification (Eyre 1980), the Society of Range Management (SRM) classification (Shiflet 1994), and the National Vegetation Classification System (NVCS) (Grossman and others 1998).

We developed an iterative process to ensure that ecologically reasonable combinations, based on literature review and expert knowledge, would result when maps created with our classes were combined for use in succession pathway development, landscape succession simulation, and fuel mapping (see appendix 2-A in Rollins and others, Ch. 2 for a LANDFIRE Prototype procedure table). We also developed a coding protocol for the map legends, which can be found in appendix 6-A. The individual biophysical and vegetation mapping classifications and associated hierarchical structures developed for prototype zones 16 and 19 are described below.

Methods

The LANDFIRE Prototype Project involved many sequential steps, intermediate products, and interdependent processes. Please see appendix 2-A in Rollins and others, Ch. 2 for a detailed outline of the procedures followed to create the entire suite of LANDFIRE Prototype products. This chapter focuses specifically on the development of vegetation map units, which was a critical intermediate step for nearly all mapping tasks in the LANDFIRE Prototype Project.

Cover Type

The LANDFIRE Prototype Project required maps of cover type (CT) representing existing distinct vegetative communities that, when combined with maps of PVT and SS, allowed for characterization of the variation in wildland fuel and fire regimes across the prototype study areas. One intent of the LANDFIRE Prototype Project was to develop a standard methodology for the development of a LANDFIRE CT classification that would be applicable across the nation and repeatable (for consistency) by other teams. In addition, field data from the LFRDB were classified to CT and used as a training database for mapping existing vegetation from Landsat imagery.

Although several authors have created classifications of existing vegetation (Eyre 1980; Grossman and others 1998; Shiflet 1994), these classifications would not suffice for use in the LANDFIRE Prototype or LANDFIRE National effort without modification or customization. No single, existing vegetation classification met the LANDFIRE design criteria and guidelines (Keane and Rollins, Ch. 3). For example, classifications such as the NVCS (Grossman and others 1998) rely on the organization of plants by morphological characteristics and do not necessarily provide the class divisions required to delineate distinct and comprehensive mapping categories. In addition, vegetation classifications based on floristics, which can describe vegetation characteristics or spatial distribution of species, have many more classes than were needed for LANDFIRE maps. Inconsistencies were also found within some of the available classifications when they were applied across several states; for example, the USGS GAP Analysis Program vegetation class mapping methodologies (Merchant and others 1998) are inconsistent across state boundaries. Finally, some of the classifications serve specific purposes and therefore exclude many vegetation types; for example, the SAF cover types were developed primarily to describe forests and woodlands (Eyre 1980). Furthermore, several of the existing classifications include types composed of two or more species with different physiognomies and more importantly, different successional roles, which made these problematic for use in vegetation modeling or succession pathway development. For example, the SRM cover type number 509, "Oak-Juniper Woodland and Mahogany-Oak" (Shiflet 1994) is identified by multiple species that have different successional roles. To simplify the process of succession pathway development, we avoided grouping different seral species within a CT. LANDFIRE CT classes were designed to be represented with a single dominant species that characterized a primary stage in successional development (Long and others, Ch. 9).

Despite our reservations with available classifications, we attempted to integrate the logic and content of existing classifications into the LANDFIRE classification development. At times, we used the current classes as they were, sometimes we modified them, and other times we used them simply as general guidelines to create unique sets of CT map legends specifically suited to meet LANDFIRE design criteria and guidelines.

After our review of several CT classifications, we approached the development of a LANDFIRE CT classification using two fundamentally different methods. The approach used for Mapping Zone 16 in the central Utah highlands was a top-down method that partitioned general vegetation types (forest, woodland, shrub, and herbaceous) into classes based on differences within these types. This top-down approach, or *divisive* method, is most aptly used for large areas where relationships and patterns are already understood (Brohman and Bryant 2005). Because the classes are more conceptual in nature, fewer observations are required for their development (Brohman and Bryant 2005). As a result, Zone 16 plot data was used only to fine-tune map units, not direct the classification. The second classification methodology, used for Zone 19 in the Northern Rockies, focused on groupings based on shared characteristics. In this bottom-up approach, we used Zone 19 plot data to specify the type to be grouped, which, in our case, was the dominant species of the plot. This agglomerative method is often used to quantify unknown relationships and patterns using empirical data (Brohman and Bryant 2005). As this was a prototype effort to develop nationally consistent maps, we decided to test both methodologies to determine which approach, conceptually based or data-driven, would prove most useful. The following sections describe these two distinct approaches used in the development of the LANDFIRE CT classification.

Mapping Zone 16: Central Utah Highlands—The general approach for Zone 16 was to construct a list of CTs applicable to 11 western states. We expected detailed descriptions of these CTs to vary significantly between different parts of the West because of regional differences in species composition. We assumed at the outset that the western U.S. list and associated descriptions of the CTs would be refined once applied to Utah and further refined when applied to other parts of the West.

Through consultation with vegetation ecologists and mapping experts, we established general guidelines for the CT classification development. We determined that a set of approximately 50 western CTs would be suitable to map existing vegetation for the LANDFIRE Prototype. These types had to have at least one percent coverage of the western U.S. in order to describe a mid- to broad-scale vegetative community. We placed emphasis on the creation of a CT legend for non-forest vegetation, which had been inadequately represented in previous national mapping efforts. We represented each CT with an individual dominant species, such as ponderosa pine or bluebunch wheatgrass, and we attempted to avoid the use of mixed life form, phenological, and morphological classes when grouping the dominant species into CTs and when these CTs were arranged into coarser hierarchical levels. Finally, we decided to use CT names that describe the dominant species, as opposed to using generic vegetation terminology. Generic terminology such as *chaparral*, for example, comprises many species, and a term such as *Pacific* comprises many geographical regions.

We developed the original legend of non-forest and forest CTs from expert knowledge of western vegetation and then improved this legend based on reviews of key literature that described similar CTs and on other existing CT classifications. We relied heavily upon the SAF cover types (Eyre 1980), the SRM cover types (Shiflet 1994), and a list of USGS Gap Analysis Program (GAP) (Merchant and others 1998) land cover classes that we compiled from western GAP state maps and standardized classes provided by the University of Idaho and BLM National Science Technology Center. Essentially, most of the western SAF, SRM, and GAP types were linked to the LANDFIRE CT legend to ensure this legend included the major vegetation types of the western U.S. A few of these were not assigned to LANDFIRE CTs because they were either too fine spatially or had wide-ranging descriptor species, which meant that the presence of a particular species did not indicate a discrete CT useful to the LANDFIRE mapping effort. With significant assistance from Forest Service Region 4 ecologists, we also adjusted sagebrush CTs to be compatible with the classification used for the sagebrush map prepared by the NatureServe for the USGS (Reid and others 2002).

We followed the Federal Geographic Data Committee (FGDC 1997) standards for vegetation classification as closely as possible when developing CT legends and the classification hierarchy, and we used hierarchical levels similar to the NVCS (Grossman and others 1998), such as class, subclass, and group, to describe our hierarchy. Although the FGDC standards do not include mapping applications, we found that FGDC guidelines for vegetation classification were useful in the development of the LANDFIRE map unit classification. When necessary, however, we altered FGDC vegetation classification definitions to better suit the requirements of the LANDFIRE Prototype Project. For example, the LANDFIRE Prototype Project defined barren as less than 10 percent cover of vegetation, whereas FGDC defined it as less than 20 percent vegetation cover. If we had used the FGDC definition of barren, we would have classified many functioning, arid plant communities that fully occupy their sites as essentially devoid of vegetation. Furthermore, because some of these communities will sustain wildland fire, particularly in years when high precipitation causes abundant growth of herbaceous fine fuel, we determined they must be included in the LANDFIRE CTs as vegetated communities.

To facilitate the creation of the CT maps (Zhu and others, Ch. 8), we developed a classification key or sequence table for assigning LANDFIRE CTs to LFRDB plots (Caratti, Ch. 4). We assigned "dominant species" to each CT according to expert knowledge and the descriptions provided with each SRM, SAF, and GAP cover type classification. We used the dominant species to represent the CT, following an approach similar to that of Brohman and Bryant (2005) and their use of a "dominance type" in the *Existing Vegetation Classification and Mapping Technical Guide*. Specifically, we represented the CT by one important plant taxa in the uppermost layer of vegetation. Species defined as dominant usually had the greatest amount of canopy cover in the uppermost layer. The identification of a single dominant overstory species was adequate to describe the plot and therefore allowed us to delineate CTs using satellite image processing (which cannot identify lower strata vegetation). However, in the case of some shrub and grassland CTs, we employed a second species or species group when the important plant species could dominate more than one CT as a result of its wide-ranging distribution.

In our final step, we improved the western U.S. CT legend, added more dominant species to some CTs, and developed criteria for identifying dominant species using plot data from the central Utah mapping zone. We assigned each additional dominant species found in the plots to the most suitable CT based on distribution, occurrence, ecological characteristics, and/or habitat requirements of the species, as described in the Fire Effects Information System (http://www.fs.fed.us/database/feis). Furthermore, we divided graminoid communities into cool-season (C3 or C4) and warm season (C4) CTs according to the dominant photosynthetic pathway of the species with highest cover. We required the dominant species to be listed by complete scientific name (*Poa pratensis*), not just genera (such as *Poa*). We also required that all big sagebrush species be listed with variety or sub-species (for example, *Artemisia tridentata* ssp. *wyomingensis*). Comprehensive methodology detailing how the CTs were assigned to plots in the LFRDB can be found in Caratti, Chapter 4.

Mapping Zone 19: Northern Rockies—In contrast to the CT classification development for Zone 16, we implemented a data-driven approach for the creation of the Northern Rockies Zone 19 CTs. This bottom-up approach relied heavily on plot data found in the LFRDB. For a national classification, this approach would require enormous amounts of data and computing capacity to classify a single field-referenced database for the entire U.S.

We also developed guidelines that promoted consistency in CT criteria, even though the plots were to be classified independently for each zone. All CT and CT hierarchy development followed the same general principles, such as consideration of the predominance of a CT on the landscape, the ecological significance of a CT, and plot data availability. As in Zone 16, the objective of the CT map classification was to represent the CT with distinct yet nationally applicable criteria at a landscape-level. We attempted to avoid the use of mixed life form, phenological, and morphological classes when grouping the dominant species into CTs and when these CTs were arranged into coarser hierarchical levels. Mixed classes may have included species with different successional roles, making them difficult to use as representatives of single seral stages for succession models.

We used LFRDB plot data for Zone 19 to determine the set of dominant species that formed the foundation of our CT map classification and hierarchy development. To establish this set of dominant species, we first assigned life forms to plots based on criteria established by the LFRDB team (see Caratti, Ch. 4). Next we determined the dominant species on the plot to be the species within that life form that had the highest percent cover (or basal area if the plot was from FIA data). As for Zone 16, a complex rule set was developed to distinguish the uppermost dominant tree species from multiple layers in certain forest types (see Caratti, Ch. 4). The attributes for these dominant species became the starting point for the bottom-up CT classification.

We based the Zone 19 dominant species groupings on a number of taxonomic, physiognomic, succession, and site characteristics. We grouped some of dominant species into CTs, and we determined that other dominant species were CTs themselves because of their continuous and distinct distribution across the landscape. In essence, we selected the criteria for developing the CT classes based on whether they resulted in CT classes that met the four LANDFIRE design requirements. That is, they had to be identifiable, scalable, mappable, and modelable. This scalable, hierarchical system facilitated both mapping and succession modeling because CTs that were most suitable for the particular product could be selected. For example, if a CT at one level did not meet the needs of a certain LANDFIRE task, a level above or below could be used instead. As a result, the CTs used in processes described in other chapters (see, for example, cover type mapping in Zhu and others, Ch. 8) existed in more than one hierarchical level.

Potential Vegetation Type

The potential vegetation type (PVT) map classification was important to several LANDFIRE processes and products. Potential vegetation types describe and classify environmental site conditions, providing succession modelers with the biophysical settings (areas with common environmental site conditions) for which they then develop succession pathways describing vegetation development (Long and others, Ch. 9). Much in the same way as in the creation of the CT map, plot data from the LFRDB were classified to a PVT in order to provide a training database for mapping PVTs (Keane and Rollins, Ch. 3; Frescino and Rollins, Ch. 7). We used the PVT map as one of the predictor layers in the mapping of CT and SS, along with Landsat imagery and biophysical gradient layers (Zhu and others, Ch. 8). Potential vegetation type effectively limited the number of CTs that could occur on any site because certain existing vegetation types had high fidelity to specific PVTs. (Zhu and others, Ch. 8). Mapped PVT formed the foundation for the simulation of historical reference conditions that served as the baseline for characterizing the ecological departure of current systems from historical conditions (Keane and Rollins, Ch. 3; Pratt and others, Ch. 10; Holsinger and others Ch. 11). The PVT map was also used to spatially parameterize disturbance dynamics in the LANDSUMv4 fire-succession model (Pratt and others, Ch. 10). Finally, the PVT classes and map were used in the development of fuel maps (Keane and others, Ch. 12). The following section presents the background of the PVT concept, the LANDFIRE PVT mapping guidelines, and the development of the PVT map classification.

Quantitative descriptions of the biophysical environment can provide a process-oriented context for mapping and modeling important biological characteristics. Litter fall, for example, is greater on warm, moist sites than on cold, dry sites. Studies have shown that incorporating a quantitative description of the biophysical environment (such as temperature, elevation, and precipitation) with satellite imagery improved the mapping of ecological characteristics such as vegetation and fuel (Keane and others 2002; Rollins and others 2004). We recognized the need to develop a biophysical classification that would be useful for both LANDFIRE mapping and modeling and for scaling LANDFIRE products to finer scales for use in local land management applications.

Due to the lack of an existing national-scale PVT classification, we developed our own biophysical classification based on a revised habitat type classification approach

(Pfister 1989; Pfister and Arno 1980; Pfister and others 1977) and other site classifications based on climax vegetation (Daubenmire 1962, 1966; Ferguson 1989). In concept, the PVT approach assumes that a climax vegetation community would eventually develop on a site in the absence of disturbance). This approach has a long history in vegetation mapping, and PVT classifications have been developed for many of the forests of the western U.S. (Ferguson 1989; Pfister 1981; Pfister and Arno 1980). However, the approach has had limited success with non-forested environments because extensive disturbance histories in rangelands have eliminated many climax species that are indicators of biophysical settings. Also, non-forest systems don't lend themselves to a single climax species, but rather a group of species or vegetation communities. This type of classification, often based on late seral species and/or gradients of shade tolerance, provides the basis for LANDFIRE's biophysical classification.

We modified traditional approaches to PVT classification to match the scope and assumptions of the LFRDB development and LANDFIRE mapping tasks. Our objective was to identify the unique biophysical setting, not the climax vegetation or endpoint of succession. As noted above, the term *climax* is often associated with communities rather than species, and many ecologists have noted that climax vegetation is an unrealistic endpoint since climate, genetics, exotic migrations, and other factors are constantly changing such that a stable climax community is impossible (Hironaka 1987; Huschle and Hironaka 1980). We assumed that PVTs for forest ecosystems could be identified from plot data based on the most shade-tolerant tree species on a plot. The hypothesis is that the tree species with the highest shade tolerance will eventually become dominant in the absence of disturbance. Following the theory of Daubenmire (1966) (the principle of competitive exclusion), the tree species with the highest shade tolerance will also have a high fidelity of occurrence in unique biophysical settings. Again, we made no assumption that the most shade tolerant species was a *climax* species in our classification. We viewed the most shade-tolerant species found on a plot as a suitable indicator of the plot's distinctive environmental condition. We named our biophysical classification after PVTs because these shade-tolerant species best indicate the biophysical setting under the current climate regime, not the ultimate climax community. This approach not only ensured the mapping of unique biophysical settings but also allowed these settings to be directly linked to succession pathways in our simulation of historical reference conditions.

The CT map classification provided the building blocks for developing the final list of PVTs for the LANDFIRE Prototype Project. The PVTs were named according to CTs, and lists of CTs that could exist in each PVT were developed so that no inconsistencies or illogical combinations existed between the CT and PVT maps and so that each PVT could occur on the CT map as an existing vegetation type. Therefore, the CT map legend provided the resolution for all LANDFIRE PVTs. For example, a Dwarf Sagebrush PVT could be created only if there was a Dwarf Sagebrush CT. This was especially important to the LANDSUMv4 modeling effort for determining the historical range of landscape conditions (Pratt and others, Ch. 10).

Potential vegetation types were assigned to forested plots in the LFRDB based on the presence of a particular tree species as determined from the coverage or tree density data collected for that plot. Using the reference database, we sorted all tree species present (≥ 1 percent cover) on a plot by shade tolerance using autoecological information found in the literature (Burns and Honkala 1990; Fowells 1965; Minore 1979). We then matched the most shade-tolerant species with the comparable CT. Again, matching PVT and CT ensured logical combinations and a consistent linkage between maps for the development of the LANDSUMv4 succession pathways for simulating historical reference conditions (Pratt and others, Ch. 10)

Rangeland ecosystems presented a special problem for the PVT concept since residual late successional species are rarely observed in plot databases because of high frequency of disturbances such as grazing and fire (Bunting 1994; Sieg 1997; Westoby 1980). For this reason, we arranged the rangeland CTs along a moisture gradient from xeric to mesic communities, and this arrangement was used as the key criterion for classifying plots in the LFRDB. We had some problems uniquely assigning rangeland PVTs to plots because of overlap and limited coverage of some indicator species along the moisture gradient. To determine the PVT for some of the rangeland plots, we had to consider other ecological species characteristics, such as ecological amplitude. Presence of an indicator species at greater than ten percent cover, rather than dominance of that indicator species (species with highest cover on a plot), was used as a criterion for classifying the rangeland PVTs in the key. Additionally, a threshold of ten percent cover was used in the PVT key because when presence alone (greater than zero percent cover) was used to implement the key, as was initially done, none of the herbaceous rangeland PVTs were assigned to plots. Most herbaceous plots had a few shrubs on them, and the presence threshold of greater than zero percent that was employed initially always led to an assignment of shrub PVT, which we knew was not always accurate (Caratti, Ch. 4). Although this method for assigning PVTs to rangeland communities was based on a myriad of assumptions, most importantly the ability to consistently model successional development, it proved to be the best approach considering the limited resources and data available.

We created a nested hierarchy of the PVT categories to aggregate similar PVTs into one type and to facilitate the development of finer divisions of biophysical settings according to the modelers' and mappers' needs (Zhu and others, Ch. 8; Long and others, Ch. 9). The order of the hierarchical levels was also important as it influenced how relevant the classification would be for LANDFIRE purposes. For example, if we used a general forest PVT, such as Spruce – Fir, as our finest level of the hierarchy, we would not be able to divide this type any further to represent finer distinctions in the biophysical settings of Spruce – Fir forest PVTs.

Structural Stage

Structural stage (SS) map classifications delineate developmental stages of vegetative communities based on characteristics such as vegetation age, height, canopy closure, and canopy structure (Quigley and Arbelbide 1997). These characteristics are the key components in modeling vegetation succession, wildland fire behavior, and the effects of wildland fire. Arno and others (1985) classified forests based on the following stand characteristics: tree canopy coverage, average diameter at breast height of the dominant tree, basal area, and stand age. Quigley and Arbelbide (1997) used the processes approach, based on growth, development, competition, and mortality, to classify SS for the Interior Columbia Basin Ecosystem Management Project. Many professional foresters have used size classes (such as diameter at breast height) to represent seral stage or age, attributes which are primarily used to determine timber volumes. Foresters often assume the bigger and taller the stand, the older the stand or the later the seral stage. However, mapping efforts using diameter-breast-height and size classes have met with limited success and may not yield even enough information to adequately determine seral stage. The USGS Center for Earth Resources Observation and Science (EROS) team, responsible for producing the LANDFIRE SS maps, found that mapping canopy cover and height to indicate seral stage was more successful (Keane and Rollins, Ch. 3), and so these two attributes were used to create the LANDFIRE SS map.

The LANDFIRE SS map classification was critical for almost all phases of the project, especially for developing the succession pathway models and for mapping wildland fuel. This classification allowed modelers to assign seral stages to the various CTs that made up the succession pathways (Long and others, Ch 9). Additionally, the SS classes quantified the horizontal and vertical configuration of vegetation, enabling a more accurate assignment of wildland fire behavior models and fire effects models and a better overall representation of wildland fuel characteristics (Keane and others, Ch. 12).

We developed the existing SS map units using similar methodologies for both zones 16 and 19. We categorized continuous canopy cover (density) and height values into classes designed to yield the highest precision based on the mid-level resolution of Landsat imagery because we did not feel confident that the imagery had sufficient resolution to detect a more complex and detailed SS resolution. We determined the threshold values separately for each life form (forest, woodland, shrubland, and herbaceous) based on expert opinion. We then combined these two variables into a matrix that enabled us to describe both attributes with one value. The combination of the two attributes provided sufficient characterization of seral stage, which was then used to map wildland fuel (Keane and others, Ch. 12) and to parameterize and implement LANDSUMv4 (Pratt and others, Ch. 10).

Results and Discussion

Cover type

Mapping Zone 16: Central Utah Highlands—Fifty CT classes were created for the western United States. Table 1 provides a legend of these CTs and illustrates the hierarchical structure of the CT classification. The western U.S. CTs included 24 forest, 4 woodland, 15 shrubland, and 7 herbaceous types. Eight of the forest CTs were refined through examination of Zone 16 plot data, in addition to 2 woodland types, 14 shrubland types, and all 7 of the herbaceous types. Appendix 6-B provides a brief description of each western CT.

We assigned dominant species to each CT to enable identification (to meet the LANDFIRE guideline that all types be "identifiable") of a CT in the field or in a database. Species are commonly recorded in field data sets, especially the dominant species, because species are usually easily identified in the field, and the connection between dominant species and CT is a commonly understood concept.

Table 1—Western U.S. cover type legend. For Zone 16, the LANDFIRE Prototype Project used a “top-down” classification approach in which vegetation classes were developed for the entire western United States. Classes that were actually mapped for Zone 16 are denoted with a superscript b.

CT#[a]	Cover type	Class	Subclass	Group
1401	Riparian Hardwood[b]	Forest	Deciduous	Broadleaf
1405	Aspen – Birch[b]	Forest	Deciduous	Broadleaf
1406	Pacific Deciduous Forest [Other Broadleaf]	Forest	Deciduous	Broadleaf
1102	Pacific Broadleaf Evergreen Forest [Other Broadleaf Evergreen]	Forest	Evergreen	Broadleaf
1501	Larch	Forest	Deciduous	Needleleaf
1201	Ponderosa Pine[b]	Forest	Evergreen	Needleleaf
1208	Pacific Ponderosa Pine Complex	Forest	Evergreen	Needleleaf
1202	Foothill Pines	Forest	Evergreen	Needleleaf
1203	Western White Pine	Forest	Evergreen	Needleleaf
1204	Lodgepole Pine[b]	Forest	Evergreen	Needleleaf
1205	Douglas-fir[b]	Forest	Evergreen	Needleleaf
1206	Grand Fir – White Fir[b]	Forest	Evergreen	Needleleaf
1207	Pacific Silver Fir – Noble Fir	Forest	Evergreen	Needleleaf
1219	Red Fir	Forest	Evergreen	Needleleaf
1220	California White Fir	Forest	Evergreen	Needleleaf
1209	Western Hemlock	Forest	Evergreen	Needleleaf
1210	Mountain Hemlock	Forest	Evergreen	Needleleaf
1211	Spruce – Fir[b]	Forest	Evergreen	Needleleaf
1212	Sitka Spruce	Forest	Evergreen	Needleleaf
1213	Cedar	Forest	Evergreen	Needleleaf
1215	Redwood	Forest	Evergreen	Needleleaf
1216	Sequoia	Forest	Evergreen	Needleleaf
1217	Cypress	Forest	Evergreen	Needleleaf
1801	Timberline Pines[b]	Forest	Mixed Evergreen-Deciduous	Needleleaf
2401	Deciduous Oak	Woodland	Deciduous	Broadleaf
2101	Evergreen Oak	Woodland	Evergreen	Broadleaf
2201	Pinyon – Juniper[b]	Woodland	Evergreen	Needleleaf
2202	Juniper[b]	Woodland	Evergreen	Needleleaf
3704	Mountain Deciduous Shrub[b]	Shrubland	Deciduous	Broadleaf
3402	Riparian Shrub[b]	Shrubland	Deciduous	Broadleaf
3403	Exotic Riparian Shrub[b]	Shrubland	Deciduous	Broadleaf
3101	Mountain Big Sagebrush Complex[b]	Shrubland	Evergreen	Broadleaf
3102	Wyoming - Basin Big Sagebrush Complex[b]	Shrubland	Evergreen	Broadleaf
3103	Dwarf Sagebrush Complex[b]	Shrubland	Evergreen	Broadleaf
3104	Sand Sagebrush[b]	Shrubland	Evergreen	Broadleaf
3105	Blackbrush[b]	Shrubland	Evergreen	Broadleaf
3106	Rabbitbrush[b]	Shrubland	Evergreen	Broadleaf
3107	Chaparral[b]	Shrubland	Evergreen	Broadleaf
3108	Soft Chaparral [Coastal Sage Scrub]	Shrubland	Evergreen	Broadleaf
3301	Montane Evergreen Shrubs[b]	Shrubland	Evergreen	Mixed Broadleaf-Needleleaf
3701	Salt Desert Shrub[b]	Shrubland	Mixed Evergreen-Deciduous	Broadleaf
3702	Desert Shrub[b]	Shrubland	Mixed Evergreen-Deciduous	Broadleaf
3703	Dry Deciduous Shrub[b]	Shrubland	Mixed Evergreen-Deciduous	Broadleaf
4101	Warm Season Grasses[b]	Herbaceous	Perennial Graminoid	Grass
4102	Cool Season Grasses[b]	Herbaceous	Perennial Graminoid	Grass
4201	Native Forbs[b]	Herbaceous	Perennial Forb	Forb
4202	Exotic Forbs[b]	Herbaceous	Perennial Forb	Forb
4301	Wetland Herbaceous[b]	Herbaceous	Mixed Perennial Graminoid/Forb	Mixed Grass/Forb
4302	Alpine[b]	Herbaceous	Mixed Perennial Graminoid/Forb	Mixed Grass/Forb
4401	Annual Grasslands[b]	Herbaceous	Annual Graminoid	Grass

[a]Coding protocol can be found in appendix 6-A
[b]Refined with plot data and mapped in Zone 16.

While we adhered to the guideline that the CTs be "mappable," we could not logically follow some of the other initial guidelines developed for the Zone 16 CT mapping classification. For example, we did not name each CT according to an individual dominant species for several reasons. First, there are more plant communities dominated by individual species than needed for the mid-scale LANDFIRE Prototype map products. Second, in many plant communities, especially non-forest, mixes of species commonly dominate. Additionally, the subtle spatial patterns in many of these diverse plant communities cannot be mapped using current remote sensing technology because satellite technology cannot distinguish these as individual plant communities. Therefore, to maintain a mid-scale CT classification and adequately describe CT variability, we used generic names such as Desert Shrub or Chaparral to identify the CT. Lastly, we encountered difficulty in assigning unique CTs to plots dominated by non-forest species with broad ecological amplitude. To classify these systems, we had to either create a map unit with a relatively coarse floristic scale or use co-dominants in the classification process.

We recognized that categorizing grasses into two types only, warm season and cool season, was quite broad and may not be suitable for all LANDFIRE Prototype applications. For example, fire behavior fuel model mapping requires knowledge of leaf blade type, fine or coarse, to assign a grass fuel model; however, a mixture of both kinds of leaf blades may dominate both the warm and cool season grass CTs.

Overall, we found that the CTs served well in landscape succession models; that is, they met the LANDFIRE guideline of being "model-able." The number of map units in each classification was sufficient for modeling disturbance processes in each map zone. Although mapping accuracies may have increased had we used fewer classes (Vogelmann and others, Ch. 13), we needed to balance the need for high map accuracies with the need to provide useful types to modelers.

Allowing more than one dominant species to represent a CT did, however, create several problems. First, the Timberline Pine CT was composed of evergreen and deciduous tree species; we therefore created a mixed-leaf phenology map unit, which did not adhere to some of our initial classification guidelines (see above). In addition, some CTs contained species that play different successional roles. For example, the Mountain Deciduous Shrub CT includes Gambel oak, a long-lived, mid-seral species, in addition to other shrubs that show up early in the succession pathway. We did try to limit the number of CTs composed of different seral species because a single map unit was used to represent several different distinct stages in different succession pathways, and we did not want to expand individual CT's definitions beyond the LANDFIRE broad-scale mapping target (Brohman and Bryant 2005; Keane and Rollins, Ch. 3). Finally, some CTs, such as Montane Evergreen Shrubs and Mountain Deciduous Shrub, included species (in these examples, mountain mahogany and Rocky Mountain maple, respectively) that the modelers used so often in Zone 16 succession pathways that they should have been separate CTs.

We arranged the CTs within a hierarchy to address the "scalable" requirement. The hierarchy consists of three coarse mapping levels, a landscape-scale level, and a species-based level (described in table 2). We also tiered the LANDFIRE hierarchical levels to those of other classification systems (table 2). We created the three coarsest levels by aggregating characteristics of the CTs' dominant species, such as leaf type and leaf periodicity. Level 5, the species-based level, allows users to scale down the CTs and link them to other published and unpublished classifications.

The LANDFIRE fuel team found the map units developed for Zone 16 to be useful. Most of the CTs provided sufficient information for describing the fuel and fire characteristics of a site because many of the CTs were based on dominant species with similar growth forms and leaf types. In the cases where dominant species were lumped to form general CTs, such as Warm Season Grasses, the LANDFIRE fuel mapping team found it more difficult to determine the vegetative characteristics. For example, the warm-season perennial grassland contains both fine- and coarse-leaved graminoids. (Keane and others, Ch.12).

We developed a table (appendix 6-C) to relate LANDFIRE CTs to other classification systems. The most closely related SAF, SRM, and western U.S. GAP types are linked to corresponding CTs. Additionally, linkages of LANDFIRE CTs to the NVCS class, subclass, group, and alliance levels are found in appendix 6-D.

Mapping Zone 19: Northern Rockies—The Zone 19 CT map legend consists of 36 CTs (table 3) and includes 14 forest types, 15 shrub types, and seven herbaceous CTs.

Use of existing data (a main design criterion for the LANDFIRE Prototype) that had incomplete species lists or general taxonomic descriptions (for example, "*Pinus*") limited the level of detail that could be extracted from the data for the bottom-up CT classification approach used in Zone 19. Many plots simply did not have enough information to "identify" the CT. For example, one data set, representing approximately one-third of the reference

Table 2—LANDFIRE Zone 16 hierarchical structure and comparison with other classification systems.

Hierarchical level	LANDFIRE cover type classification	FGDC (FGDC 1997)	U.S. National Vegetation Classification System (NVCS) (Grossman and others 1998)	FS Ecosystem Management Coordination Staff (Brohman and Bryant 2003)
Class	Broad-scale map unit classes based on vegetation physiognomy (life form, structure, and canopy cover).	A level in the classification hierarchy defined by the relative percent canopy cover of the tree, shrub, dwarf shrub, herb, and nonvascular life form in the uppermost strata during the peak of the growing season.	Growth form and structure of vegetation (Forest, Woodland, Shrubland, Dwarf-shrubland, Herbaceous, Non-vascular, & Sparse vegetation).	Same definition as FGDC. Classification criteria are based on the following structural attributes: •Tree canopy cover •Shrub height and canopy cover •Herbaceous vs. non-vascular canopy cover
SubClass	Broad-scale map unit classes based on vegetation physiognomy, leaf phenology of woody plants, and leaf type and periodicity of herbaceous plants	Leaf phenology (evergreen, deciduous, mixed evergreen deciduous) and average height of herbaceous stratum (tall, medium, short).	Growth form characteristics, e.g., leaf phenology (e.g., Deciduous Woodland).	Same definition as FGDC. Classification criteria are based on the following structural attributes: •Leaf phenology (e.g., evergreen vs. deciduous) •Gross morphology (e.g., graminoid vs. forb) •Herb periodicity (e.g., annual vs. perennial)
Group	Broad-scale map unit classes formed by grouping cover types on broad leaf morphology.	Combinations of climate, leaf morphology, and leaf phenology.	Leaf types, corresponding to climate (e.g., Cold-deciduous woodland).	Same definition as FGDC. Classification criteria are based on the following structural attributes: •Climatic Regime (e.g., temperate, tropical, subpolar) •Leaf morphology (e.g., extremely xeromorphic) •Leaf phenology (e.g., cold- vs. drought-deciduous) •Presence of a sparse woody layer in grasslands.
Subgroup	N/A – Definition is problematic, particularly in forest plantations of native species (Brohman and others 2003)	A level of the hierarchy that splits Natural/Semi-Natural vegetation types from the Planted/Cultivated vegetation types.	Relative human impact (Natural/Semi-natural, or Cultural).	Same definition as FGDC. Classification criteria are based on the following structural attributes: •Natural/Semi-Natural - Areas dominated by native or established vegetation that has not been cultivated or treated with any annual management or manipulation regime. •Planted/Cultivated - Areas dominated with vegetation that has been planted in its current location by humans and/or is treated with annual tillage, a modified conservation tillage, or other intensive management or manipulation.

Table 2—(Continued)

Hierarchical level	LANDFIRE cover type classification	FGDC (FGDC 1997)	U.S. National Vegetation Classification System (NVCS) (Grossman and others 1998)	FS Ecosystem Management Coordination Staff (Brohman and Bryant 2003)
Formation	N/A – Difficult to apply because the plethora of attributes make many types that are not mutually exclusive, making it impossible to consistently assign plot or associations to formations (Brohman and others 2003).	Ecological groupings of vegetation units; broadly defined environmental and physiognomic factors.	Additional physiognomic and environmental factors, including hydrology (e.g., Temporarily Flooded Cold-deciduous Woodland).	Same definition as FGDC. Classification criteria are based on the following structural attributes: •Elevation zone (e.g., alpine, submontane) •Flooding regime (Cowardin 1979). •Leaf morphology (e.g., xeromorphic) •Tree crown shape (e.g., cylindrical) •Presence of sparse tree layer in shrublands •Leaf phenology and morphology of sparse tree layer in shrublands •Leaf phenology and morphology of sparse woody layer in grasslands •Shrub growth form (e.g., suffruticose, cushion, mat) •Presence of succulents in shrublands •Leaf phenology of shrubs (e.g., facultative-deciduous) •Plant height in herbaceous vegetation •Graminoid rooting habit (e.g., sod-forming vs. bunch)
Cover Type	Mid-level map unit classes that depict the distribution of one to several dominance types that cover a large geographic area. Grouping of dominance types are basedon combinations of factorsrelating to ecology, physiognomy, and succession.	N/A	N/A	N/A
Dominance Type or Dominant Species	Dominant Species or Species groups: A dominant species or a few dominant species that indicate a recurring landscape level (mid-) plant community. It is	N/A	N/A	Dominance Type: A recurring plant community “defined by the dominance of one or more species which are usually the most important ones in the [uppermost] layer of the community, but sometimes of a lower layer of higher coverage.” Dominance types are most simply defined by the single species with the greatest canopy cover in the uppermost stratum.

Table 2—(Continued)

Hierarchical level	LANDFIRE cover type classification	FGDC (FGDC 1997)	U.S. National Vegetation Classification System (NVCS) (Grossman and others 1998)	FS Ecosystem Management Coordination Staff (Brohman and Bryant 2003)
	defined by dominance of one or more plant taxa, which are usually the most important ones in the uppermost layer of the community and are usually determined from the plot data.			
Alliance	N/A – Difficult to delineate for this project as presently defined by FGDC 1997.	A physiognomically uniform group of Associations sharing one or more diagnostic (dominant, differential, indicator, or character) species, which, as a rule, are found in the uppermost stratum of the vegetation.	Dominant/diagnostic species of uppermost or dominant stratum (e.g., Populus deltoids Temporarily Flooded Woodland Alliance).	A group of associations with a characteristic hysiognomy and habitat and which share one or more pdiagnostic species, at least one of which is typically found in the uppermost or dominant stratum of the vegetation.
Association	N/A – Difficult to delineate for this project as presently defined by FGDC 1997.	A physiognomically uniform group of vegetation stands that share one or more diagnostic (dominant, differential, indicator, or character) overstory and understory species.	Additional dominant/ diagnostic species from any strata (e.g., Populus deltoides - [Salix amygdaloides] / Salix exigua Woodland).	A recurring plant community with a characteristic range in species composition, specific diagnostic species, and a defined range in habitat conditions and physiognomy.

Brohman, R. J.; Bryant, L. D. 2003. Existing Vegetation Classification and Mapping Technical Guide - REVIEW DRAFT. USDA Forest Service, Washington Office, Ecosystem Management Coordination Staff. p.

FGDC, ed. [Online]. Available: http://www.fgdc.gov/standards/documents/standards/vegetation/vegclass.pdf. accessed 1997.

Grossman, D. H.; Faber-Langendoen, D.; Weakley, A. S.; Anderson, M.; Bourgeron, P.; Crawford, R.; Goodin, K.; Landaal, S.; Metzler, K.; Patterson, K.; Pyne, M.; Reid, M.; Sneddon, L. 1998. International classification of ecological communities: Terrestrial vegetation of the United States Volume I. The National Vegetation Classification System: development, status, and applications. Arlington VA, USA: The Nature Conservancy. 126 p.

Table 3—Zone 19 cover type legend. The taxonomic groups are not listed because, where an individual group was continuous and had a distinct distribution across the landscape, it was made into a unique cover type and listed under the cover type column.

CT#	Cover type Forest	Subclass	Group		
1201	Cedar	Evergreen	Needleleaf		
1202	Douglas-fir	Evergreen	Needleleaf		
1203	Grand Fir	Evergreen	Needleleaf		
1204	Hemlock	Evergreen	Needleleaf		
1205	Lodgepole Pine	Evergreen	Needleleaf		
1206	Juniper	Evergreen	Needleleaf		
1207	Ponderosa Pine	Evergreen	Needleleaf		
1208	Spruce – Fir	Evergreen	Needleleaf		
1209	Limber Pine	Evergreen	Needleleaf		
1212	White Pine	Evergreen	Needleleaf		
1401	Aspen – Birch	Deciduous	Broadleaf		
1402	Riparian Hardwood	Deciduous	Broadleaf		
1403	Western Larch	Deciduous	Needleleaf		
1801	Timberline Forest	Mixed	Needleleaf		
	Shrub	**Nativity**	**Site modifier**	**Leaf type**	**Height**
2101	Upland Broadleaf Dwarf Shrubland	Native	Upland	Broadleaf	Dwarf
2102	Upland Broadleaf Medium Shrubland	Native	Upland	Broadleaf	Medium
2103	Upland Broadleaf Tall Shrubland	Native	Upland	Broadleaf	Tall
2202	Upland Microphyllous Medium Shrubland	Native	Upland	Microphyllous	Medium
2211	Dwarf Sage	Native	Upland	Microphyllous	Dwarf
2212	Shrubby Cinquefoil	Native	Upland	Microphyllous	Medium
2213	Threetip Sage	Native	Upland	Microphyllous	Medium
2218	Mountain Big Sage	Native	Upland	Microphyllous	Medium
2219	Wyoming – Basin Big Sage	Native	Upland	Microphyllous	Medium
2220	Rabbitbrush	Native	Upland	Microphyllous	Medium
2222	Greasewood	Native	Upland	Microphyllous	Medium
2223	Mountain Mahogany	Native	Upland	Microphyllous	Tall
2300	Upland Needleleaf				
	Shrubland	**Native**	**Upland**	**Needleleaf**	**Medium**
2400	Upland Sclerophyllous Shrubland	Native	Upland	Sclerophyllous	Dwarf
2600	Riparian Broadleaf Shrubland	Native	Riparian	Broadleaf	Tall
	Herbaceous	**Site Modifier**	**Lifeform**	**Growth Form**	**Nativity**
3110	Annual Forb	Upland	Annual Forb	Na	Native
3120	Annual Graminoid	Upland	Annual Gram.	Bunch	Exotic
3130	Perennial Forb	Upland	Perennial Forb		
3141	Perennial Exotic Bunch Graminoid	Upland	Perennial Graminoid	Bunch	
3142	Perennial Native Bunch Graminoid	Upland	Perennial Graminoid	Bunch	
3151	Perennial Exotic Fhizomatous Graminoid	Upland	Perennial Graminoid	Rhizomatous	
3152	Perennial Native Rhizomatous Graminoid	Upland	Perennial Graminoid	Rhizomatous	
3200	Wetland Herbaceous	Riparian	Perennial Gram.	Rhizomatous	Native

plots in Zone 19, had so few species listed that it did not contain sufficient information to classify plots using more than one plant taxa. Usually, the dominant species on the plot was named at the species level, but other taxonomic levels were sometimes used. A generic level (for example, *Purshia*) was used when it was specific enough to identify a CT, and a sub-species level was used sometimes when a species level was not detailed enough to classify the CT, for example, mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*). Most often, however, generic level dominant species were not distinctive enough for LANDFIRE CTs in Zone 19. For example, when *Acer* or *Abies* were described as the dominant species on a plot, they were considered too taxonomically coarse for LANDFIRE map unit purposes and were not used in the classification process.

Many forested plots in Zone 19 were dominated typically by one or two taxa, and the classification of these species into CTs was relatively simple, as was the arrangement of the CTs into a hierarchy. Forest CTs were easily identified from plot data as only two plots of 6,532 forested plots were not classified to a CT. These two plots listed "*Pinus*" as the dominant tree species, which was not sufficient for classification. However, most of the forest plot data listed the full species name, and the dominant species (or group of dominant species) determined the CT. For example, ponderosa pine, Douglas-fir, and lodgepole pine typically form single species-dominated stands that occupy vast areas of the West. In such instances, the CT was simply the dominant species. In other instances, a few dominant species were grouped into a single CT, such as in the case of the Timberline Pine CT. These CTs were grouped into coarser hierarchical levels by leaf type and then leaf phenology. Species mixtures in other areas, such as the Sierra Nevada or the eastern U.S., where many species could potentially define the dominant species on a plot, may require different approaches to classification. The Zone 19 CT hierarchy can be found in table 4.

Shrubs presented unique challenges to the development of the LANDFIRE mapping classification due to the number of taxa, mixes in species composition, and the generally broad ecological amplitude of shrub species. The process of assigning dominant species to shrub plot data was the same as for forested plots; they were assigned according to the single taxa with the highest cover on the plot. Fifty-two of 3,352 plots (1.5%) remained unclassified because the plot data did not describe the species sufficiently. As with forest types, the dominant types were then grouped into taxonomic and physiognomic categories. However, the criteria for assigning the categories to shrub types were different from the criteria used to assign categories to forest types, and the resulting hierarchy had five levels above the dominant species because these different life forms have different criteria by which to group them (table 5).

We considered using the NVCS classification criteria (Grossman and others 1998) for the shrub classification but discovered that certain criteria did not meet LANDFIRE design criteria and guidelines. For example, we chose to exclude the xeromorphic leaf type (adapted to drought) since it is not always distinguishable (from a remote sensing or mapping standpoint) from the microphyllous (small) or sclerophyllous (small and leathery,

Table 4—Zone 19 forest cover type hierarchy structure and definitions.

Levels	Descriptions	Categories/examples
Subclass	Coarse classes based on leaf phenology.	Evergreen, Deciduous, Mixed Evergreen-Deciduous
Group	Classes based general leaf type.	Broadleaf, Needleleaf
Site modifier	Classes based primarily on similar physiognomy, successional ecology, and site characteristics. We also considered the "mappability" of similar vegetation types from other projects and advice given by remote sensing experts.	Ponderosa Pine, Timberline Pine,
Dominant species	A species in the uppermost vegetation layer that indicates a recurring plant community as determined from the plot data.	Douglas-fir

Table 5—Zone 19 shrub cover type hierarchy structure and definitions.

Level	Descriptions	Categories
Nativity	Categories refer to whether the dominant species occurred in North America prior to western settlement or was introduced to North America and is growing naturally in wild areas without cultivation.	Native, Exotic
Site modifier	Cover type level based on site characteristics. Specifically, dominant species may occur in upland and riparian-wetland areas or are obligate riparian-wetland.	Facultative Upland, Riparian
Leaf type	Map units based on leaf type.	Broadleaf, Microphyllous, Needleleaf (scale-leaf), Sclerophyllous, Succulents
Height	Broad, mature height categories of the dominance types.	Dwarf (<1 ft), Medium (1-8 ft) Tall (>8 ft)
Taxonomic group	Grouping of dominant species based on shared taxonomic and morphologic characteristics. The taxonomic level on which the grouping is based may occur at the specific, generic, or family level depending on the taxonomic level of the dominance type. We also considered the “mappability” of similar vegetation types from other projects and advice given by remote sensing experts.	
Dominant species	A species in the uppermost vegetation layer that indicates a recurring plant community as determined from the plot data.	Big sagebrush

drought adapted) leaf types. The terms *evergreen* and *deciduous* were also discarded due to confusion in applying the terms to specific taxa and the fact that two taxa that are similar morphologically may be different in leaf phenology. Distinguishing among drought deciduous shrubs that typically occur in arid environments, cold deciduous shrubs, and evergreen shrubs was problematic because it is difficult to know, based simply on leaf morphology, the phenology of a plant, whether a plant is evergreen or deciduous, and what causes it to drop its leaves.

Herbaceous CTs differed from forest and shrub CTs in the vast number of species within a zone and across the U.S. and because of the introduction and dominance of many exotic species – which made it difficult to use a single species to determine a unique CT. Only 30 of the 731 (4%) herbaceous plots were not classified to a CT. Unlike the forested plots, most of the dominant species were grouped in order to result in a reasonable number of CTs for LANDFIRE mapping purposes. Herbaceous-dominated plots were grouped into CTs based on a small number of criteria that can be consistently applied across the country. The hierarchical categories include site characteristics, growth characteristics, and nativity of the dominant taxa (table 6). The classification does not identify systems such as desert grassland, mixed grass prairie, tall grass prairie, and short grass prairie; however, these types can be delineated using geographic and ecological criteria, if necessary. Descriptions of all the Zone 19 CTs are found in appendix 6-E.

For the prototype effort, we required that any CT generated for Zone 19 must describe a western community at the landscape level; that is, it had to cover at least one percent of the western landscape. The amount of cover defining a landscape-level community may differ in other regions of the U.S. This criterion applied mainly to CTs

Table 6—Zone 19 herbaceous cover type hierarchy structure and definitions.

Levels	Descriptions	Categories
Site modifier	Map unit level based on site characteristics. Specifically, dominant species may occur in upland and riparian-wetland areas or are obligate riparian-wetland.	Upland
Life form	Map unit based on leaf type and periodicity of herbaceous plants	Annual Forb, Perennial Forb, Annual Graminoid, Perennial Graminoid
Growth form	Map unit based on the growing habits of graminiods (not applicable to forbs).	Bunch-forming, Rhizomatous
Nativity	Categories refer to whether the dominant species occurred in North America prior to western settlement or was introduced to North America and is growing naturally in wild areas without cultivation.	Native, Exotic
Dominant species	A species in the uppermost vegetation layer that indicates a recurring plant community as determined from the plot data.	Cheatgrass

that were also dominant species. For example, we could have grouped mountain big sage, rabbitbrush, shrubby cinquefoil, threetip sage, or Wyoming big sagebrush under the Upland Microphyllous Medium Shrublands CT. Instead, we considered these dominant species individually as CTs because of their abundance across the western U.S., their ecological importance, and/or the large total number of plots available within each type in the Zone 19 reference data. However, we grouped bitterbrush, horsebrush, shrubby chenopods, silver sage, and snakeweed into the Upland Microphyllous Medium Shrublands CT because the number of plots classified to the individual dominant species was few, ranging from 10 to 16 plots each.

If a CT was assigned to less than 20 to 30 plots, the CT was either unused or grouped with a similar type, if one existed. For example, only one plot (dominated by *Yucca glauca*) fell within the succulent leaf type. Due to its minor importance and single plot number, succulent was not used as a CT.

The data-driven nature of the bottom-up classification approach was the main strength of the LANDFIRE classification approach used for Zone 19. This approach enabled us to classify all plot data that had detailed species lists. However, there are drawbacks to this data-driven approach. The bottom-up approach is completely dependent upon reference plot data quality and quantity. Cover types that are represented by too few plots within a zone were not mapped because the Landsat-based mapping process requires a minimum number of plots from which to develop training sites (Zhu and others, Ch. 8). Moreover, it was difficult to build a hierarchy with data from a single zone that would encompass all of the CTs that would be encountered across the entire United States and allow for incorporation of new classes as they were identified. Finally, the data driven approach requires that the plot data be available before the classification can begin, which may or may not be realistic.

Modelers (Long and others, Ch. 9) found the 15 shrub types identified in Zone 19 too numerous; as a result, even though they were “model-able,” the number of succession classes found in some of the pathways became inflated. It was our intention that LANDFIRE vegetation modelers would have more choice in determining what scale of CT to use; they could collapse or expand the definition of the CT depending upon their needs. It was a “scalable” system. However, the modelers did not take advantage of the scalability of the CTs primarily because of a misunderstanding surrounding this design. In general, vegetation modelers (Long and others, Ch. 9) found it confusing to use CTs from different hierarchical levels throughout the succession pathway creation.

In addition, the LANDFIRE vegetation mapping team did not want flexibility in regards to which CTs they would map. They requested that we simply give them a

CT legend for Zone 19 and they would attempt to map those types. They determined that a flexible legend would complicate the process greatly. The legend provided was considered "mappable."

As with Zone 16 CTs, the LANDFIRE fuel mapping team found the Zone 19 CTs useful. Use of the bottom-up classification approach, in addition to the fact that many of the classification criteria were based on vegetation characteristics (such as leaf type or growth from), facilitated a clear description of the wildland fuel characteristics for many of the CTs. Some of the graminoid CTs, however, did not adequately distinguish between fine and coarse grass sites, which posed the same problem encountered in Zone 16 with grass fuel models (Keane and others, Ch. 12).

Potential Vegetation Type

We established four hierarchical levels to define the potential vegetation types (PVTs) and assigned indicator species to each PVT. Species within the PVTs in each level share similar site characteristics. Level 1, the top level, designates the life form of the PVT as forest, shrubland, or herbaceous. The CTs that would potentially dominate the site in the absence of disturbance form the next two lower levels of the PVT classification. We named level 2 according to either the CT or the species that was the most shade-tolerant, such as a "Spruce-Fir cover type," or the species or CT with the narrowest ecological amplitude that could occur on a shrub or herbaceous site, such as a "Riparian Shrub cover type." Level 3 was named according to the indicator species on that site or the geographical setting that differentiates fire regimes of the potential dominant vegetation type, an example being "montane." A fourth level was added to discriminate between major seral vegetation types of the PVTs because they represented an even finer resolution with which to identify unique site conditions. Level 4 was named according to the secondary indicator species, CT, or a geographical term such as "north." We identified a PVT by a linking the names in levels 2 through 4 with forward slashes (/). PVTs could also be collapsed back to coarser levels. Finally, a classifier key or sequence table was developed to automate the linkage of plots in the LFRDB to PVT classes using the indicator species (Caratti, Ch. 4).

We calculated the proportions of CTs occurring in each PVT using plot data from the LFRDB. The LANDFIRE vegetation mapping team used this information to limit the number of specific CTs that could possibly occur in each PVT. The probabilities generated from reference plot data form the foundation for evaluating the probability of CTs existing on sites with specific biophysical characteristics. This, in turn, allows a measure of certainty with regard to whether certain CTs can occur in specific areas on the map. Incorporating these probabilities into the LANDFIRE vegetation mapping process distinguishes the LANDFIRE mapping process from other broad-scale vegetation mapping efforts. A hierarchically organized list of the PVTs developed for zones 16 and 19 can be found in tables 7 and 8, respectively. Appendices 6-F and 6-G provide descriptions of the PVTs created for zones 16 and 19, respectively. Additional information on how the PVT classification formed the basis for vegetation modeling may be found in Long and others (Ch. 9).

The LANDFIRE fuel mapping team found that the number of PVT map classes was adequate to represent different site conditions that may influence surface and canopy fuel. The scale of the fire behavior fuel models and fuel loading models was much coarser than that of the PVT classification. To map surface fire behavior fuel models and fuel loading models, the LANDFIRE fuel mapping team used the upper levels of the PVT classification as a stratification to identify unique environmental site conditions. A general description of environmental site conditions was adequate for creating fire behavior fuel maps because few fuel classes exist for the entire United States. However, when mapping the Fuel Characteristic Classification System (FCCS) national fuelbeds, the LANDFIRE fuel mapping team found the levels 2 and 3 PVT classes helpful in determining the crosswalks between PVTs and fuelbeds (Keane and others, Ch. 12; Sandberg and others 2001).

Structural Stage

The structural stages (SS) for Zone 16 were composed of 16 classes based on a matrix of canopy density classes and height classes by life form (table 9). However, as the LANDFIRE vegetation modelers combined the SS units developed for Zone 16 with CT classes to represent seral stages in the succession pathways, they found the two height classes per life form insufficient. This insufficiency became especially evident when the modelers needed to use a mixed CT to represent a broad category of vegetation and had to use multiple seral stages in multiple pathways; however, the modelers had the use of only two height classes with which to describe distinctive seral stages within a CT. To allow more flexibility with regard to illustrating the age and structure of a CT, we needed a better way to describe situations in which the CT was general but potential seral stages were more floristically narrow . In response, for

Table 7—Zone 16 potential vegetation type partitioned by hierarchical level.

PVT#	Level 1	Level 2	Level 3	Level 4
1601	Forest	Spruce – Fir	Blue Spruce	
1602	Forest	Spruce – Fir	Blue Spruce	Lodgepole Pine
1603	Forest	Spruce – Fir	Spruce – Fir	
1604	Forest	Spruce – Fir	Spruce – Fir	Lodgepole Pine
1611	Forest	Grand Fir	White Fir	
1612	Forest	Grand Fir	White Fir	Maple
1621	Forest	Douglas-fir	Timberline Pine	
1622	Forest	Douglas-fir	Douglas-fir	
1623	Forest	Douglas-fir	Lodgepole Pine	
1631	Forest	Timberline Pine		
1632	Forest	Ponderosa Pine		
1633	Forest	Lodgepole Pine		
1634	Forest	Aspen		
1641	Forest	Pinyon – Juniper	Mountain Big Sagebrush	North
1642	Forest	Pinyon – Juniper	Mountain Big Sagebrush	South
1643	Forest	Pinyon – Juniper	Wyoming – Basin Big Sagebrush	North
1644	Forest	Pinyon – Juniper	Wyoming – Basin Big Sagebrush	South
1645	Forest	Pinyon – Juniper	Mountain Mahogany	
1646	Forest	Pinyon – Juniper	Gambel Oak	
1651	Shrubland	Blackbrush		
1652	Shrubland	Salt Desert Shrub		
1653	Herbaceous	Warm Herbaceous		
1661	Shrubland	Dwarf Sagebrush		
1662	Shrubland	Wyoming – Basin Big Sagebrush		
1663	Shrubland	Mountain Big Sagebrush		
1671	Forest	Riparian Hardwood		
1672	Shrubland	Riparian Shrub		
1673	Herbaceous	Wetland Herbaceous		
1680	Herbaceous	Alpine		

Zone 19, the vegetation modelers were consulted and a third height map unit was incorporated for both tree and shrub vegetation types (table 10). As a result, the LANDFIRE vegetation modelers had more groups with which to characterize seral stage, and fewer changes had to be made to rectify the SS map with the PVT and CT maps. For example, a tree SS would be valid for a forest or woodland CT.

The SS threshold breaks deemed adequate for vegetation modeling did not suffice for describing diverse wildland fuel characteristics when applied to fuel maps in zones 16 and 19. Two classes for vegetation cover, while perhaps increasing map accuracy (Vogelman and others, Ch. 13), were not sufficient for the derivation of fuel characteristics. In addition, the height classes were insufficient for portraying surface and canopy fuel. Many fire behavior fuel models require specific structural thresholds that are often different from those used by the LANDFIRE vegetation modelers. For example, whereas a five-meter class was sufficient to represent early seral forest in the succession models (Long and others, Ch. 9), this map unit was not fine enough for use in surface fuel descriptions where surface fuel height ranges only from 0 to 1.8 meters (Keane, Ch. 12).

Recommendations for National Implementation

To apply the LANDFIRE mapping approach across the United States, we recommend that a vegetation working group (VWG) be formed to ensure that the LANDFIRE classification systems meet national classification and mapping standards. The VWG should consist of members of the LANDFIRE technical teams

Table 8—Zone 19 potential vegetation types partitioned by hierarchical levels.

PVT#	Level 1	Level 2	Level 3	Level 4
1902	Forest	Western Redcedar		
1914	Forest	Grand Fir – White Fir		
1920	Forest	Spruce – Fir	Montane	Western Larch
1921	Forest	Spruce – Fir	Montane	Douglas-fir
1922	Forest	Spruce – Fir	Timberline	
1924	Forest	Spruce – Fir	Subalpine	
1930	Forest	Douglas-fir	Ponderosa Pine	Western Larch
1931	Forest	Douglas-fir	Ponderosa Pine	Douglas-fir
1932	Forest	Douglas-fir	Lodgepole Pine	
1934	Forest	Douglas-fir	Timberline Pine	
1936	Forest	Douglas-fir	Douglas-fir	
1940	Forest	Lodgepole Pine		
1942	Forest	Ponderosa Pine		
1944	Forest	Timberline Pine	Limber Pine	
1946	Forest	Timberline Pine	Whitebark Pine	
1950	Forest	Rocky Mountain Juniper		
1952	Forest	Riparian Hardwood		
1960	Shrubland	Riparian Shrub		
1962	Shrubland	Mountain Mahogany		
1964	Shrubland	Dry Shrub		
1965	Shrubland	Dry Shrub	Conifer	
1970	Shrubland	Dwarf Sagebrush Complex		
1971	Shrubland	Dwarf Sagebrush Complex	Conifer	
1972	Shrubland	Mountain Big Sagebrush Complex		
1973	Shrubland	Mountain Big Sagebrush Complex	Conifer	
1974	Shrubland	Threetip Sagebrush		
1975	Shrubland	Threetip Sagebrush	Conifer	
1976	Shrubland	Wyoming – Basin Big Sagebrush Complex		
1977	Shrubland	Wyoming – Basin Big Sagebrush Complex	Conifer	
1980	Herbaceous	Wetland Herbaceous		
1982	Herbaceous	Alpine		
1984	Herbaceous	Fescue Grasslands		
1985	Herbaceous	Fescue Grasslands	Conifer	
1986	Herbaceous	Bluebunch Wheatgrass		
1987	Herbaceous	Bluebunch Wheatgrass	Conifer	

Table 9—Zone 16 structural stage list and descriptions.

SS#	Structural stage name	Structural stage description
11	Low Cover, Low Height Forest	Cover ≤ 40% and Height ≤ 10M
12	High Cover, Low Height Forest	Cover > 40% and Height ≤ 10M
13	High Cover, High Height Forest	Cover > 40% and Height > 10M
14	Low Cover, High Height Forest	Cover ≤ 40% and Height > 10M
21	Low Cover, Low Height Woodland	Cover ≤ 40% and Height ≤ 10M
22	High Cover, Low Height Woodland	Cover > 40% and Height ≤ 10M
23	High Cover, High Height Woodland	Cover > 40% and Height > 10M
24	Low Cover, High Height Woodland	Cover ≤ 40% and Height > 10M
31	Low Cover, Low Height Shrubland	Cover ≤ 40% and Height ≤ 1M
32	High Cover, Low Height Shrubland	Cover > 40% and Height ≤ 1M
33	High Cover, High Height Shrubland	Cover > 40% and Height > 1M
34	Low Cover, High Height Shrubland	Cover ≤ 40% and Height > 1M
51	Low Cover, Low Height Herbaceous	Cover ≤ 40% and Height ≤ 0.24M
52	High Cover, Low Height Herbaceous	Cover > 40% and Height ≤ 0.24M
53	High Cover, High Height Herbaceous	Cover > 40% and Height > 0.24M
54	Low Cover, High Height Herbaceous	Cover ≤ 40% and Height > 0.24M

Table 10—Zone 19 structural stage list and descriptions.

SS#	Structural stage name	Structural stage description
10	Low Cover, Low Height Trees	Trees - Cover ≤ 40% and Height ≤ 5M
11	Low Cover, Low - Mod Height Trees	Trees - Cover ≤ 40% and Height ≤ 10M
12	High Cover, Low - Mod Height Trees	Trees - Cover > 40% and Height ≤ 10M
13	Low Cover, Mod Height Trees	Trees - Cover ≤ 40% and 5M < Height ≤ 10M
14	High Cover, Mod Height Trees	Trees - Cover > 40% and 5M < Height ≤ 10M
15	Low Cover, High Height Trees	Trees - Cover ≤ 40% and Height > 10M
16	High Cover, High Height Trees	Trees - Cover > 40% and Height > 10M
21	Low Cover, Low Height Shrubs	Shrubs - Cover ≤ 40% and Height ≤ 0.24M
22	High Cover, Low Height Shrubs	Shrubs - Cover > 40% and Height ≤ 0.24M
23	Low Cover, Mod Height Shrubs	Shrubs - Cover ≤ 40% and 0.24M < Height ≤ 1M
24	High Cover, Mod Height Shrubs	Shrubs - Cover > 40% and 0.24M < Height ≤ 1M
25	Low Cover, High Height Shrubs	Shrubs - Cover ≤ 40% and Height > 1M
26	High Cover, High Height Shrubs	Shrubs - Cover > 40% and Height > 1M
31	Low Cover, Low Height Herbs	Herbs - Cover ≤ 40% and Height ≤ 0.24M
32	High Cover, Low Height Herbs	Herbs - Cover > 40% and Height ≤ 0.24M
35	Low Cover, High Height Herbs	Herbs - Cover ≤ 40% and Height > 0.24M
36	High Cover, High Height Herbs	Herbs - Cover > 40% and Height > 0.24M

as well as national vegetation classification and mapping experts. An informed and involved VWG could have addressed and alleviated problems encountered during the LANDFIRE Prototype Project. This group should oversee all aspects of the biophysical and vegetation map classification development and work closely with modeling, vegetation mapping, and wildland fuel mapping teams to develop LANDFIRE map legends (ensuring standards are followed) for the nation, descriptions of the classes in these legends, classification keys linking the classes to LFRDB plot data, and cross-walks to existing national vegetation classification systems.

We recommend considering the use of an available national classification system as a starting point for the classification and legend development. New systems have been published since the LANDFIRE Prototype Project map classification effort, such as the vegetation classification developed by NatureServe called “Ecological Systems” (Comer and others 2003), which is an existing vegetation classification that uses biophysical information to classify types.

While the above recommendation seems to be more in concert with the Zone 16 CT classification development approach (a top-down approach initially based on other national classifications), plot data should not be discounted. Its value was illustrated specifically in the Zone 19 CT methodology. Zone 16 CT classes were refined from plot data, whereas Zone 19 CT classes were *developed* using plot data. Although existing reference data do not support Zone 19’s bottom-up approach for the national implementation of LANDFIRE, plot information from the reference database should play a significant role in the creation, improvement, and refinement of the LANDFIRE National’s biophysical and vegetation map units. Map units should be assigned to the plot data, and an analysis of the results should lead to refinements of the classification. In addition, these national CT, PVT, and SS map legends should be completed at the start of the national effort and should then be refined as the national effort moves to individual zones in different regions.

Cover types that have been assigned to plot data (via either approach) form the foundation for the training database that is critical to most of the LANDFIRE products. It is imperative that an adequate amount of reliable reference data be acquired in a timely fashion for CT refinement before the mapping of each new zone is initiated. Cooperative arrangements should be in place at the beginning of the national effort so that the data are available for use within a practical time frame. A plan should also exist for the collection of new data in areas lacking sufficient amounts.

In addition, as CTs are defined for each zone, it is important to ensure that the criteria for distinguishing CTs are applicable across the United States and that the developers of the CT classification apply these criteria in all zones. This will minimize artificial boundaries in the maps resulting from inconsistent classification efforts.

The CT classification should be developed in concert with the PVT and SS classifications. Developers should work together to ensure that all classes are ecologically consistent between classification systems. We recommend that the developers be the same group for all the biophysical and vegetation map classifications. A vegetation working group should be the arbitrator of all LANDFIRE classification systems to ensure consistency. In the LANDFIRE Prototype, the PVT and CT map legends had to be adjusted even after the maps were created because multiple versions of each classification were available and used, resulting in inconsistency between legends. For example, at one point, there was an "Herbaceous" PVT, but there was not an "Herbaceous" CT. These classifications must be consistent from the beginning so that the maps made from them correspond ecologically. In addition, LANDSUMv4 (Pratt and others, Ch. 10) requires that the maps be consistent with the succession pathway models described in Long and others, Ch. 9.

Throughout the development of the LANDFIRE vegetation classifications, we received feedback regarding our use of certain terminology and definitions. We found that the *potential vegetation* concept is not uniformly accepted among vegetation ecologists, especially range scientists. Alternative terminology, such as *potential natural vegetation group* (PNVG), is also not well received by some specialists. For national implementation, we recommend that the term *biophysical setting* (BpS) be used instead of PVT because this term applies to a wide range of environmental conditions in which vegetation occurs and does not imply an assumption of linear succession processes or the integration (or not) of disturbance into the classification system. We also recommend that the term *cover type* (CT) be changed to *existing vegetation* (EV) to more clearly indicate what is being represented.

Another problem that affected the PVT development particularly was the numerous personnel changes throughout the development process. The instability of the personnel resource available to the LANDFIRE Prototype Project resulted in inconsistent and sometimes conflicting approaches and insufficient documentation. For example, some ecologists tended to split biophysical characteristics, whereas others tended to lump them; the PVT classification therefore went through many phases of adjustment and revision. A clearly documented and detailed explanation of the purpose of the PVT classification would help developers understand their objectives, and documented procedures would help developers avoid conflicts in methodologies. Again, the VWG should oversee this effort throughout the implementation of LANDFIRE National to ensure standards are followed as PVTs are classified within and across mapping zones.

As mentioned above, the scalable nature of the PVT classification allowed flexibility in representing PVTs, but this characteristic was not utilized in the prototype effort. By choosing not to employ the scalable nature of the classification (not grouping to broader and thus fewer classes), the LANDFIRE vegetation modelers ended up with succession models that were too numerous and complicated, with over 40 CTs in the succession pathway for many PVTs in both prototype mapping zones (Long and others, Ch. 9). We do not recommend this level of complexity in vegetation modeling for LANDFIRE National. Various levels of the PVT classes could be used to represent different scales and interpretations of potential vegetation. For example, level 1 could be used to represent major environmental settings, as indicated by life form. In another example, level 3 – which differentiates between the historical fire regimes of PVTs – could be used as a link to potential natural vegetation types, which include natural disturbance in their definitions and descriptions. We recommend that vegetation modelers use coarser scale PVTs (and CTs) to simplify the models.

Conclusion

To meet the needs of vegetation and fuel mappers, we developed three ecologically consistent vegetation and biophysical map unit classifications that were identifiable, scaleable, mappable, and model-able. We found that successful implementation of such an endeavor requires detailed knowledge of many vegetation systems and their succession, fuel, and fire dynamics; awareness of differing scientific approaches to vegetation classification; recognition and understanding of the varying user needs; and recognition and understanding of the varying needs relating to different areas of the country. We emphasize the importance of creating a vegetation working group for the implementation of LANDFIRE National or any similar large scale effort. Lastly, centralized coordination and oversight of the development of these map unit classifications is crucial to promote the efficiency, consistency, and high scientific standards required for this type of project.

For further project information, please visit the LANDFIRE website at www.landfire.gov.

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Appendix 6-A—Biophysical and vegetation map classification coding protocol

The purpose of the biophysical and vegetation map classification coding protocol was to create cover type (CT), potential vegetation type (PVT), and structural stage (SS) codes that allowed for informed interpretation of the vegetation map units. In other words, users of the classification would have access to information about the specific CT, PVT, or SS simply by referencing the code definition tables included below.

Cover Type

Zone 16: Central Utah Highlands

The cover type code for Zone 16 is a four-digit, two-level code representing the life form and life form subclass of the cover type. The life form is the first digit (app. 6-A: table 1). Note: Here, life form represents the *existing* vegetation life form, not the potential.

App. 6-A: Table 1—Zone 16 life form (1-digit)

Code	Life form
1	Forest (trees dominate)
2	Woodland (trees dominate)
3	Shrubland (shrubs dominate)
4	Herbaceous (herbs dominate)

The second digit (app. 6-A: tables 2 and 3) is the life form subclass (a delineation of leaf phenology and morphology). The herbaceous life form subclass is different from the shrub and forest subclass because leaf phenology and morphology in woody species (shrubs and trees) are described with different terms than those used for herbaceous or non-woody species. The final two digits represent the dominant species or group of species that indicates that type and are found in table 1 of Long and others, Ch. 6. For example, a cover type code of "3101" indicates that it is a shrub life form, broadleaf evergreen life form subclass, and the dominant species is mountain big sagebrush. A cover type of Warm Season Perennial Grasslands with code 4101 has an herbaceous life form, perennial graminoid life form subclass, and the dominant species group is warm season grasses.

App. 6-A: Table 2—Zone 16 life form subclass (1-digit) (excluding herbaceous)

Code	Life form subclass
1	Broadleaf evergreen
2	Needleleaf evergreen
3	Mixed broadleaf-needleleaf evergreen
4	Broadleaf deciduous
5	Needleleaf deciduous
6	Mixed broadleaf-needleleaf deciduous
7	Broadleaf mixed evergreen-deciduous
8	Needleleaf mixed evergreen-deciduous
9	Mixed broadleaf-needleleaf mixed evergreen-deciduous

App. 6-A: Table 3—Zone 16 herbaceous life form subclass (1-digit)

Code	Life form subclass
1	Perennial graminoids
2	Perennial forbs
3	Perennial mixed graminoids-forbs
4	Annual graminoid
5	Annual forb
6	Annual mixed graminoids-forbs
7	Mixed perennial-annual graminoid
8	Mixed perennial-annual forb
9	Mixed perennial-annual mixed graminoids-forbs

Zone 19: Northern Rockies

In Zone 19, the cover type code is a 4-digit code representing the life form and the hierarchical mapping level of the cover type, which are differentiated by criteria based on this life form. However, in all life forms, the first digit (app. 6-A: table 4) represents the life form of the current or existing vegetation. Note that these life form categories are different from those used in Zone 16.

App. 6-A: Table 4—Zone 19 life form (1-digit)

Code	Life form
1	Forest (trees dominate)
2	Shrubland (shrubs dominate)
3	Herbaceous (herbs dominate)

In the forest life form, the second digit represents the life form subclass (app. 6-A: table 5) and the third and fourth digits represent the dominant species or species groups found within the preceding life form and subclass (see table 3, Long and others, Ch. 6). For example, a forest cover type code of "1402" represents the Riparian Hardwood cover type, where the life form is forest, the life form subclass is broadleaf deciduous, and the dominant species group is riparian hardwoods.

App. 6-A: Table 5—Zone 16 forest life form subclass (1-digit)

Code	Life form subclass
1	Broadleaf evergreen
2	Needleleaf evergreen
3	Mixed broadleaf-needleleaf evergreen
4	Broadleaf deciduous
5	Needleleaf deciduous
6	Mixed broadleaf-needleleaf deciduous
7	Broadleaf mixed evergreen-deciduous
8	Needleleaf mixed evergreen-deciduous
9	Mixed broadleaf-needleleaf mixed evergreen-deciduous

In the shrub life form, the second digit represents the life form subclass (app. 6-A: table 6), which is categorized differently than the forest life form subclass. The third and fourth digits (app. 6-A: table 7) represent either the height class of the cover type (01-03) or the dominant species groups (beginning with 11). For example, a shrub cover type with code "2202" indicates that it is an Upland Microphyllous Medium [Height] Shrubland cover type and a cover type with code 2213 is the Threetip Sage cover type where the life form is shrub, the life form subclass is facultative-upland microphyllous, and the dominant species group is threetip sagebrush.

App. 6-A: Table 6—Zone 16 shrub life form subclass (1-digit)

Code	Life form-subclass
1	Facultative-upland broadleaf
2	Facultative-upland microphyllous
3	Facultative-upland needleleaf
4	Facultative-upland sclerophyllous
5	Facultative-upland succulent
6	Riparian broadleaf

App. 6-A: Table 7—Zone 16 shrub height class (1-digit)

Code	Height class
01	Dwarf
02	Medium
03	Tall

Herbaceous cover types have been coded differently from shrub and forest starting at the second digit, which represents the physiognomy (app. 6-A: table 8), not the life form subclass. The third digit (app. 6-A: table 9) represents the life history and growth form. The final and fourth digit (app. 6-A: table 10) represents the nativity of the cover type. For example, 3142 indicates that the cover type is herbaceous, facultative-upland, perennial bunch graminoid and native. It is called a Perennial Native Bunch Graminoid cover type.

App. 6-A: Table 8—Zone 16 herbaceous life form subclass (1-digit)

Code	Life form subclass
1	Facultative-upland
2	Riparian

App. 6-A: Table 9—Zone 16 life history and growth form (1-digit)

Code	Life history and growth form
1	Annual forb
2	Annual graminoid
3	Perennial forb
4	Perennial bunch gramminoid
5	Perennial rhizomatous gramminoid

App. 6-A: Table 10—Zone 16 herbaceous nativity class (1-digit)

Code	Nativity class
1	Exotic
2	Native

Potential Vegetation Type

The PVT code is a four-digit, two-level code which includes the zone number in the first and second digits and the potentially dominant species or species group in the last two digits (app. 6-A: tables 11 and 12). Exhaustive lists of the codes may be found in tables 7 and 8, Long and others, Ch. 6.

App. 6-A: Table 11—Zone 16 potentially dominant species (2-digit)

Code	Potential species
01-39	Forest-dominated life form
40-49	Woodland-dominated life form
50-69	Upland shrub- or herbaceous-dominated life form (non-alpine)
70-79	Riparian shrub- or herbaceous-dominated life form (non-alpine)
80-89	Alpine herbaceous-dominated life form

App. 6-A: Table 12—Zone 19 potentially dominant species (2-digit)

Code	Potential species
01-59	Tree-dominated life form
60-79	Shrub-dominated life form
80-89	Herbaceous-dominated life form

Structural Stage

The structural stage codes used in the LANDFIRE Prototype Project are quite simple because they are a two digit, two-level numeric code. The first digit is the life form (app. 6-A: tables 13 and 4). The second digit describes the cover and height for all life forms in Zone 16. Appendix 6-A: tables 14 and 15 describe the Zone 19 cover and height classes by life form.

App. 6-A: Table 13—Zone 16 structural stage life form (1-digit)

Code	Life form
1	Forest (trees dominate)
2	Woodland (trees dominate)
3	Shrubland (shrubs dominate)
5	Herbaceous (herbs dominate)

App. 6-A: Table 14—Zone 16 structural stage (1-digit)

Code	Structural stage
1	Low Cover, Low Height
2	High Cover Low Height
3	High Cover, High Height
4	Low Cover, High Height

App. 6-A: Table 15—Zone 19 structural stage (1-digit)

Code	Structural stage
0	Low Cover, Low Height Trees
1	Low Cover, Low Height Shrub and Herbaceous (Low, Moderate Trees)
2	High Cover, Low Height Shrub and Herbaceous (High, Low-Moderate Trees)
3	Low Cover, Moderate Height Trees and Shrubs
4	High Cover, Moderate Height Trees and Shrubs
5	Low Cover, High Height Trees, Shrubs, and Herbaceous
6	High Cover, High Height Trees, Shrubs, and Herbaceous

Appendix 6-B—Cover types for the western U.S.

CT#	Cover type	Description
1401	Riparian Hardwood[a]	Riparian hardwood forests in the western U.S. can be dominated by many species of deciduous trees, including cottonwoods (*Populus spp.*), which are the most wide ranging group. Other riparian hardwoods include green ash (*Fraxinus pennsylvanica*), and American elm (*Ulmus americana*) on the Great Plains; in California, California sycamore (*P. racemosa*), and California walnut (*Juglans californica*); Arizona sycamore (*Platanus wrightii*) in the southwest; netleaf hackberry (*Celtis laevigata* var. *reticulata*) in the southwest, intermountain west and Great Plains; and white alder (*Alnus rhombifolia*) and Oregon ash (*Fraxinus latifolia*) in the Pacific Northwest.
1405	Aspen -- Birch[a]	Extensive areas of upland forests that occur in the West and are dominated by trembling aspen (*Populus tremuloides*), the most widely distributed North American tree species (Burns and Honkala 1990).
1406	Pacific Deciduous Forest [Other Broadleaf]	Pure stands dominated by species such as red alder (*Alnus rubra*) and bigleaf maple (*Acer macrophyllum*) can occur in the Northwest, with red alder ranging from central California to southeast Alaska, and bigleaf maple extending only as far north as southwestern British Columbia. These species can co-occur and are often found in mixtures with other conifers and hardwoods (Minore 1979; Harrington 1990; Minore and Zasada 1990).
1101	Pacific Broadleaf Evergreen Forest [Other Broadleaf Evergreen]	Stands of California bay (*Umbellularia californica*) that are found in California and southwest Oregon (Stein 1990) or stands of tanoak (*Lithocarpus densiflorus*) (Tappeiner, McDonald et al. 1990). Both species commonly occur in mixes with other species.
1501	Larch	Stands dominated by western larch (*Larix occidentalis*) occur in the northern Rockies and east slopes of the Cascades. One of two species of deciduous conifers in the western U.S., western larch is most commonly associated with Douglas-fir, although it can grow with many other species of conifers (Schmidt and Shearer 1990).
1201	Ponderosa Pine[a]	Stands dominated by interior ponderosa pine (*Pinus ponderosa var. scopulorum*) are found in the interior West and Rocky Mountains, and Arizona pine (*Pinus ponderosa var. arizonica*) is found in the Southwestern U.S.
1218	Pacific Ponderosa Pine	Mixes of many coniferous species can dominate forests in middle to lower elevations in the Sierra Nevada Range, with Pacific ponderosa pine (*Pinus ponderosa var. pacifica*) being "the biological thread that holds the phases of this forest together" (Barbour and Minnich 2000). Other species that can dominate a site include sugar pine (*Pinus lambertiana*), incense–cedar (*Calocedrus decurrens*), Jeffrey pine (*Pinus jeffreyi*), white fir, and Douglas-fir (Barbour and Minnich 2000).
1202	Foothill Pines	The California endemics, Coulter pine (*Pinus coulteri*), and knobcone pine (*Pinus attenuata*) of California and Oregon have some or a high degree of cone serotiny in various populations. Where they occur in pure stands, these species occupy a transition zone between chaparral and coniferous forest or woodland at higher elevations (Howard 1992; Cope 1993).
1203	Western White Pine	Seral stands dominated by western white pine occur in the northern Rockies. It is a minor species in other forest communities in this area and occurs in mixed stands in the Pacific Northwest and Sierra Nevadas (Boyd 1980).
1204	Lodgepole Pine[a]	Lodgepole pine has four varieties, two of which are assigned to the lodgepole pine map type: Sierra lodgepole pine (*Pinus contorta var. murrayana*) and Rocky Mountain lodgepole pine (*P. contorta var. latifolia*). Extensive pure stands occur, as well as in association with many other species (Lotan and Critchfield 1990).

Appendix 6-B—(Continued)

CT#	Cover type	Description
1205	Douglas-fir[a]	Douglas-fir can be a dominant in large areas of forest in the West, occurring in pure stands, although frequently with a mix of many other species. Both coast Douglas-fir (*Pseudotsuga menziesii var. menziesii*) and Rocky Mountain Douglas-fir (*P. m. var. glauca*) are included in the Douglas-fir cover type.
1206	Grand Fir -- White Fir[a]	This type consists of stands dominated by grand fir (*Abies grandis*) or Rocky Mountain white-fir (*Abies concolor var. concolor*), a species and a variety of true fir that occur in somewhat similar habitats in the Interior West.
1207	Pacific Silver Fir -- Noble fir	Stands dominated by the conifers, Pacific silver fir (*Abies amabilis*) or noble fir (*Abies procera*), indicate a moist coastal site in the Pacific Northwest. These species often co-occur with other species of conifers, most consistently western hemlock (*Tsuga heterophylla*), and mountain hemlock (*Tsuga mertensiana*) (Franklin 1980).
1219	Red Fir	Red fir (*Abies magnifica and A. magnifica var. shastensis*) is a climax, high elevation species that can occur in pure stands in the Sierra Nevadas, southern Cascades, and Coast Ranges, although it also intergrades with other conifers (Laacke 1990a).
1220	California White Fir	Stands of this type are indicated by California white fir (*Abies concolor var. lowiana*) and occur in forested stands of California and Oregon. It commonly co-occurs in mixture with other conifer species typical of drier sites in the Sierra, Klamath, and Siskiyou Mountains, such as ponderosa pine, red fir, Jeffery pine, sugar pine and Douglas-fir. White fir is commonly a later seral species (Laacke 1990b).
1209	Western Hemlock	Pure or mixed stands dominated by western hemlock (*Tsuga heterophylla*) occur in mild, humid climatic zones of the Pacific Northwest, coastal Alaska, and the northern Rockies. It is a major or minor component of at least 20 different forest types (Packee 1990).
1210	Mountain Hemlock	In cold, snowy, high altitude forests of the Pacific Northwest, coastal Alaska, the Sierra Nevadas, and the northern Rocky Mountains, mountain hemlock (*Tsuga mertensiana*) can be the sole dominant or mixed with other high altitude conifers (Means 1990).
1211	Spruce -- Fir[a]	In the western U.S., the spruce-fir complex is a high elevation or montane forest community dominated by Engelmann spruce (*Picea engelmannii*) and/or subalpine fir (*Abies lasiocarpa*). Other species assigned to this complex include blue spruce (*Picea pungens*), and Brewer's spruce (*Picea breweriana*), a species of the mountains of northwest California and southwest Oregon (Thornburgh (1990b).
1212	Sitka Spruce	Pure stands of Sitka spruce (*Picea sitchensis*) occur in a narrow band along the Pacific coast, from central California to coastal Alaska (Harris 1980), although it is often associated with western hemlock (*Tsuga heterophlla*).
1213	Cedar	Western redcedar (*Thuja plicata*) is the most common western species in this Pacific Northwest type, commonly occurring in moist or wet locations, frequently in association with other moist site conifers (Minore 1990). Alaska cedar (*Chamaecyparis nootkatensis*) can dominate the canopy in Pacific Northwest forests, although it often occurs with many other tree species (Harris, 1990.). Port Orford cedar (*Chamaecyparis lawsoniana*) usually occurs in mixed stands in a small area of coastal southwest Oregon and adjacent northern California (Zobel 1990).

Appendix 6-B—(Continued)

CT#	Cover type	Description
1215	Redwood	Forested stands dominated by redwood (*Sequoia sempervirens*) are found in northern California and extreme southwestern Oregon, occurring in pure stands and in mixtures with other species.
1216	Sequoia	Giant sequoia (*Sequoiadendron giganteum*) occurs in a very limited distribution in the central and southern Sierra Nevada Mountains where it dominates stands where other coniferous species are commonly present.
1217	Cypress	The cypress cover type consists of stands dominated by one of three species of cypress, generally small trees with serotinous cones. Arizona cypress (*Cupressus arizonica*) (Sullivan 1993) sometimes occurs in pure stands or mixed with other species in riparian and some upland habitats of the southwest. MacNab's cypress (*Cupressus macnabiana*) (Esser 1994a) and Sargent's cypress (*Cupressus sargentii*) both occur in California (Esser 1994b), occurring in pure stands or mixed with at least one other conifer species.
1801	Timberline Pines[a]	This type consists of species of pines dominating forests and woodlands at upper and lower timberlines, including the high elevation species foxtail pine (*Pinus balfouriana*) of California, bristlecone pine (*Pinus aristata*), Great Basin bristlecone pine (*Pinus longaeva*), whitebark pine (*Pinus albicaulis*) and limber pine (*Pinus flexilis*), a species that can appear at both upper and lower timberline. Alpine larch (*Larix lyallii*), a deciduous conifer, is also included because it mixes with some of these species in the northern Rockies.
2401	Deciduous Oak	These woodlands are open stands dominated by a species of deciduous oak, including the California endemics, blue oak (*Quercus douglasii*) or California white oak (*Quercus lobata*) (Howard 1992b). These species co-occur at lower elevations (McDonald 1990b) Other species of deciduous oak that may each dominate forest or woodland stands include bur oak (*Quercus macrocarpa*) in the northern plains (Johnson 1990); California black oak (*Quercus kelloggii*), endemic to California (McDonald 1990a); and Oregon white oak (*Quercus garryana*), which ranges from southwestern British Columbia to central California (Stein 1990a).
2101	Evergreen Oak	Evergreen oak woodlands are open stands of generally small stature trees, occurring in the southwest and in California. Coast live oak (*Quercus agrifolia*), Engelmann's oak (*Quercus engelmannii*), and interior live oak (*Quercus wislizenii*) are common California woodland species (Finch and McCleery 1990; Tirmenstein 1989). Canyon live oak (*Quercus chrysolepis*) is a species of evergreen-leaved oak that dominates forest and woodland stands in Oregon, California, and Arizona (Thornburgh 1990a). In the Southwest, these woodlands may be dominated by Emory oak (*Quercus emoryi*) (Pavek 1994a), gray oak (*Quercus grisea*) (Pavek 1994b), Mexican blue oak (*Quercus olongifolia*) (Pavek 1993), or Arizona white oak (*Quercus arizonica*) (Pavek 1994c). Some of these southwestern woodland species can co-occur, as well as grow with conifers (Pavek 1994).
2201	Pinyon -- Juniper[a]	The pinyon-juniper type contains open stands dominated by a species of tree-like juniper and a species of pinyon pine, with the pinyon at least 20% of the total tree cover. Juniper species include alligator juniper (*Juniperus deppeana*), California juniper (*J. californica*), oneseed juniper (*J. monosperma*), Pinchot's juniper (*J. pinchottii*), redberry juniper (*J. coahuilensis*), Rocky Mountain juniper (*J. scopulorum*), Utah juniper (*J. osteosperma*), and western juniper (*J. occidentalis*). Pinyon species can include singleleaf pinyon (*Pinus monophylla*), two-needle pinyon (*Pinus edulis*), Mexican pinyon (*Pinus cembroides*), papershell pinyon (*Pinus remota/cembroides*), and Parry pinyon (*Pinus quadrifolia*).
2202	Juniper[a]	Open stands dominated by juniper, with pinyon less than 20% of the total tree cover, or absent. Juniper species are those listed for pinyon-juniper.

Appendix 6-B—(Continued)

CT#	Cover type	Description
3704	Mountain Deciduous Shrub[a]	These associations of medium to tall deciduous shrubs are usually in mesic upland sites, generally at lower elevations than continuous forest. In the eastern Great Basin, species can include serviceberry (*Amelanchier utahensis*), gambel oak (*Quercus gambelii*), chokecherry (*Prunus virginiana*), and snowberry (*Symphoricarpos oreophilus*).
3402	Riparian Shrub[a]	Riparian zones dominated by tall and medium sized shrubs, with one to several species of willows, occur throughout the West. In the Intermountain West, riparian willows include Bebb willow (*Salix bebbiana*), Booth willow (*S. boothii*), Drummond willow (*S. drummondiana*), coyote willow (*S. exigua*), Geyer willow (*S. geyeriana*), and yellow willow (*S. lutea*) (Welsh et. al. 1987). Thinleaf alder (*Alnus incana*), water birch (*Betula occidentalis*), and golden currant (*Ribes aureum*) are also common in riparian zones.
3403	Exotic Riparian Shrub[a]	Riparian communities can be dominated by pure or hybrid species of tamarisk (*Tamarix* spp.), a complex of hybridizing exotic species.
3101	Mountain Big Sagebrush Complex[a]	Common throughout the Intermountain West, this complex is usually dominated by mountain big sagebrush (*Artemisia tridentata ssp. vaseyana*). Other shrubs of similar ecological requirements that indicate this complex include mountain silver sagebrush (*Artemisia cana ssp. viscidula*), snowfield sagebrush (*Artemisia tridentata ssp. spiciformis*), *A. tridentata var. pauciflora*, Rothrocks's artemisia (*A. rothrockii*), and tall threetip sagebrush (*A. tripartita ssp. tripartita*)(Tart 2003). Occurring at higher elevations and more mesic conditions than the other big sagebrush subspecies, it is usually characterized by the presence of a moderately productive herbaceous understory of both grasses and forbs. No particular herbaceous species are consistently found in this complex.
3102	Wyoming -- Basin Big Sagebrush Complex[a]	Occurring at lower elevation and drier sites than mountain big sagebrush, this complex is usually identified by the pre ence of Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis*), or basin big sagebrush (*A. tridentata ssp. tridentata*). Other shrubs that indicate this complex include plains silver sagebrush (*A. cana ssp. cana*), Bolander silver sagebrush (*A. cana ssp. bolanderi*), and *Artemisia tridentata ssp. xericensis* (Tart 2003). The herbaceous understory is less productive than on mountain big sagebrush sites. No herbaceous species is known consistently occur in this complex.
3103	Dwarf Sagebrush Complex[a]	Communities dominated by any of a group of small sagebrush species, usually with a sparse understory. Species can include black sagebrush (*Artemisia nova*), Rigid (stiff) sagebrush (*A. rigida*), Wyoming threetip sagebrush (A. *tripartita ssp. rupicola*), birdfoot sagebrush (*A.pedatifida*), and three subspecies of low sagebrush (*A. arbuscula ssp. longiloba, A. a. ssp. thermopopola and A. t. ssp. arbuscula*).
3104	Sand Sagebrush[a]	A shrub community common on the Great Plains is that dominated by sand sagebrush (*Artemisa filifolia*).
3105	Blackbrush[a]	This desert shrub community common in the arid Southwest is dominated by almost pure stands of blackbrush (*Coleogyne ramosissima*).
3106	Rabbitbrush[a]	Semi-arid to arid shrub communities are found in the Intermountain West that are dominated by any of several species of rabbitbrush, including rubber rabbitbrush (*Ericameria nauseosa*), Greene rabbitbrush (*Chrysothamnus greenei*), and stickyleaf rabbitbrush (*Chrysothamnus viscidiflorus*).

Appendix 6-B—(Continued)

CT#	Cover type	Description
3107	Chaparral[a]	Chaparral communities have moderate to dense cover of tall, stiffly branched evergreen-leaved shrubs, sometimes dominated by chamise (*Adenostoma fasciculatum*), and often composed of a mix of many shrub species. Other common chaparral species include: hoaryleaf ceanothus (*Ceanothus crassifolius*), buckbrush (*C. cuneatus*), cupleaf ceanothus (*C. greggii*), hairy ceanothus (*C. oliganthus*), whitethorn ceanothus (*Ceanothus cordulatus*), bigberry manzanita (*Arctostaphylos glauca*), Eastwood manzanita (*A. glandulosa*), pointleaf manzanita (*A. patula*), Nuttall's scrub oak (*Quercus dumosa*), and turbinella oak (*Q. turbinella*). This type occurs in occurs in California, Arizona, and southern Utah.
3108	Soft Chaparral	This is a coastal shrub community of central and southern California, occurring on dry, sometimes rocky slopes, dominated by a mix of species with soft, pliable leaves. Diagnostic species include black sage (*Salvia mellifera*), purple sage (*Salvia leucophylla*), white sage (*Salvia apiana*), and coastal sagebrush (*Artemisia californica*).
3301	Other Evergreen Shrubs[a]	These are characteristic, upland, mesic site shrub communities dominated by evergreen-leaved shrubs, such as curleaf mountain-mahogany (*Cercocarpus ledifolius*), littleleaf mountain-mahogany (*Cercocarpus intricatus*), or snowbrush (*Ceanothus velutinus*).
3701	Salt Desert Shrub[a]	This cover type consists of arid shrub communities that occur throughout the West and are dominated by mixes of halophytic (salt tolerant) shrub species, such as shadscale (*Atriplex confertifolia*), iodine bush (*Allenrolfea occidentalis*), black greasewood (*Sarcobatus vermiculatus*) and winterfat (*Krascheninnikovia lanata*) (West and Young 2000).
3702	Desert Shrub[a]	Desert shrub communities occur in arid lands of the Southwest, including the Sonoran and Mojave Deserts, often with a sparse herbaceous understory. Creosotebush (*Larrea tridentata*), and frequently bursage (*Ambrosia dumosa*), often dominate, although many other shrub species can be the dominant. Other species include tarbush (*Flourensia cernua*), paloverde (*Cercidium* spp.), catclaw acacia (*Acacia greggii*), and smoke tree (*Dalea spinosa*).
3703	Dry Deciduous Shrub[a]	Dry sites in the Intermountain West that can support a plant community dominated by deciduous leaved shrubs, including bitterbrush (*Purshia tridentata*), Utah serviceberry (*Amelanchier utahensis*), and true mountain mahogany (*Cercocarpus montanus*).
4101	Warm Season Grasses [a]	These are communities of grasses that grow during late spring and summer in climates where moisture is not limiting at that time of the year and remain green during the hottest part of the summer (C-4 grasses).
4102	Cool Season Grasses [a]	These plant communities are dominated by species of grasses that grow best during cool and moist periods of the year. They green up early in the growing season, cure during the heat of the summer, and can green up in the fall, depending on species characteristics and weather (C-3 grasses).
4201	Native Forbs[a]	These plant communities can be dominated by a high diversity of perennial forb species, usually occurring on mesic to moist sites in the mountains. Many different forb species can indicate this type including mountain bluebell (*Mertensiana ciliata*), northern mule's-ear (*Wyethia amplexicaulis*), nettleleaf giant-hyssop (*Agastache urticifolia*), fernleaf wild lovage (*Ligusticum filicinum*), Sitka valerian (*Valeriana sitchensis*), and Arctic lupine (*Lupinus arcticus ssp. subalpinus*) (Natureserve 2004).
4202	Exotic Forbs[a]	Communities of exotic forbs that can be dominated by weedy species such as spotted knapweed (*Centaurea maculosa*), leafy spurge (*Euphorbia esula*), or St. John's wort (*Hypericum perforatum*).

Appendix 6-B—(Continued)

CT#	Cover type	Description
4301	Wetland Herbaceous[a]	Riparian, wet meadows, and seep communities are dominated by graminoids and forbs and usually have soils that are saturated for at least part of the growing season. Common species of these communities include sedges (e.g. *Carex aquatilis*, *C. nebrascensis* and *C. rostrata*), alkali cordgrass (*Spartina gracilis*), marsh spikerush (*Eleocharis palustris*), and forbs such as primrose monkey-flower (*Mimulus primuloides*) and white marsh-marigold (*Caltha leptosepala*) (Natureserve 2004). Whether a community is considered riparian, wet meadow, or seep depends on the source of its water.
4302	Alpine[a]	These plant communities occur above upper treeline and are dominated by herbaceous species, usually mixes of sedges, grasses, and perennial forbs. Indicator forbs include Ross' avens (*Geum rossii*), white coil-beak lousewort (*Pedicularis contorta*), spreading phlox (*Phlox diffusa*), Colorado blue columbine (*Aquilegia caerulea*), and graminoids include shorthair reedgrass (*Calamagrostis breweri*), and Drummond's rush (*Juncus drummondii*) (Natureserve 2004).
4401	Annual Grasslandsa	Any extensive area of annual grasslands in the western U.S. that are dominated by exotic species, including cheatgrass (Bromus tectorum), and medusahead (Taeniaetherum caput-medusae).

[a]Indicates type was refined with Zone 16 plot data.

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Appendix 6-C—Crosswalk of western LANDFIRE cover types to Gap Analysis Program (GAP), Society of American Foresters (SAF), and Society for Range Management (SRM) cover types (Eyre 1980, Merchant and others 1998, Shiflet 1994)

CT#	(Western U.S.) LANDFIRE cover type	GAP cover type	SRM#	SRM cover type	SAF#	SAF cover type
1401	Riparian Hardwood	Maple	203	Riparian Woodland	222	Black Cottonwood-Willow
					235	Cottonwood-Willow
1405	Aspen -- Birch	Aspen			217	Aspen
		Aspen - Conifer			18	Paper Birch
1406	Pacific Deciduous Forest [Other Broadleaf]				221	Red Alder
1101	Pacific Broadleaf Evergreen Forest [Other Broadleaf Evergreen]	California Bay				
1501	Larch	Western Larch - Douglas-fir	109	Ponderosa Pine-Shrubland	212	Western Larch
1201	Ponderosa Pine	Ponderosa Pine			237	Interior Ponderosa Pine
		Ponderosa Pine/Shrub				
		Ponderosa Pine/Oak - Juniper-Pinyon				
		Ponderosa Pine - Lodgepole Pine				
		Interior Ponderosa Pine				
	Pacific Ponderosa Pine	Jeffrey Pine			247	Jeffrey Pine
		California Foothill Pine			245	Pacific Ponderosa Pine
		Mixed Sugar Pine			244	Pacific Ponderosa Pine-Douglas-fir
					243	Sierra Mixed Conifer
1202	Foothill Pine	California Foothill Pine			248	Knobcone Pine
		Knobcone Pine				
		Monterey Pine				
1203	Western White Pine	Western White Pine			215	Western White Pine
1204	Lodgepole Pine	Lodgepole Pine			218	Lodgepole Pine
		Lodgepole Pine - Douglas-fir				
		Coastal Lodgepole Pine				
		Sierra Lodgepole Pine				
1205	Douglas-fir	Inland Douglas-fir			210	Interior Douglas-fir
		Inland Douglas-fir - Western Red Cedar			230	Douglas-fir-Western Hemlock
		Douglas-fir - Ponderosa Pine - Incense Cedar			229	Pacific Douglas-fir
		Westside Douglas-fir - Western Hemlock			234	Douglas-fir-Tanoak-Pacific Madrone
		Westside Douglas-fir				
		Douglas-fir - Tanoak - Pacific Madrone				
		Douglas-fir - Sugar Pine - Ponderosa Pine				
		Douglas-fir - White Fir - Blue Spruce				
1206	Grand Fir -- White Fir	Grand Fir - Douglas-fir			213	Grand Fir
		White Fir - Douglas-fir			210	Interior Douglas-fir
		White Fir				
		White Fir - Douglas-fir/Shrub				

Appendix 6-C—(Continued)

CT#	LANDFIRE cover type	(Western U.S.) GAP cover type	SRM#	SRM cover type	SAF#	SAF cover type
1207	Pacific Silver Fir – Noble Fir	Pacific Silver Fir			226	Coastal True Fir-Hemlock
1219	Red Fir	Red Fir			207	Red Fir
1220	California White Fir				211	White Fir
1209	Western Hemlock	Westside Western Hemlock - Western Red Cedar			224	Western Hemlock
					225	Western Hemlock-Sitka Spruce
		Inland Western Red Hemlock				
1210	Mountain Hemlock	Subalpine Spruce - Fir - Mountain Hemlock			205	Mountain Hemlock
1211	Spruce – Fir	Subalpine Spruce Fir - Mountain Hemlock			216	Blue Spruce
					206	Engelmann Spruce-Subalpine Fir
1212	Sitka Spruce	Sitka Spruce			223	Sitka Spruce
1213	Cedar	Inland Western Red Cedar - Western Hemlock			231	Port-Orford-Cedar
					228	Western Redcedar
					227	Western Redcedar-Western Hemlock
1215	Redwood	Coastal Redwood			232	Redwood
1216	Sequoia	Giant Sequoia			243	Sierra Mixed Conifer
1217	Cypress	Cypress			240	Arizona Cypress
1801	Timberline Pines	Subalpine Pine			209	Bristlecone Pine
		Limber Pine			256	California Mixed Subalpine
					219	Limber Pine
					208	Whitebark Pine
2401	Deciduous Oak	California Oak	201	Blue Oak Woodland	250	Blue Oak-Foothills Pine
		California Oak - Conifer			246	California Black Oak
		Mixed Oak			233	Oregon White Oak
		Oregon White Oak				
		Oregon White Oak - Conifer				
2101	Evergreen Oak	Madrean Oak	202	Coast Live Oak Woodland	241	Western Live Oak
		California Oak	509	Oak–Juniper Woodland and Mahogany-Oak	249	Canyon Live Oak
					255	California Coast Live Oak
2201	Pinyon – Juniper	Pinyon - Juniper	412	Juniper–Pinyon Woodland	239	Pinyon-Juniper
		Pinyon Juniper	504	Juniper-Pinyon Pine Woodland		
		Madrean Pinyon-Juniper	509	Transition Oak – Juniper Woodland and Mahogany Oak Association		
2202	Juniper		504	Juniper-Pinyon Pine Woodland	239	Pinyon-Juniper
					220	Rocky Mountain Juniper
			412	Juniper–Pinyon Woodland	238	Western Juniper
			107	Western Juniper-Big Sagebrush–Bluebunch Wheatgrass	66	Ashe-Redberry (Pinchot) Juniper

Appendix 6-C—(Continued)

CT#	LANDFIRE cover type	(Western U.S.) GAP cover type	SRM#	SRM cover type	SAF#	SAF cover type
			509	Oak–Juniper Woodland and Mahogany-Oak		
3704	Mountain Deciduous Shrub	Mixed oak	421	Chokecherry-Serviceberry-Rose		
			413	Gambel Oak		
3402	Riparian Shrub	Riparian/Wetland	422	Riparian		
3403	Exotic Riparian Shrub					
3101	Mountain Big Sagebrush Complex	Sagebrush	612	Sagebrush–Grass		
		Sagebrush/Perennial Grass	404	Threetip Sagebrush		
			314	Big Sagebrush–Bluebunch Wheatgrass		
			315	Big Sagebrush–Idaho Fescue		
			316	Big Sagebrush–Rough Fescue		
			402	Mountain Big Sagebrush		
			408	Other Sagebrush Types		
			324	Threetip Sagebrush-Idaho Fescue		
3102	Wyoming -- Basin Big Sagebrush Complex	Sagebrush	401	Basin Big Sagebrush		
		Sagebrush/Perennial Grass	403	Wyoming Big Sagebrush		
			612	Sagebrush–Grass		
			408	Other Sagebrush Types		
			314	Big Sagebrush–Bluebunch Wheatgrass		
3103	Dwarf Sagebrush Complex	Sagebrush	320	Black Sagebrush–Bluebunch Wheatgrass		
		Sagebrush/Perennial Grass	321	Black Sagebrush–Idaho Fescue		
			404	Threetip Sagebrush		
			405	Black Sagebrush		
			406	Low Sagebrush		
			407	Stiff Sagebrush		
3104	Sand Sagebrush		722	Sand Sagebrush-Mixed Prairie		
3105	Blackbrush	Blackbrush	212	Blackbrush		
3106	Rabbitbrush					
3107	Chaparral	California Chaparral	206	Chamise Chaparral		
		Coastal Scrub	208	Ceanothus Mixed Chaparral		
		Coastal Dune Scrub	209	Montane Shrubland		
		Interior Chaparral	207	Scrub Oak Mixed Chaparral		
		Southern Rockies Oak - Manzanita Scrub	503	Arizona Chaparral		
	Soft Chaparral	Coastal sage	205	Coastal Sage Shrub		
3301	Montane Evergreen Shrubs	Mountain Mahogany	415	Curlleaf Mountain Mahogany		
			417	Littleleaf Mountain Mahogany		
			420	Snowbush		
3701	Salt Desert Shrub	Salt Desert Shrub	414	Salt Desert Shrub		
		Shadscale- Mixed Grass - Mixed Scrub	501	Saltbush-Greasewood		
		Hopsage				

Appendix 6-C—(Continued)

CT#	LANDFIRE cover type	(Western U.S.) GAP cover type	SRM#	SRM cover type	SAF#	SAF cover type
		Greasewood				
		Great Basin Saltbush Scrub				
3702	Desert Shrub	Creosote-Bursage	506	Creosotebush-Bursage		
		Mojave Creosotebrush - Yucca	211	Creosotebush Scrub		
		Paloverde - Mixed Cacti - Scrub	508	Creosotebush-Tarbush		
		Catclaw Acacia	507	Palo Verde-Cactus		
		Smoketree				
		Chihuahuan Creosotebush Scrub				
3703	Dry Deciduous Shrub	Bitterbrush	210	Bitterbrush		
		Mixed Oak	317	Bitterbrush-Bluebunch Wheatgrass		
		Mountain Mahogany	318	Bitterbrush-Idaho Fescue		
			319	Bitterbrush-Rough Fescue		
			416	True Mountain Mahogany		
			730	Sand Shinnery Oak		
4101	Warm Season Grasses	Chihuahuan Grassland	502	Grama-Galetta		
		Great Basin Grassland	702	Black Grama-Alkali Sacaton		
		Semidesert Mixed Grass	703	Black Grama-Sideoats Grama		
		Semidesert Tobosa Grass - Scrub	705	Blue Grama-Galetta		
			708	Bluestem-Dropseeed		
4102	Cool Season Grasses	California Native Perennial	302	Bluebunch Wheatgrass-Sandberg Bluegrass		
		Grassland	303	Bluebunch Wheatgrass-Western Wheatgrass		
		Great Basin Grassland	304	Idaho Fescue-Bluebunch Wheatgrass		
			305	Idaho Fescue-Richardson Needlegrass		
			306	Idaho Fescue-Slender Wheatgrass		
			307	Idaho Fescue-Threadleaf Sedge		
			309	Idaho Wheatgrass-Western Wheatgrass		
			614	Crested Wheatgrass		
4201	Native Forbs		409	Tall forb		
4202	Exotic Forbs					
4301	Wetland Herbaceous	Riparian/Wetland	422	Riparian		
		Forest Meadow	216	Montane Wetlands		
		Meadow	217	Wetlands		
4302	Alpine	Alpine/Subalpine Meadows	410	Alpine Rangeland		
			213	Alpine Grassland		
4401	Annual Grasslands		215	Valley Grassland		

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Appendix 6-D—Crosswalk of LANDFIRE cover types to the National Vegetation Classification System (NVCS) hierarchy (Grossman and others 1998)

CT#	Cover type	NVCS class	NVCS subclass	NVCS group
1401	Riparian Hardwood[a]	Forest	Deciduous	Cold-deciduous
1405	Aspen -- Birch[a]	Forest	Deciduous	Cold-deciduous
1406	Pacific Deciduous Forest [Other Broadleaf]	Forest, Woodland	Deciduous	Cold-deciduous woodland
1101	Pacific Broadleaf Evergreen Forest [Other Broadleaf Evergreen]	Forest	Evergreen	Winter-rain broad-leaved evergreen sclerophyllous forest
1501	Larch	Forest	Deciduous	Cold-deciduous
1201	Ponderosa Pine[a]	Forest, Woodland, Herbaceous	Evergreen, Mixed evergreen-deciduous forest, Evergreen woodland, Perennial graminoid	Temperate or subpolar needle-leaved evergreen forest, Temperate or subpolar needle-leaved evergreen woodland, Mixed needle-leaved- evergreen - cold-deciduous forest, Mixed needle-leaved- evergreen - cold-deciduous woodland, Temperate or subpolar grassland with sparse tree layer
1218	Pacific Ponderosa Pine	Forest, Woodland	Evergreen	Temperate or subpolar needle-leaved evergreen forest; Temperate or subpolar needle-leaved evergreen woodland
1202	Foothill Pines	Forest, Woodland	Evergreen	Needle-leaved, Temperate or subpolar needle-leaved-evergreen woodland
1203	Western White Pine	Forest	Evergreen	Temperate or subpolar needle-leaved-evergreen forest
1204	Lodgepole Pine[a]	Forest, Woodland	Evergreen, Mixed evergreen-deciduous	Temperate or subpolar needle-leaved evergreen forest, Temperate or subpolar needle-leaved evergreen woodland, Mixed needle-leaved evergreen - cold-deciduous forest
1205	Douglas-fir[a]	Forest	Evergreen, Mixed evergreen-deciduous	Temperate or subpolar needle-leaved evergreen forest, Mixed needle-leaved evergreen - cold-deciduous forest

Appendix 6-D—(Continued)

CT#	Cover type	NVCS class	NVCS subclass	NVCS group
1206	Grand Fir -- White Fir[a]	Forest	Evergreen, Mixed evergreen-deciduous	Temperate or subpolar needle-leaved evergreen forest, Mixed needle-leaved evergreen - cold-deciduous forest
1207	Pacific Silver Fir -- Noble fir	Forest	Evergreen	Temperate or subpolar needle-leaved evergreen forest
1219	Red Fir	Forest	Evergreen	Temperate or subpolar needle-leaved evergreen forest
1220	California White Fir	Forest	Evergreen	Temperate or subpolar needle-leaved evergreen forest
1209	Western Hemlock	Forest	Evergreen	Temperate or subpolar needle-leaved evergreen forest
1210	Mountain Hemlock	Forest	Evergreen	
1211	Spruce -- Fir[a]	Forest, Woodland	Evergreen, Mixed evergreen-deciduous	Needle-leaved, Temperate or subpolar needle-leaved evergreen forest, Mixed needle-leaved evergreen - cold-deciduous forest
1212	Sitka Spruce	Forest	Evergreen	Temperate or subpolar needle-leaved evergreen forest
1213	Cedar	Forest	Evergreen	Temperate or subpolar needle-leaved evergreen forest
1215	Redwood	Forest	Evergreen	Temperate or subpolar needle-leaved evergreen forest
1216	Sequoia	Forest	Evergreen	Temperate or subpolar needle-leaved evergreen forest
1217	Cypress	Forest, Woodland	Evergreen	Temperate or subpolar needle-leaved evergreen forest, Temperate or subpolar needle-leaved evergreen woodland
1801	Timberline Pine[a]	Forest, Woodland	Evergreen, Mixed evergreen-deciduous forest	Temperate or subpolar needle-leaved evergreen forest, Temperate or subpolar needle-leaved evergreen woodland, Mixed needle-leaved evergreen - cold-deciduous forest

Appendix 6-D—(Continued)

CT#	Cover type	NVCS class	NVCS subclass	NVCS group
2101	Evergreen Oak	Forest, Woodland, Shrubland	Evergreen, Evergreen-deciduous	Broad-leaved evergreen forest,Temperate broadleaf evergreen forest, Temperate broadleaf evergreen woodland, Extremely xeromorphic evergreen woodland, Mixed broad-leaved evergreen cold-deciduous forest, Temperate broad-leaved evergreen shrubland
2401	Deciduous Oak	Forest, Woodland, Shrubland, Herbaceous, Shrubland	Deciduous, Mixed evergreen-deciduous	Cold-deciduous, Mixed needle-leaved-evergreen-cold-deciduous woodland, Temperate or subpolar grassland with a sparse tree layer
2201	Pinyon -- Juniper[a]	Woodland	Evergreen	Temperate or subpolar needle-leaved evergreen
2202	Juniper[a]	Woodland	Evergreen	Temperate or subpolar needle-leaved evergreen
3704	Mountain Deciduous Shrub[a]	Shrubland	Deciduous	Cold-deciduous
3402	Riparian Shrub[a]	Shrubland	Deciduous	Cold-deciduous
3403	Exotic Riparian Shrub[a]	Shrubland	Deciduous	Cold-deciduous
3101	Mountain Big Sagebrush Complex[a]	Shrubland, Dwarf-shrubland, Herbaceous	Evergreen, Perennial graminoid	Microphyllous evergreen, Extremely xeromorphic evergreen, Temperate or subpolar grassland with sparse shrub layer
3102	Wyoming -- Basin Big Sagebrush Complex[a]	Shrubland	Evergreen	Microphyllous evergreen
3103	Dwarf Sagebrush Complex[a]	Shrubland, Herbaceous	Evergreen, Perennial graminoid, Deciduous	Microphyllous evergreen, Temperate or subpolar grassland with a sparse shrub layer, Extremely xeromorphic deciduous shrubland
3104	Sand Sagebrush	Shrubland	Evergreen	Microphyllous Evergreen
3105	Blackbrush[a]	Shrubland	Evergreen	Extremely xeromorphic evergreen shrubland
3106	Rabbitbrush[a]	Shrubland, Herbaceous	Evergreen, Perennial graminoid	Microphyllous evergreen, Temperate or subpolar grassland with a sparse shrub layer
3107	Chaparral[a]	Shrubland	Evergreen	Temperate broadleaf evergreen

Appendix 6-D—(Continued)

CT#	Cover type	NVCS class	NVCS subclass	NVCS group
3108	Soft Chaparral	Shrubland	Evergreen	Temperate broad-leaved evergreen shrubland; Microphyllous evergreen shrubland
3301	Montane Evergreen Shrubs[a]	Shrubland	Evergreen	Microphyllous evergreen, Temperate broadleaf evergreen
3701	Salt Desert Shrub[a]	Shrubland, Dwarf shrubland	Deciduous shrubland, Evergreen dwarf shrubland, Evergreen	Extremely xeromorphic evergreen shrubland, Extremely xeromorphic deciduous shrubland
3702	Desert Shrub[a]	Shrubland	Evergreen shrubland, Deciduous shrubland	Extremely xeromorphic evergreen shrubland, Extremely xeromorphic deciduous shrubland, Drought deciduous shrubland
3703	Dry Deciduous Shrub[a]	Shrubland	Evergreen shrubland, Deciduous	Microphyllous evergreen shrubland, Temperate broadleaf evergreen, Cold-deciduous shrubland
4101	Warm Season Grasses [a]	Herbaceous	Perennial graminoid	Temperate or subpolar grassland
4102	Cool Season Grasses [a]	Herbaceous	Perennial graminoid	Temperate or subpolar grassland
4201	Native Forbs[a]	Herbaceous	Perennial forbs	Forbs
4202	Exotic Forbs[a]	Herbaceous		
4301	Wetland Herbaceous[a]	Herbaceous	Mixed perennial graminoid/forb, Hydromorphic herbs	Mixed Grass/Forbs
4302	Alpine[a]	Herbaceous	Mixed perennial graminoid/forbs	Mixed Grass/Forbs
4401	Annual Grasslands[a]	Herbaceous	Annual herbs	

[a]Refined with Zone 16 plot data.

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Appendix 6-E—Zone 19 cover type legend and descriptions

CT#	Cover type	Description
1201	Cedar	Western redcedar (*Thuja plicata*) is limited to the northwest corner of Zone 19 where it reaches the eastern limit of its distribution. It is the second most shade-tolerant coniferous species in the zone after western hemlock. Cedar commonly occurs in stands with many other conifer species including *Abies grandis, Larix occidentalis, Tsuga heterophylla, Pinus contorta, Pseudotsuga menziesii, Pinus monticola* and *Picea engelmannii*. Understory species may be abundant, and common species include *Oploplanax horridus, Gymnocarpium dryopteris, Tiarella trifoliata* and *Taxus brevifolia.* This is a minor type in the zone and is represented by less than 1 percent of the forested plots in the LFRDB.
1202	Douglas-fir	This is a major type within Zone 19 and across the western U.S., dominated by Douglas-fir (*Pseudotsuga menziezii*) and typically occurring at mid- elevation on a variety of aspects and slopes. This cover type mixes with or may be adjacent to many other cover types across the zone depending on location and local site factors. Common overstory associates include *Pinus contorta, Pinus ponderosa, Larix occidentalis* and *Abies lasiocarpa*. Common understory species vary widely depending on local site factors and stand history but may include *Xerophyllum tenax, Calamagrostis rubescens, Vaccinium membranaceum* and *Symphoricarpos albus*. Cover of Douglas-fir averages 32 percent and ranges from 3 to 90 percent. Thirty-three percent of all forested plots fall into this category and 20 percent of all plots.
1203	Grand Fir	Grand fir (*Abies grandis*) occurs only in the northern half of the zone and west of the continental divide. It commonly occurs in stands with other conifer species including *Pseudotsuga menziesii, Abies lasiocarpa, Thuja plicata, Larix occidentalis* and *Picea engelmannii*. Understory species may be abundant and include *Taxus brevifolia, Acer glabrum, Arnica spp., Linnaea borealis* and *Amelanchier alnifolia*. Cover of grand fir averages 40 percent with a range of 10 to 90 percent. This is a minor type in the zone and is represented by less than 1 percent of the plots in the database.
1204	Hemlock	This cover type, dominated by western hemlock (*Tsuga heterophylla*), is restricted to the northwest corner of the zone and is the most shade-tolerant conifer in the zone. Western hemlock cover averages 51 percent with a range of 30 to 90 percent. Common overstory associates include *Thuja plicata, Abies lasiocarpa, Larix occidentalis, Picea engelmannii, Pseudotsuga menziesii* and *Pinus contorta*. Understory vegetation may be abundant to non-existent depending on the overstory canopy and includes *Xerophyllum tenax, Taxus brevifolia, Amelanchier alnifolia, Acer glabrum,* and *Arnica latifolia*. Western hemlock reaches its eastern range limit within the northwestern portion of the zone and thus is a minor type with only 0.3 percent of forested plots occurring here.
1205	Lodgepole Pine	Lodgepole Pine is a major type within Zone 19, across the middle and northern Rockies and in portions of the Cascades and Sierra Nevadas. It typically occurs in the montane and lower subalpine zones on a variety of aspects and slopes. This cover type commonly mixes with or is adjacent to Douglas-fir and Spruce-fir types and is typically seral to those types. Dominated by lodgepole pine (*Pinus contorta*), common overstory associates include *Pinus ponderosa, Larix occidentalis* and *Abies lasiocarpa*. Common understory species vary widely depending on local site factors and stand history, but may include *Xerophyllum tenax, Calamagrostis rubescens, Vaccinium membranaceum* and *Symphoricarpos albus*. Cover of lodgepole pine averages 35 percent and ranges from 3 to 98 percent. Sixteen percent of all forested plots fall into this category and 20 percent of all plots.
1206	Juniper	Juniper species are wide-ranging though, as cover types, are found primarily east of the divide in Montana or in the very southern part of Zone 19. Communities are usually open and dominated by species including *Juniperus scopulorum* and *Juniperus osteosperma,* with cover averaging 22 percent with a range from 3 to 50 percent. Common associated species include *Artemisia nova, Artemisia tridentata* ssp. *vaseyana, Pseudoroegneria spicata, Festuca idahoensis* and *Koeleria macrantha*. This is a minor woodland type in the zone and only 0.5 percent of forest and woodland plots occur in this type.

Appendix 6-E—(Continued)

CT#	Cover type	Description
1207	Ponderosa Pine	Ponderosa pine (*Pinus ponderosa*) is distributed across large areas of the zone, though it is absent from several areas including the area south of Salmon, ID. As a cover type, it is limited to some of the lowest elevations and driest sites that are occupied by forest and woodland communities in the zone. At higher elevations or on more mesic sites, *Pseudotsuga menziesii* quickly replaces ponderosa pine. *Larix occidentalis* and *Pinus contorta* are other common overstory associates. Understory vegetation may be abundant and common species include *Mahonia repens, Calamagrostis rubescens, Symphoricarpos albus, Arctostaphylos uva-ursi, Spiraea betulifolia, Amelanchier alnifolia* and *Carex geyeri*. Cover of ponderosa pine averages 32 percent and ranges from 5 to 70 percent. Only 2 percent of the forested plots are classified to the cover type.
1208	Spruce -- Fir	Spruce-fir is a widespread cover type throughout Zone 19, dominating at high elevations and often mixing with the Lodgepole Pine, Douglas-fir, and Timberline Pine types. Stands are usually dominated by *Abies lasiocarpa* (subalpine fir) and *Picea engelmannii* (Engelmann spruce). Common overstory associates include *Pinus albicaulis, Pseudotsuga menziesii* and *Pinus contorta.* Understory species commonly occurring in this type include *Vaccinium membranaceum, Xerophyllum tenax, Menziesia ferruginea, Arnica latifolia, Vaccinium scoparium* and *Luzula glabrata*. Approximately 25 percent of forested plots occur in this cover type.
1209	Limber Pine	The distribution of this type, dominated by *Pinus flexilis,* is primarily east of the divide in Montana and in several mountain ranges in the southern portion of the zone. The Limber Pine type occurs at lower elevations where it may co-occur with juniper species and at high elevation timberline sites where it may mix with *Pinus albicaulis*. Common overstory associates are *Pseudotsuga menziesii* and *Juniperus scopulorum*. Common understory species include *Arctostaphylos uva-ursi, Dasiphora floribunda, Pseudoroegneria spicata, Festuca idahoensis, Shepherdia canadensis, Juniperus horizontalis* and *Juniperus communis*. Cover of limber pine averages 13 percent with a range of 3 to 50 percent. Approximately 1 percent of all forested plots occur in this type.
1212	White Pine	This cover type's distribution is primarily to the west of Zone 19, just reaching into the northwest corner of Zone 19 and, as such, is only represented by 3 plots in the LFRDB. It is dominated by *Pinus monticola*, western white pine.
1401	Aspen -- Birch	The Aspen-Birch type is most common east of the Continental Divide, where it ranges from low elevation riparian areas to the montane and lower subalpine zones and is usually dominated by *Populus tremuloides* (trembling aspen). In the northwest portion of Zone 19, however, *Betula papyrifera* (paper birch) as the dominant overstory species is more common than aspen. Understory diversity is high and includes many shrub and herbaceous species, including *Osmorhiza occidentalis, Prunus virginiana, Acer glabrum, Amelanchier alnifolia, Symphoricarpus albus, Calamagrostis rubescens, Angelica arguta* and *Thalictrum occidentale*. Cover of *Populus tremuloides* averages 42 percent with a range of 3 to 90 percent. Aspen-birch is much more common in other zones and in Zone 19 is represented by only 1.5 percent of the forest plots in the LFRDB.
1402	Riparian Hardwood	The widespread Riparian Hardwood cover type has limited coverage because of its restricted habitat requirements. It occupies low elevation riparian areas along major drainages where it often intermingles with the Riparian Broadleaf Shrubland cover type. Stands of riparian hardwoods at higher elevations are usually small and isolated. Only two cottonwood species occur in riparian hardwoods forests in the zone, *Populus angustfolia* (narrowleaf cottonwood), which largely occurs east of the Continental Divide in the eastern and northeastern part of the zone, and *Populus balsamifera* ssp. *trichocarpa* (black cottonwood), which occurs throughout the zone. Other deciduous trees such as *Acer negundo*, and *Salix amygdaloides* also occur in riparian hardwood communities as well as *Pinus ponderosa*, *Picea engelmannii,* and *Populus tremuloides*. Some common understory associated species include *Symphoricarpos albus, Salix spp., Poa pratensis, Acer glabrum* and *Amelanchier alnifolia*. Cover of cottonwood in these communities averages 30 percent with a range of 10 to 60 percent. This is a minor forest type and is represented in the LFRDB by less than 1 percent of the forest plots.

Appendix 6-E—(Continued)

CT#	Cover type	Description
1403	Western Larch	This type occurs in the northern half of the zone, predominantly west of the continental divide. Stands dominated by *Larix occidentalis* typically occur at mid-elevations and frequently mix with Douglas-fir and lodgepole pine types. Larch forests are usually seral to Douglas-fir, grand fir and spruce-fir types. Typical overstory associates are *Pseudotsuga menziesii* and *Pinus contorta*. Understory species are numerous with some of the most commonly occurring species being *Vaccinium membranaceum, Paxistima myrsinites, Rubus parviflorus, Xerophyllum tenax* and *Acer glabrum*. Approximately 4 percent of forested plots occur in this cover type.
1801	Timberline Forest	The Timberline Forest type occurs across the zone and occupies the highest elevations of any of the forested communities. It is generally dominated by *Pinus albicaulis* (whitebark pine) and can include *Larix lyallii* (alpine larch). At lower elevations, Timberline Forests typically mix with the Spruce-Fir cover type, and *Picea engelmannii* and *Abies lasiocarpa* are both common overstory associates. Common understory associated species include *Vaccinium scoparium, Xerophyllum tenax, Luzula glabrata* and *Carex geyeri*. Cover of *Pinus albicaulis* and *Larix lyallii* averages 19 percent and ranges from 3 to 50 percent. Approximately 4 percent of forested plots occur in this cover type.
2101	Upland Broadleaf Dwarf Shrubland	This cover type consists of three main dwarf shrub species, *Vaccinium scoparium*, *Salix artica,* and *Vaccinium caespitosum*. It is found from the upper montane region to the alpine region. In 77 percent of the plots, the dominant species is *Vaccinium scoparium*. The remaining plots are dominated by either *Vaccinium caespitosum* or *Salix arctica*. Both *Vaccinium* species resprout following fire. *Salix arctica* occurs in communities that rarely experience fire. Common associates in Vaccinium communities include *Xerophyllum tenax, Carex geyeri, Vaccinium membranaceum* and *Luzula glabrata*. This is a minor shrub type with approximately 0.5 percent of the total plots falling into this cover type and 1.5 percent of all shrub dominated plots occurring here.
2102	Upland Broadleaf Medium Shrubland	This cover type is dominated by numerous species characterized by medium stature (generally 1 to 8 feet in height) broadleaf shrubs including *Symphocarpus* spp., *Vaccinium membranaceum*, *Menziesia ferruginea*, *Physocarpus malvaceus*, *Spirea betufolia*, *Rubus parviflorus,* and various *Rosa*, *Ribes,* and *Lonicera* species. Common associated species outside of those indicated by the dominant species very widely depending on the dominant species and local site factors. Approximately 8 percent of shrub dominated plots occur in this type.
2103	Upland Broadleaf Tall Shrubland	This cover type consists of several dominant species characterized as tall stature (generally greater than 8 feet in height) broadleaf shrubs. These include *Alnus viridus* ssp. *sinuate*, *Acer glabrum*, *Amelanchier alnifolia*, *Sorbus scopulina,* and several *Prunus* species. Common associated species outside of those indicated by the dominant species include lower stature broadleaf shrubs and a variety of herbaceous species. Approximately 7 percent of shrub dominated plots occur in this type.
2202	Upland Microphyllous Medium Shrubland	This physiognomic grouping is composed of several dominant species characterized as medium stature microphyllous shrubs. These communities are generally on lower elevation arid sites and restricted to the southern portion of the zone. Dominant species include *Atriplex confertifolia*, *Purshia tridentata*, *Artemisia cana*, *Tetradymia canescens*, *Gutierrezia sarothrae,* and *Atriplex canescens*. Common associated species include *Artemisia frigida, Hesperostipa comata and Pseudoroegneria spicata*. These communities become much more common south of Zone 19. This cover type is of minor importance in the zone with approximately 1 percent of shrub dominated plots occurring in this type.
2211	Dwarf Sage	This cover type is dominated by two morphologically similar species, *Artemisia arbuscula* and *Artemisia nova*. Vegetative cover is generally low with only a few commonly occurring shrub and grass species. Common associates include *Pseudoroegneria spicata*, *Artemisia tridentata* ssp. *wyomingensis, Artemisia frigida* and *Heterostipa comata*. Cover of sagebrush average 17 percent with a range of 3 to 50 percent. Occurrence of this cover type in Zone 19 is minor though it is much more abundant in other parts of the western U.S. Very little plot data exists for dwarf sage communities in the zone with 0.1 percent of the total plots falling into this cover type and 0.4 percent of all shrub dominated plots occurring here.

Appendix 6-E—(Continued)

CT#	Cover type	Description
2212	Shrubby Cinquefoil	This cover type occurs at mid to upper elevations between 4,500 ft and 8,500 ft. *Dasiphora floribunda* (shrubby cinquefoil), the dominant species in this type, possesses the ability to resprout following fire depending on fire severity; it is usually killed by high severity fire. Common associated species include *Festuca idahoensis, Koeleria macrantha, Fragaria virginiana, Danthonia intermedia* and *Potentilla gracilis*. Cover of shrubby cinquefoil averages 15 percent with a range of 3 to 40 percent. This is a minor type in the zone with less than 1 percent of shrub dominated plots occurring in this cover type.
2213	Threetip Sage	This is a minor type in southwest Montana and becomes more abundant in the Idaho portion of the zone. *Artemisia tripartita* (threetip sage) is different from other sagebrush types in the zone because of its ability to resprout after fire, though the ability varies among populations. Common associated species include *Chrysothamnus viscidiflorus*, *Gutierrezia sarothrae*, *Pseudoroegneria spicata*. Cover of threetip sage averages 28 percent with a range of 10 to 45 percent. This type is represented by 23 percent of the shrub dominated plots in the zone. An abundance of plot data exists for this type, but it is clustered in a relatively small area of the zone so the amount of plot data over-represents its actual occurrence in the zone.
2218	Mountain Big Sage	Mountain Big Sage cover type (dominated by *Artemisia tridentata* ssp. *vaseyana*) generally occurs at higher elevations than the Wyoming-Basin Big Sage cover type and ranges to the subalpine region. Though present throughout Zone 19, it is most abundant in Idaho and in Montana generally south and east of Missoula. Common associated species include *Festuca idahoensis, Pseudoroegneria spicata, Geranium viscosissimum* and *Lupinus* species. Cover of *Artemisia tridentata* ssp*. vaseyana* averages 29 percent with a range of 3 to 70 percent. This is a major shrub type across the zone with 18 percent of shrub-dominated plots occurring here.
2219	Wyoming -- Basin Big Sage	This is a major shrub type in the southern half of the zone and a landscape dominant across vast areas of the West. Dominant species for this type are *Artemisia tridentata* ssp. *tridentate,* and *Artemisia tridentata* ssp. *wyomingensis*. Other common species include *Agropyron cristatum, Pseudoroegneria spicata, Poa fendleriana, Artemisia frigida, Achnatherum hymenoides, Heterostipa comata, Chrysothamnus viscidiflorus* and *Koeleria macrantha*. This type is represented by 31 percent of the shrub dominated plots in the zone. An abundance of plot data exists for this type but it is clustered in a relatively small area of the zone so the amount of plot data over-represents its actual occurrence in the zone.
2220	Rabbitbrush	This cover type is composed of two species of rabbitbrush within the zone, including *Chrysothamnus viscidiflorus* (yellow rabbitbrush) and *Ericameria nauseosa* (rubber rabbitbrush). It is a minor type in the zone and is usually adjacent to Wyoming-Basin Big Sage, Mountain Big Sage or herbaceous dominated cover types. Rabbitbrush may quickly recolonize a site following fire from sprouts and from seed. Common associated species include *Artemisia frigida, Pseudoroegneria spicata, Festuca idahoensis, Hesperostipa comata, Artemisia tridentata* ssp*. wyomingensis, Artemisia tridentata* ssp*. vaseyana, Poa fendleriana* and *Agropyron cristatum*. Cover of rabbitbrush species averages 8 percent with a range of 3 to 30 percent. Less than 2 percent of shrub-dominated plots occur in this cover type.
2222	Greasewood	*Sarcobatus vermiculatus* is the sole dominant species in this cover type. Though a minor type in Zone 19, it is a common species in other areas of the west with a distribution centered on the Great Basin Floristic Division. Black greasewood communities generally occur below the more moist sagebrush or shadscale zones and in Zone 19 are typically found on old alluvial terraces (Roundy and others 1978). Greasewood commonly grows in pure stands in high saline areas with little or no understory vegetation, but in less saline areas, other shrubs may be common as well as a grass component (McArthur and Plummer 1978). Generally, greasewood communities suffer little damage from fire and fire occurrence is minimal due to a lack of fine fuels. However, greasewood communities invaded by cheatgrass may have an increase in fire occurance. Species diversity is low, but common associates include *Agropyron cristatum, Artemisia frigida* and *Pseudoroegneria spicata*. Cover of greasewood averages 45 percent with a range of 10 to 70 percent. Plot data is almost nonexistent for greasewood communities in the zone and less than 0.1 percent of the total plots fall into this cover type and 0.2 percent of all shrub dominated plots occur here.

Appendix 6-E—(Continued)

CT#	Cover type	Description
2223	Mountain Mahogany	This cover type is restricted to the south half of the zone where it reaches its northerly range limit. Stands of this type typically occur at mid elevations on dry, southerly slopes. *Cercocarpus ledifolius* (mountain mahogany), the dominant species in this type, is usually killed by fire and relies on seed to reoccupy a site though regeneration may be slow (Scheldt and Tisdale 1970). Common associated species include *Festuca idahoensis, Pseudoroegneria spicata, Artemisia tridentata* ssp*. vaseyana* and *Artemisia tridentata* ssp*. wyomingensis*. Mountain mahogany cover averages 40 percent with a range of 4 to 70 percent. This type is relatively minor across the zone though locally abundant in Idaho. Less than 1 percent of shrub dominated plots are classified to this type.
2300	Upland Needleleaf	This physiognomic grouping is composed of dwarf to medium height needle-leaved shrub that typically form small patches in a variety of sites. On lower elevation dry sites, the dominant Shrubland species are *Juniperus communis* and *Juniperus horizontalis*, which account for 85 percent of the plots. These sites typically have sparse fuel. The remaining plots are dominated by *Phyllodoce empetriformis,* which occupies sites within the subalpine to lower alpine zones and are adjacent to or intermingled with subalpine forest types, herbaceous dominated alpine communities, or barren, rocky slopes. This is a very minor shrub type with approximately 0.2 percent of the total plots falling into this cover type and 0.8 percent of all shrub dominated plots occurring here.
2400	Upland Sclerophyllous Shrubland	This physiognomic grouping is composed of dwarf to medium height sclerophyllous-leaved shrubs that typically form small patches mainly within the montane zone. It is comprised of three dwarf shrubs, *Arctostaphylos uva-ursi*, *Paxistima myrsinites,* and *Mahonia repens,* which dominate 72 percent of the plots in this type, and one medium-height shrub species, *Ceanothus velutinus*, on 28 percent of the plots. All species possess the ability to resprout following fire and *Ceanothus velutinus* in particular may recolonize a site after fire from on-site seed sources. This is a minor shrub type with approximately 0.4 percent of the total plots falling into this cover type and 1 percent of all shrub dominated plots occurring here.
2600	Riparian Broadleaf Shrubland	This cover type is composed of native shrub communities dominated mainly by *Alnus incana* or by one of several *Salix* species. This type occupies riparian areas along major drainages. Where it is intermingled with the Riparian Hardwood cover type, the shrubs are usually quite tall and some species may be single-stemmed and tree-like. At lower elevations, these communities usually have a patchy distribution due to flood dynamics and more recently, human disturbances. At higher elevations, communities may occur as narrow stringers along low gradient streams or as broader patches that extend away from streams and into adjacent wet meadows where they often form mosaics with herbaceous-dominated communities. Overall, this is a minor though important landscape component with approximately 0.6 percent of the total plots falling into this cover type and 2 percent of all shrub dominated plots occurring here.
3110	Annual Forb	The Annual Forb cover type includes forbs that are annual or biennial species. This type usually occurs at lower elevation xeric sites across the zone and is composed of mostly naturalized species but also includes species that may be the result of seeding for restoration or forage in the cases of *Melilotus officianalis* or *Triticum aestivum*. Species composition varies widely and includes numerous forbs, natives and exotics, and annual and perennials in various mixtures. Approximately 0.2 percent of the total plots fall into this cover type and 3 percent of all herbaceous dominated plots occur in this cover type when combined with annual graminoid.
3120	Annual Graminoid	*Bromus tectorum* is the dominant species on the zone 19 plots classified to this cover type. This type usually occurs at lower elevation xeric sites across the zone and is composed of mostly naturalized species. Species composition varies widely and includes numerous graminoids, natives, and exotics, and annuals, biennals and perennials in various mixtures. Approximately 0.2 percent of the total plots fall into this cover type.

Appendix 6-E—(Continued)

CT#	Cover type	Description
3130	Perennial Forb	The Perennial Forb cover type consists of communities dominated mainly by native and occasionally exotic forbs. Occurring on xeric to mesic sites and ranging from the lowest elevations in the zone to the alpine region, species composition may vary widely. *Artemisia frigida* is the dominant species on almost 30 percent of the plots, and no other species dominant on more than 5 percent. The vertical structure of this type ranges from tall forbs such as *Chamerion angustifolium* to cushion plants such as *Phlox hoodii*. Approximately 2 percent of the total plots fall into this cover type and 24 percent of all herbaceous dominated plots.
3141	Perennial Exotic Bunch Gramminoid	Fifty-eight percent of the plots in this type are dominated by *Phleum pratense* (timothy). Plots occur on a variety of sites, ranging from low elevation xeric to mesic montane sites. Areas dominated by these grasses may be the result of seeding for restoration or pasture or at least have been subject to moderate to heavy disturbance in the past. Approximately 0.2 percent of the total plots fall into this cover type and 3 percent of all herbaceous dominated plots are classified to this type.
3142	Perennial Native Bunch Gramminoid	This cover type is mainly composed of low to moderate elevation communities dominated by *Festuca idahoensis*, *Festuca altaica,* and *Pseudoroegneria spicata*. These dominant species account for 82 percent of the plot data in this type and are the dominant grassland communities in Zone 19. These plots may occur at any elevation and on xeric to mesic sites. These species usually have a clumped or bunched growth form but may possess short rhizomes in some cases. Approximately 4 percent of the total plots fall into this cover type and 49 percent of all herbaceous dominated plots are classified to this cover type.
3151	Perennial Exotic Rhizomatous Gramminoid	Fifty percent of the plots in this cover type are dominated by *Poa pratensis.* The plots typically occur on low elevation xeric to mesic montane sites. Areas dominated by these grasses may be the result of seeding for restoration or pasture or at least have been subject to moderate to heavy disturbance in the past. Approximately 0.2 percent of the total plots fall into this cover type and 3 percent of all herbaceous dominated plots are classified to this type.
3152	Perennial Native Rhizomatous Gramminoid	*Calamagrostis rubescens* and *Carex geyeri* dominate 80 percent of the plots in this cover type. The remaining plots are dominated by a variety of species. Plots are found in areas ranging from low elevation xeric sites to mesic montane or subalpine sites. This cover type is composed of species that typically have a rhizomatous, stoloniferous, or sod-forming growth form, but may be clumped or bunched in some cases. Approximately 0.4 percent of the total plots fall into this cover type and 5 percent of all herbaceous dominated plots are classified to this cover type.
3200	Wetland Herbaceous	This cover type is dominated by perennial native rhizomatous gramminoids, including *Carex* and *Juncus* species, and several native perennial forb dominated communities would also be classified here. This minor type is scattered across the zone from low to high elevations. Approximately 0.4 percent of the total plots fall into this cover type and 5 percent of all herbaceous dominated plots are classified to this cover type.

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Appendix 6-F—Zone 16 potential vegetation type legend and descriptions

PVT#	Potential vegetation type	Description
1601	Spruce -- Fir / Blue Spruce	This type is dominated by *Picea pungens* along with *Abies lasiocarpa* as the climax species. *Picea engelmannii* may be a co-climax species in some areas. Common associates include *Pseudotsuga menziesii, Abies lasiocarpa, Pinus contorta,* and *Populus tremuloides.* Elevational ranges are generally between 7,600 and 9,000 feet. Sites tend to be relatively dry and generally occur on the warmer portion of the area where Spruce-Fir types are found. Understories are varied with *Juniperus communis* common on many sites. *Berberis repens* and *Carex geyeri* are common along with a wide variety of lesser shrubs and forbs.
1602	Spruce -- Fir / Blue Spruce / Lodgepole Pine	This type is dominated by *Picea pungens* along with *Abies lasiocarpa* as the climax species. *Picea engelmannii* may be a co-climax species in some areas. Common associates include *Pseudotsuga menziesii, Abies lasiocarpa, Pinus contorta,* and *Populus tremuloides.* Elevational ranges are generally between 7,600 and 9,000 feet. Sites tend to be relatively dry and generally occur on the warmer portion of the area where Spruce-Fir types are found. Understories are varied with *Juniperus communis* common on many sites. *Berberis repens* and *Carex geyeri* are common along with a wide variety of lesser shrubs and forbs. This PVT occurs in the northern portion of the zone where *Pinus contorta* occurs as a common seral species.
1603	Spruce -- Fir / Spruce -- Fir	This is a major type found throughout the zone. The major indicators for this type are *Abies lasiocarpa* and/or *Picea engelmannii.* Common associates include *Pseudotsuga menziesii* and *Populus tremuloides. Abies concolor* is locally present. Elevations range from 8,000 feet to above 11,000 feet and sites are cool to cold and moist to moderately dry. Understories are highly variable, ranging from shrub dominated to grasses to forbs. Common species include *Berberis repens, Juniperus communis, Ribes montigenum, Symphoricarpos oreophilus, Pachistima myrsinites, Vaccinium scoparium, Carex geyeri,* and *Arnica spp.*
1604	Spruce -- Fir / Spruce -- Fir / Lodgepole Pine	This is a major type found throughout the zone. The major indicators for this type are *Abies lasiocarpa* and/or *Picea engelmannii.* Common associates include *Pseudotsuga menziesii* and *Populus tremuloides.* This PVT occurs in the northern portion of the zone where *Pinus contorta* occurs as a common seral species. *Abies concolor* is locally present. Elevations range from 8,000 feet to above 11,000 feet and sites are cool to cold and moist to moderately dry. Understories are highly variable ranging from shrub dominated to grasses to forbs. Common species include *Berberis repens, Juniperus communis, Ribes montigenum, Symphoricarpos oreophilus, Pachistima myrsinites, Vaccinium scoparium, Carex geyeri,* and *Arnica spp.*
1611	Grand Fir -- White Fir	This type is represented by *Abies concolor* within the zone. Common associates include *Pseudotsuga menziesii* and *Populus tremuloides. Pinus ponderosa* and lesser amounts of *Pinus flexilis* may be found on the southern portion of the type. Sites range from about 6,200 feet up to 9,600 feet and are usually cool and dry, northerly aspects. Major understory associates include *Symphoricarpos oreophilus, Berberis repens, Juniperus communis,* and *Carex geyeri.*

Appendix 6-F—(Continued)

PVT#	Potential vegetation type	Description
1612	Grand Fir -- White Fir / Maple	This PVT is indiciated by *Acer grandidentatum* and generally occurs in relatively pure stands or interspersed with *Quercus, Artemisia, Pseudotsuge menziezii,* and *Abies concolor* communities and is usually found in canyon bottoms and on portions of side slopes with deep, well developed modal soils. In settings where it is at the edge of its ecological range, it normally occurs more shrublike.
1621	Douglas-fir / Timberline Pine	*Pseudotsuga menziesii,* in conjunction with either *Pinus flexilis* or *Pinus longaeva,* are indicators for this PVT. Other species commonly found include *Pinus ponderosa, Juniperus scopulorum* and *Populus tremuloides.* Minor amounts of *Pinus edulis* may also be encountered. The PVT is generally found on steep southerly aspects where windy conditions are common resulting in very dry sites. Elevations range from 6,500 to 9,000 feet and the site represents the very dry end of *Pseudotsuga menziesii* sites. Understories are usually sparse, shrubby and composed of various mixtures of *Symphoricarpos oreophilus, Juniperus communis, Cercocarpus ledifolius, Pachistima myrsinites, Artemisia spp.,* and *Amelanchier alnifolia*. The type occurs sporadically throughout the zone.
1622	Douglas-fir / Douglas-fir	*Pseudotsuga menziesii* is the sole indicator of this type. *Pinus ponderosa* and *Populus tremuloides* are common associates. *Juniperus scopulorum* may be a minor associate. The type is found on a variety of site conditions ranging in elevation from 5,000 to 9,500 feet. Sites range from warm and dry to cool, moderately moist conditions. Understories are a mixture of shrubs and grasses including *Physocarpus malvaceus, Acer glabrum, Amelanchier alnifolia, Berberis repens, Arnica cordifolia,* and *Carex geyeri.*
1623	Douglas-fir / Lodgepole Pine	This type is indicated by the combination of *Pseudotsuga menziesii* and *Pinus contorta*. While sites may be relatively warm, they represent the cooler portion of the *Pseudotsuga menziesii* environment and vary from moist to dry. Other common species include *Pinus ponderosa* and Populus *tremuloides.* Elevations range from about 5,500 to 7,500 feet. The type is found only in the northern half of the zone. Understories tend to be shrubby and include *Symphoricarpos oreophilus, Berberis repens,* and *Juniperus communis* along with some taller shrubs such as *Amelanchier alnifolia.*
1631	Timberline Pine	*Pinus flexilis* and/or *Pinus longaeva* are the indicators of this type. *Juniperus scopulorum* and minor amounts of *Pseudotsuga menziesii* or *Populus tremuloides* may be present on some sites. Stands are frequently found on very steep south or southwest aspects. Conditions are generally the most adverse for tree growth and the type often represents the lower timberline. Elevations range from 7,000 to 10,200 feet. Understories are shrubby and composed of various mixtures of *Artemisia tridentata, Symphoricarpos oreophilus, Berberis repens, Cercocarpus ledifolius, Pachistima myrsinites,* and *Juniperus communis.*
1632	Ponderosa Pine	*Pinus ponderosa* is the only indicator species for this type. Other trees commonly found are *Juniperus scopulorum* and *Populus tremuloides.* Occasionally *Pinus edulis* and *Juniperus osteosperma* may be found. Sites range in elevation from 6,800 to 9,000 feet. Sites are typically gentle to moderate usually on southerly exposures. Understories are varied and vary from shrubby to grass dominated. Common species include *Amelanchier alnifolia, Artemisia tridentata, Quercus gambelii, Symphoricarpos oreophilus, Carex geyeri, Festuca idahoensis,* and *Sitanion hystrix.*

Appendix 6-F—(Continued)

PVT#	Potential vegetation type	Description
1633	Lodgepole Pine	*Pinus contort,a* in the absence of other shade tolerant conifers, is the sole indicator of this type. *Populus tremuloides* may occupy some sites. The type is found on a variety of landforms, which are mostly warm and droughty although it is also found on seasonally moist sites. Elevations range from about 7,600 to 10,000 feet. Understories are commonly sparse and variable. The most commonly found species include *Juniperus communis, Vaccinium scoparium, Vaccinium caespitosum, Arctostaphylos uva-ursi, Berberis repens,* and *Calamagrostis canadensis.* The type is confined to the northern half of the zone.
1634	Aspen	The PVT is characterized by *Populus tremuloides* that frequently makes up pure stands. The type spans a broad range of environments ranging from high-elevation cool, moist spruce-fir forests to the relatively dry, low-elevation sagebrush steppes. As a result of this wide environmental span, the understory vegetation is highly variable. *Symphoricarpos oreophilus* is a common shrub along with varying amounts of *Berberis repens, Juniperus communis, Rosa woodsii,* and *Amelanchier alnifolia. Bromus carinatus* and E*lymus glaucus* are common grasses and *Geranium viscosissimum, Rudbeckia occidentalis, Lathyrus leucanthus,* and *Lathyrus lanszwertii* are common forbs.
1641	Pinyon -- Juniper / Mountain Big Sagebrush / North	This type is indicated by the presence of *Pinus edulis* and/or *Juniperus osteosperma* in conjuction with *Artemisia tridentata* var. *vaseyana*. Sites are at moderate elevations and occupy the upper reaches of the Pinyon-Juniper PVTs. Slopes may be gradual to steep. This type occurs mostly in the northern part of the zone where pinyon pine is less prevalent.
1642	Pinyon -- Juniper / Mountain Big Sagebrush / South	This type is indicated by the presence of *Pinus edulis* and/or *Juniperus osteosperma* in conjuction with *Artemisia tridentata* var. *vaseyana*. Sites are at moderate elevations and occupy the upper reaches of the Pinyon-Juniper PVTs. Slopes may be gradual to steep. This type occurs mostly in the southern part of the zone where pinyon pine is more prevalent..
1643	Pinyon -- Juniper / Wyoming -- Basin Big Sagebrush / North	This type is indicated by the presence of *Pinus edulis* and/or *Juniperus osteosperma* in conjuction with *Artemisia tridentata* var. *wyomingensis* or var. *tridentata*. Sites are at low to moderate elevations and occupy the lower reaches of the Pinyon-Juniper PVTs. Slopes may be gradual to steep. This PVT commonly intermixes with the Wyoming-Basin Big Sagebrush PVT at the lower end. This type is very common in the northern part of the zone where pinyon pine is less prevalent.
1644	Pinyon -- Juniper / Wyoming -- Basin Big Sagebrush / South	This type is indicated by the presence of *Pinus edulis* and/or *Juniperus osteosperma* in conjuction with *Artemisia tridentata* var. *wyomingensis* or var. *tridentata*. Sites are at low to moderate elevations and occupy the lower reaches of the Pinyon-Juniper PVTs. Slopes may be gradual to steep. This PVT commonly intermixes with the Wyoming-Basin Big Sagebrush PVT at the lower end. This type is very common in the southern part of the zone where pinyon pine is more prevalent.
1645	Pinyon -- Juniper / Mountain Mahogany	*Cercocarpus ledifolius* is the indicator species for this PVT. Sites are typically on mid elevation, steep slopes and are usually interspersed with Pinyon-Juniper, Douglas-fir, or White Fir PVTs. This

Appendix 6-F—(Continued)

PVT#	Potential vegetation type	Description
		type may occur throughout most of the zone. However, it usually occurs in relatively small patches and is of minor importance since most sites that are dominated by *Cercocarpus ledifolius* are probably seral to other PVTs.
1646	Pinyon -- Juniper / Gambel Oak	The indicator for this PVT is *Quercus gambelii*. Sites are typically on mid elevation slopes (5,500 ft. to 7,800 ft.) and are frequently bordered by Pinyon-Juniper PVTs on lower slopes and Douglas-fir or White Fir PVTs on the upper end. This type may occur throughout most of the zone.
1651	Blackbrush	*Coleogyne ramosissima* is the sole indicator species in this PVT. Sites occur in a transition zone between the Mohave and Great Basin Deserts and in the Colorado River Drainage in the southern portion of the zone. The Salt Desert Shrub PVT commonly intermixes with Blackbrush at the lower end of the PVT.
1652	Salt Desert Shrub	These sites are indicated by the presence of various shrub species, mostly in the Chenopodiaceae family. Species representative of this PVT include *Atriplex confertifolia, Atriplex corrugata, Kochia americana, Sarcobatus vermiculatus, Sueda torreyana,* and/or *Artemisia spinescens*. Sites are low elevation and usually occupy basin bottoms that have accumulations of saline or alkaline deposits. Sites may also occur on slopes with fine textured soils derived from formations such as the Mancos Shale and Tropic Shale. Total vegetation cover is usually relatively sparse though may be dense in some communities such as black greasewood.
1653	Warm Herbaceous	This PVT is represented by mid to low elevation grassland types, generally intermixed with Wyoming-Basin Big Sagebrush PVT and the Salt Desert Shrub PVT.
1654	Cool Herbaceous	This PVT is represented by mid to high elevation grassland types, generally intermixed with the Mountain Big Sagebrush PVT and the Alpine PVT.
1661	Dwarf Sagebrush	This PVT includes sites occupied by either *Artemisia nova* or *Artemisia arbuscula*. Sites are harsher than adjacent *Artemisia tridentata* PVT's and typically have shallow soil development. These communities are mostly at low elevations but may occur much higher in limited areas.
1662	Wyoming -- Basin Big Sagebrush	*Artemisia tridentata* var. *wyomingensis* or var. *tridentata* are the indicators of this type. Sites are low elevation and are commonly on flat to gradual slopes. These sites commonly intermix with the Pinyon-Juniper/Wyoming-Basin Big Sagebrush and Mountain Big Sagebrush PVTs on the upper end of the type. On lower elevations, it commonly intermixes with the Dwarf Sagebrush and the Salt Desert Shrub PVTs. This is a dominant PVT thoughout the zone in valley locations.
1663	Mountain Big Sagebrush	*Artemisia tridentata* var. *vaseyana* is the indicator of this type. Sites are at moderate to high elevations and are common on unforested areas on the central plateaus. Slopes may be almost flat to relatively steep. Many other PVTs may border this one depending on elevation, soils and local topographic features.

Appendix 6-F—(Continued)

PVT#	Potential vegetation type	Description
1671	Riparian Hardwood	This PVT is indicated by the presence of broadleaf trees such as *Populus angustifolia* and *Acer negundo.* Varying amounts of *Acer grandidentatum, Betula occidentalis, Populus acuminate,* and *Populus fremontii* are also present. *Juniperus scopulorum* may be present in limited amounts. Sites are usually low elevations along major drainages though they may extend into the mountains as narrow stringers along streams. Understories are highly variable. *Rosa spp.* is the most common shrub along with *Cornus serice. Smilacina stellata* is a common forb and *Poa pratensis* is the major grass.
1672	Riparian Shrub	This type is found adjacent to major drainages throughout the zone. A number of species of *Salix* plus *Alnus incana, Betula occidentalis, Lonicera involucrate, Cornus stolonifera, Ribes lacustre,* and *Rhus aromatica* var. *trilobata* are the major types found in the community.
1673	Wetland Herbaceous	This community is composed of mixtures of wetland forbs and grasses usually found in high mountain basins. Soils are seasonally saturated. Common species include *Calamagrostis canadensis, Streptopus amplexifolius, Senecio triangularis,* and *Equisetum arvense.*
1680	Alpine	These sites include all vegetated areas above treeline. Sites are generally above 11,000 ft. in elevation and occur in the Tushar, Uinta, and Wasatch Mtn Ranges. Grasses, sedges, forbs, and/or dwarf willows may dominate areas.

Appendix 6-G – Zone 19 potential vegetation type legend and descriptions

PVT#	Potential vegetation type	Description
1902	Western Redcedar	This is a small PVT found only in the northwest corner of the zone. Along with *Thuja plicata,* other common tree associates are *Pseudotsuga menziesii, Picea engelmannii, Larix occidentalis, and Tsuga heterophylla* plus lesser amounts of *Pinus monticola, Pinus contorta,* and *Abies grandis.* Sites are typically very moist and warm bottomland or northerly exposures and range in elevation from 2,000 to 5,000 feet. Understories are dominated by a variety of forbs including *Clintonia uniflora* with the shrubs *Menziesia ferruginea* and *Oplopanax horridum* found on some sites. Under dense stand conditions, understories may be very limited.
1914	Grand Fir -- White Fir	This type is represented by *Abies grandis* within the zone. Common associates are *Pseudotsuga menziesii, Picea engelmannii,* and *Pinus contorta*. Minor amounts of *Populus tremuloides* and *Pinus ponderosa* may also be present. In the northwestern portion of the zone, *Larix occidentalis* is a major component and *Pinus monticola* can be found in the extreme northwest corner in minor amounts. It is found on warm, moist sites between 2,500 and 5,500 feet elevation. *Vaccinium spp., Calamagrostis rubescens,* and *Xerophyllum tenax,* along with a wide variety of forbs and shrubs, may be found in a relatively dense understory.
1920	Spruce -- Fir / Montane / Western Larch	This PVT is represented by *Picea engelmannii* and *Abies lasiocarpa. Pseudotsuga menziesii* is a major component along with *Pinus contorta* and in the northwest corner. *Larix occidentalis* may be common. This type represents the lower elevations where *Abies lasiocarpa* is found. Sites are generally moist and cool however they are warm enough to support *Pseudotsuga menziesii*. Elevations range from 4,500 to 6,500 feet. Understories are dominated by *Vaccinium globulare, Xerophyllum tenax,* and *Arnica latifolia* with *Menziesia ferruginea* common on some sites.
1921	Spruce -- Fir / Montane / Douglas-fir	This PVT is represented by *Picea engelmannii* and *Abies lasiocarpa. Pseudotsuga menziesii* is a major component along with *Pinus contorta.* This type represents the lower elevations where *Abies lasiocarpa* is found. Sites are generally moist and cool however they are warm enough to support *Pseudotsuga menziesii*. Elevations range from 4,500 to 6,500 feet. Understories are dominated by *Vaccinium globulare, Xerophyllum tenax,* and *Arnica latifolia,* with *Menziesia ferruginea* common on some sites.
1922	Spruce -- Fir / Timberline	These areas represent the highest elevations of the subalpine area where a closed forest can develop. *Picea engelmannii, Abies lasiocarpa,* and *Pinus albicaulis* are all major species in the PVT, along with lesser amounts of *Pinus contorta.* The PVT is found along the major ridges above 7,000 feet throughout the zone. Understories are dominated by *Vaccinium scoparium* along with *Luzula hitchcockii* and lesser amounts of *Xerophyllum tenax* with *Menziesia ferruginea* on some sites. On some sites, this understory may be very sparse.
1924	Spruce -- Fir / Subalpine	This PVT is found on wet sites above the limits of *Pseudotsuga menziesii. Picea engelmannii* is the major tree species along with *Abies lasiocarpa* and *Pinus contorta.* Minor amounts of *Pinus albicaulis* may also be present. Elevations range from 6,000 to 8,000 feet and stands commonly are adjacent to wet meadows. Understories are mixtures of *Calamagrostis canadensis* and *Vaccinium scoparium* along with *Arnica latifolia* and a variety of other forbs and shrubs.
1930	Douglas-fir / Ponderosa Pine / Western Larch	This type is found on warm, dry sites where *Pseudotsuga menziesii* is the indicated climax; however, while *Pseudotsuga menziesii* may be present, the stand is dominated by fire maintained *Pinus ponderosa*. With the lack of disturbance, *Pseudotsuga menziesii* may eventually dominate the site. Minor amounts of *Larix occidentalis* may be found in the northwestern portion of the zone and pockets of *Pinus contorta* on the cooler, moister sites. Elevations range from about 2,700 to 6,400 feet. Understories are about equally divided between forb or grassy sites and shrub communities with *Calamagrostis rubescens, Pseudoroegneria spicata, Carex geyeri, Balsamorhiza sagittata, Arctostaphylos uva-ursi,* and *Symphoricarpos albus* as major species.

Appendix 6-G—(Continued)

PVT#	Potential vegetation type	Description
1931	Douglas-fir / Ponderosa Pine / Douglas-fir	This type is found on warm, dry sites where *Pseudotsuga menziesii* is the indicated climax; however, while *Pseudotsuga menziesii* may be present, the stand is dominated by fire maintained *Pinus ponderosa*. With the lack of disturbance, *Pseudotsuga menziesii* may eventually dominate the site. Minor amounts of *Pinus contorta* are found on the cooler, moister sites. Elevations range from about 2,700 to 6,400 feet. Understories are about equally divided between forb or grassy sites and shrub communities with *Calamagrostis rubescens, Pseudoroegneria spicata, Carex geyeri, Balsamorhiza sagittata, Arctostaphylos uva-ursi,* and *Symphoricarpos albus* as major species.
1932	Douglas-fir / Lodgepole Pine	This type is indicated by the combination of *Pseudotsuga menziesii* and *Pinus contorta*. Minor amounts of *Larix occidentalis* may be found in the northwestern portion of the zone. The type is found on relatively cold sites at the upper elevations of *Pseudotsuga menziesii* occurrence (4,800 to 7,000 feet). *Calamagrostis rubescens* and *Arnica spp.,* along with some *Linnaea borealis, Vaccinium globulare,* and *Xerophyllum tenax* typically dominate understories.
1934	Douglas-fir / Timberline Pine	This PVT is found on dry sites that are to cold for *Pinus ponderosa. Pseudotsuga menziesii* dominates most sites. East of the Continental Divide it may share dominance with *Pinus flexilis* on dry, wind-exposed slopes. *Juniperus scopulorum* is a minor component in some stands. Sites are typically cool and dry and range from 4,800 to 8,200 feet in elevation. Understory vegetation may be sparse and frequently dominated by bunchgrasses including *Pseudoroegneria spicata* and *Festuca idahoensis* or scattered forbs. Shrubs such as *Artemisia spp.* and *Juniperus communis* may be common on some sites.
1936	Douglas-fir / Douglas-fir	*Pseudotsuga menziesii* is the sole indicator of this type. Minor amounts of *Pinus contorta* may be present and occasionally *Larix occidentalis* or *Pinus ponderosa*. Sites are normally at the moist, cool end for *Pseudotsuga menziesii* and located on benches or north slopes ranging from 2,500 feet to about 6,000 feet. A minor amount may be found at elevations up to 6,700 ft. on southerly aspects. Shrubby understories composed of *Physocarpus malvaceus, Symphoricarpos albus,* and *Linnaea borealis* are common along with *Calamagrostis rubescens, Carex geyeri* ,and *Arnica cordifolia*.
1940	Lodgepole Pine	*Pinus contorta* is the only indicator of this fire maintained type. During long fire free periods, *Picea engelmannii* and *Abies lasiocarpa* will generally become abundant. Minor amounts of *Pseudotsuga menziesii* may also be present. Stands are typically found between 6,000 to 7,200 feet on cool to cold sites with moderate moisture. Understories composed of the low shrubs *Vaccinium scoparium; Vaccinium caespitosum,* and *Linnaea borealis* are common along with *Calamagrostis rubescens* and *Carex geyeri.*
1942	Ponderosa Pine	*Pinus ponderosa* is the only indicator species for this type. The only other conifer commonly represented is *Juniperus scopulorum. Pinus flexilis* may be found on some sites as an accidental. Sites range in elevation from the lower timberline, which is from about 2,600 feet, up to 5,000 feet in warm, dry environments associated with the larger valleys in the zone. Isolated stands may be found at higher elevations on steep southerly slopes. Understories are usually open and dominated by bunchgrasses including *Pseudoroegneria spicata, Festuca idahoensis,* and *Festuca scabrella.* Shrubs such as *Symphoricarpos albus, Amelanchier alnifolia, and Purshia tridentata* are common on some sites.
1944	Timberline Pine / Limber Pine	This PVT represents the lower elevation timberline where conditions become too dry to support tree growth. *Pinus flexilis* is the major overstory species along with some *Juniperus scopulorum* and scattered *Pseudotsuga menziesii*. Sites are generally marginal for tree growth and trees are short and open-grown. The type is generally confined to the east side of the Continental Divide between 4,000 and 8,000 feet. Lower elevation sites are dominated by *Pseudoroegneria spicata* while the higher elevations tend to be dominated by *Juniperus communis*. *Artemisia spp.* may be common on some sites.

Appendix 6-G—(Continued)

PVT#	Potential vegetation type	Description
1946	Timberline Pine / Whitebark Pine	This PVT is characterized by stands that are open and wind stunted. *Pinus albicaulis* is the principle species along with varying amounts of *Picea engelmannii*. *Abies lasiocarpa* may be present but normally very stunted and growing in the protection of the other two species. Site conditions are cold and dry and stands are usually found above about 7,800 feet. Understories may be depauperate and composed of a mixture of *Vaccinium scoparium, Juniperus communis, Phyllodoce glanduliflora* or *empetriformis, Festuca idahoensis,* and *Luzula hitchcockii.*
1950	Rocky Mountain Juniper	*Juniperus scopulorum* is the main indicator species in this PVT, although *Juniperus osteosperma* may also indicate this type. The Rocky Mountain Juniper PVT may be wide-ranging found on both sides of the divide in Montana. Communities are usually open with *Juniperus* cover averaging around 25 percent. Common associated species include: *Artemisia nova, Artemisia tridentata* ssp. *vaseyana, Pseudoroegneria spicata, Festuca idahoensis* ,and *Koeleria macrantha*. This is a minor woodland type in the zone.
1952	Riparian Hardwood	This is the only PVT where broadleaf trees are the major component. It is limited to the riparian area along the major rivers in the zone and dominated by *Populus trichocarpa* and some *Populus tremuloides.* Minor amounts of *Pinus ponderosa, Pseudotsuga menziesii,* and *Pinus contorta* may also be present. This type generally represents the lowest elevations in the zone and is rarely found outside of the major river valleys. Understories appear to be highly variable with *Cornus stolonifera, Rosa spp., Salix spp.,* and *Juniperus spp.* common with a wide variety of forbs and grasses also present.
1960	Riparian Shrub	This type is found adjacent to major drainages throughout the zone. A number of species of *Salix* plus *Alnus incana, Betula occidentalis, Lonicera involucrate, Cornus stolonifera, Ribes lacustre,* and *Rhus aromatica var trilobata* are the major types found in the community.
1962	Mountain Mahogany	*Cercocarpus ledifolius* is the indicator species for this PVT. Sites are typically on mid elevation, steep slopes and are usually interspersed with Rocky Mountain Juniper and Douglas-fir PVTs. This type may occur throughout most of the zone. However, it usually occurs in relatively small patches.
1964	Dry Shrub	*Dasiphora floribunda* is an indicator of this PVT on moderately moist Montana grassland and shrub foothill communities east of the Continental Divide. This is a productive mountain shrub type found under relatively mesic to dry site conditions with limited occurrence in the zone. It occurs at mid to upper elevations between 4,500 ft and 8,500 ft.
1965	Dry Shrub / Conifer	*Dasiphora floribunda* is an indicator of this PVT on moderately moist Montana grassland and shrub foothill communities east of the Continental Divide usually along with *Pseudotsuga menziesii,* which indicate conifer encroachment in this PVT. This is a productive mountain shrub type found under relatively mesic to dry site conditions with limited occurrence in the zone. It occurs at mid to upper elevations between 4,500 ft and 8,500 ft. This PVT has a conifer encroachment succession pathway.
1970	Dwarf Sagebrush Complex	This PVT is associated with nearly pure stands or mixtures of “low sagebrush” species. The indicator species are *Artemisia arbuscula* and *A. nova* and are usually associated with areas having little soil profile development in desert valleys and on west and south exposures along the lower slopes of the high desert foothills. It occurs most abundantly at elevations between 4,900 to 7,000 feet where annual precipitation ranges between 7 and 18 inches.

Appendix 6-G—(Continued)

PVT#	Potential vegetation type	Description
1971	Dwarf Sage Complex / Conifer	This PVT is associated with nearly pure stands or mixtures of “low sagebrush” species and possible conifer encroachment. The indicator of this type are *Artemisia arbuscula* and *A. nova* and are usually associated with areas having little soil profile development in desert valleys and on west and south exposures along the lower slopes of the high desert foothills. It occurs most abundantly at elevations between 4,900 to 7,000 feet where annual precipitation ranges between 7 and 18 inches. This PVT has a conifer encroachment succession pathway.
1972	Mountain Big Sagebrush Complex	*Artemisia tridentata* ssp*. vaseyana* is a major indicator species of this PVT in the zone. It is one of the more productive grassland sites. Mountain Big Sagebrush PVT extends from generally above Wyoming Big Sagebrush to forest edges and at times borders the subalpine area. Though present throughout the zone, it is most abundant in Idaho and in Montana generally south and east of Missoula.
1973	Mountain Big Sagebrush Complex / Conifer	*Artemisia tridentata* ssp*. vaseyana* is a major indicator species of this PVT in the zone along with conifer encroachment. It is one of the more productive grassland sites. Mountain Big Sagebrush PVT extends from generally above Wyoming Big Sagebrush to forest edges and at times borders the subalpine area. Though present throughout the zone, it is most abundant in Idaho and in Montana generally south and east of Missoula. This PVT has a conifer encroachment succession pathway.
1974	Threetip Sagebrush	*Artemisia tripartita* is the indicator of this PVT. It is a minor type in southwest Montana but becomes more abundant in the Idaho portion of the zone. It generally occurs on gentle, alluvial slopes or benches with moderately deep soils. This species is set apart by other sagebrush types in the zone by its ability to resprout after fire.
1975	Threetip Sagebrush / Conifer	The Threetip Sagebrush is the indicator of this PVT. It is a minor type in southwest Montana, but becomes more abundant in the Idaho portion of the zone. It generally occurs on gentle, alluvial slopes or benches with moderately deep soils. This species is set apart by other sagebrush types in the zone by its ability to resprout after fire. . This PVT has a conifer encroachment succession pathway.
1976	Wyoming -- Basin Big Sagebrush	The Wyoming-Basin Big Sagebrush PVT is a major type in the southern half of the zone. Both *Artemisia tridentata* ssp*. tridentata* and *Artemisia tridentata* ssp*. wyomingensis* are represented in this PVT.
1977	Wyoming -- Basin Big Sagebrush / Conifer	The Wyoming-Basin Big Sagebrush PVT is a major shrub type in the southern half of the zone. Both *Artemisia tridentata* ssp*. tridentata* and *Artemisia tridentata* ssp*. wyomingensis* are represented in this PVT. This PVT has a conifer encroachment succession pathway.
1980	Wetland Herbaceous	This type is confined to riparian stream areas and high mountain basins. Soils are seasonally saturated. Common species include *Calamagrostis canadensis, Streptopus amplexifolius, Senecio triangularis,* and *Equisetum arvense.*
1982	Alpine	These sites include all vegetated areas above treeline. Sites are generally above 9000 ft. in elevation and occur in small patches in various mountain ranges throughout the zone. Grasses, sedges, forbs, and/or dwarf willows may dominate areas.
1984	Fescue Grasslands	The Fescue Grassland PVT is indicated by *Festuca idahoensis* and *Festuca altaica*. *Pseudoroegneria spicata* is another major component as are a number of other cool season grasses depending on soil and moisture conditions. In general, this PVT occurs at low to moderate elevations.
1985	Fescue Grasslands / Conifer	The Fescue Grassland PVT is indicated by *Festuca idahoensis* and *Festuca altaica*. *Pseudoroegneria spicata* is another major component as are a number of other cool season grasses depending on soil and moisture conditions. In general, this PVT occurs at low to moderate elevations. This PVT has a conifer encroachment succession pathway.

Appendix 6-G—(Continued)

PVT#	Potential vegetation type	Description
1986	Bluebunch Wheatgrass	The Bluebuch Wheatgrass PVT is represented by grassland communities including *Pseudoroegneria spicata*/*Bouteloua gracilis*, *Pseudoroegneria spicata*/*Pascopyrum smithii,* and *Pseudoroegneria spicata*/*Poa secunda* along with *Festuca altaica*/*Pseudoroegneria spicata*. It is generally found east of the continental divide on toe-slopes of the foothills and steeper slopes and primarily occurs on southern slopes.
1987	Bluebunch Wheatgrass / Conifer	The Bluebuch Wheatgrass PVT is represented by grassland communities including *Pseudoroegneria spicata*/*Bouteloua gracilis*, *Pseudoroegneria spicata*/*Pascopyrum smithii,* and *Pseudoroegneria spicata*/*Poa secunda* along with *Festuca altaica*/*Pseudoroegneria spicata*. It is generally found east of the continental divide on toe-slopes of the foothills and steeper slopes and primarily occurs on southern slopes. This PVT has a conifer encroachment succession pathway.