United States Department of Agriculture

Forest Service
Intermountain Region

DIXIE NATIONAL FOREST

MID-LEVEL EXISTING VEGETATION CLASSIFICATION AND MAPPING

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DIXIE
NATIONAL FOREST

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Executive Summary

Existing vegetation classification, mapping, and quantitative inventory (VCMQ) products for the Dixie National Forest (DNF) were developed to help better understand the spatial distributions of vegetation types, structural classes, and canopy cover. These products were developed collaboratively with the DNF, the Geospatial Technology and Applications Center (GTAC) (formerly known as the Remote Sensing Application Center (RSAC)), the Intermountain Regional Office (RO), and the Interior West Forest Inventory and Analysis (IWFIA) program. The final maps align with the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015). The vegetation maps comprise 32 vegetation type map units, eight canopy cover classes for trees and shrubs, and eight tree size classes for forest and woodland types. An accuracy assessment was completed to help users quantify the reliability of the map products and support management decisions that use this information. The existing vegetation products discussed in this document will help users to better understand the extent and distribution of vegetation characteristics for mid-level planning purposes, and disclose the methods and accuracies of these products. The DNF mid-level existing vegetation project is one among many VCMQ Forest projects currently being completed in the Intermountain Region.

Introduction

Existing vegetation classification, inventory, and mapping was completed on almost 2 million acres of the Dixie National Forest (DNF) in Utah to standards established by the Intermountain Region Vegetation Classification, Mapping, and Quantitative Inventory (VCMQ) team and outlined in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015). The purpose of the project was to provide up-to-date and more complete information about vegetative communities, structure, and patterns across the DNF landscape. Fulfilling this purpose is important in measuring compliance with National Forest Management Act (NFMA) obligations, such as providing for a diversity of vegetation and associated habitat for terrestrial wildlife species.

Some resource management applications of the existing vegetation products may include ecosystem and wildlife habitat assessments, rangeland and watershed assessments, fuel load assessments, benchmark analysis, range allotment management plan updates, threatened and endangered species modeling, and recreation management. This document provides an overview of the methods, products, and results of classification, inventory, mapping, and accuracy assessment activities that were completed for the DNF.

Region 4 VCMQ Objectives

The Intermountain Region (Region 4) has identified the development of vegetation map products and associated inventory and classification work as one of its highest priorities since 2008. The goal of this effort has been to facilitate sustaining or restoring the integrity, biodiversity, and productivity of ecosystems within the Region by providing a sound ecological understanding of plant communities and their composition and structure.

Specific goals are to:

i. Help our forests continue to manage the lands according to their land management plans
ii. Provide the public with an initial classification, inventory, and map of mid-level existing vegetation in the Intermountain Region
iii. Establish a baseline of landscape ecological conditions, including vegetation type, tree size, and canopy cover distributions and locations throughout the Region

iv. Establish consistent methodologies and standardized data that meet best available science requirements, eliminate redundancies, leverage consistency, save money, and establish a framework for future activities
v. Develop scientifically credible products that meet business requirements at multiple scales and for multiple purposes
vi. Develop an update and maintenance program to ensure decisions are made based on the best available information

Intended Uses

The products discussed in this document can be used to address a variety of important land management issues related to watersheds, forest characteristics, rangelands, fuel loads and wildlife habitat. Feasible applications include resource and ecosystem assessments, species habitat modeling, benchmark analysis, design of monitoring procedures, and a variety of other natural resource analysis applications. Specifically for the DNF, the products will be useful for habitat assessments, grazing analyses, planning large-scale fuel reduction projects, landscape-level post-fire restoration projects, providing information to the public, and Forest Plan revisions. These products may provide information for targeting areas requiring investigation for potential projects or determining where more detailed studies are needed. Additionally, data collected during this effort may feed into broader-level analyses, such as determining estimates of nation-wide biomass, analyzing climate change responses, or mapping land cover.

Business Needs Requirements

The development of existing vegetation classification, inventory, and map products is at the heart of our Agency's mission (http://www.fs.fed.us/about-agency/what-we-believe), "Our mission, as set forth by law, is to achieve quality land management under the sustainable multiple-use management concept to meet the diverse needs of people." One mission activity that is directly related to the development of vegetation products is identified as "developing and providing scientific and technical knowledge aimed at improving our capability to protect, manage, and use forests and rangelands."

More recent Forest Service initiatives strengthen the need for acquiring existing vegetation information for our Forests and Grasslands. The National Forest System Land Management Planning Rule (36 CFR Part 219) Subpart A—National Forest System Land was published in the Federal Register on April 9, 2012, and became effective 30 days following the publication date. The new planning rule establishes "ecological sustainability" as a primary objective in forest management, and addresses "conservation of water flow and assurance of a continuous supply of timber as set out in the Organic Act, and the five objectives listed in the Multiple-Use Sustained Yield Act of 1960 (Public Law 86-517): outdoor recreation, range, timber, watershed, and wildlife and fish."

Included in the new planning rule regulations, the plan monitoring program addresses the applicability of eight requirements per 36 CFR 219.12(a) (5). The DNF's existing vegetation effort addresses three of the eight plan monitoring program requirements: 1) the status of select watershed conditions, 2) the status of select ecological conditions including key characteristics of terrestrial and aquatic ecosystems, and 3) the status of a select set of the ecological conditions required under §219.9 to contribute to the recovery of federally listed threatened and endangered species, conserve proposed and candidate species, and maintain a viable population of each species of conservation concern.

The 2012 planning rule also requires the responsible official to use the "best available scientific information" to inform the assessment, the development of the plan (including plan components), and the monitoring program. The planning rule requires that responsible officials document how the best available scientific information was used.

More recently, the Forest Service has developed a strategy for inventory, monitoring, and assessment (IM&A) activities as directed in the Forest Service Manual (FSM-1940). The strategy establishes a comprehensive approach for conducting IM&A activities in the agency that responds to our priority business requirements. The IM&A strategy lists existing vegetation as a sidebar for the strategy, and includes the statement "Existing vegetation, for example, is the primary natural resource managed by the Forest Service and is the resource on which the agency spends the most money for inventories and assessments" (USDA Forest Service 2013).

The DNF existing vegetation mapping project attempts to meet the requirements, policy, and guidelines for properly managing our Forests through standardized protocol development and implementation, data standardization, reliable data processing, defensible methodologies, and full disclosure. These policy, guidelines, and requirements establish the collection of existing vegetation information and mapping products as requisite to proper land management in the area.

General Characteristics of the Area

The Intermountain Region of the Forest Service encompasses nearly 34 million acres of the National Forest System. This region contains 12 Forests in the states of Idaho, Utah, Nevada, Wyoming, Colorado, and California where four major geographic provinces come together (i.e., Great Basin, Colorado Plateau, Northern Rocky Mountains, and Middle Rocky Mountains). This geographic diversity is one reason for the Region's variety of ecosystems and landscapes. The

Intermountain Regional Office in Ogden, Utah, provides administrative support for the Region's National Forests and Grasslands.

The DNF is the largest National Forest in Utah and spans almost 2 million acres in southern Utah (Figure 1). The Forest comprises the Cedar City, Escalante, Pine Valley, and Powell Ranger Districts. This mapping project includes the former Teasdale Ranger District of the DNF, which is now administered as part of the Fremont River Ranger District by the Fishlake National Forest. The Forest Supervisor's Office is located in Cedar City, Utah.

The DNF is located among the Mojave Desert, Southeastern Great Basin, Utah High Plateau, Bonneville Basin, Grand Canyon, and Northern Canyonlands Ecomap Sections. These ecological sections are comprised of sedimentary, granitic, and volcanic rocks, alluvial and glacial deposits, plateaus, and sheer-walled cliffs (McNab et al. 2007). Elevations on the forest range from 2,800 to 11,322 feet. Desert shrubs, sagebrush, rabbitbrush, and pinyon-juniper vegetation dominate lower and mid-elevations, and aspen, spruce, fir and pine dominate at higher elevations. Summers are generally hot and dry, and winters are generally cold and snowy. Precipitation across this semi-arid ecoregion varies according to altitude. The majority of annual precipitation at higher elevations occurs as snow from late fall through early spring, while August may be the wettest month with heavy rains at lower elevations (USDA 1986).

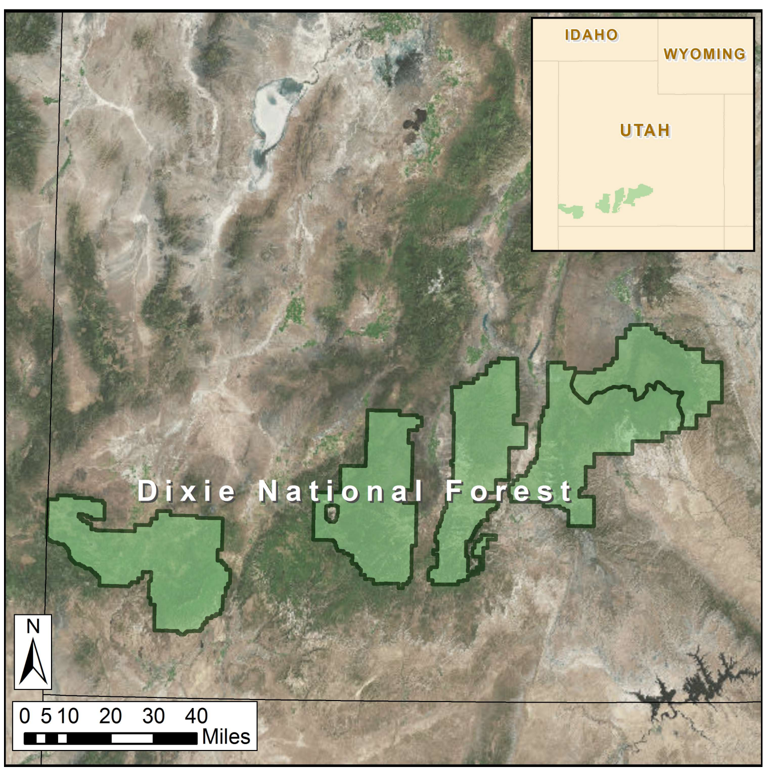

Figure 1: The Dixie National Forest, located in southern Utah, stretches over almost two million acres.

Partnerships

The mid-level existing vegetation products were collaboratively planned, developed, and implemented by technicians and experts within the Forest Service. These partnerships were critical to ensuring the highest level of integrity, objectivity, and usefulness for internal uses and for external consumption by the public. The primary participants in the development included DNF and Regional Office staffs, the Geospatial Technology and Applications Center (GTAC) (formerly known as the Remote Sensing Applications Center (RSAC)), and the Interior West Forest Inventory and Analysis (IWFIA) Program of the Rocky Mountain Research Station (Figure 2).

The Intermountain Regional Office established the VCMQ core team in 2009 to create existing vegetation products for regional and forest-level uses, such as forest-planning-level analysis, broad-scale analysis, monitoring, assessments, and as a framework for project-level analysis. The team provides expertise in botany, ecology, forestry, soils, remote sensing, inventory and mapping, GIS, information technology, and program management.

The DNF is a primary stakeholder in the derived outcomes of this project since they administer the lands and use these products for land management activities. The DNF has collaborated on all aspects of the vegetation mapping project from the initial needs assessment to the final accuracy assessment. A focused group of forest resource specialists, contract specialists, and GIS specialists helped identify tasks and deliverables, made recommendations based on user needs, and served as Forest representatives to the collaborative effort. A broader audience of resource specialists and program managers reviewed draft map products, provided field-based knowledge, and offered suggestions to make the deliverables more meaningful from a Forest perspective.

GTAC is a national technical service center of the USDA Forest Service. The mission of GTAC is to provide the Forest Service with the knowledge, tools, and technical services required to use remote sensing data to meet the Agency's stewardship responsibilities. GTAC's Mapping, Inventory, and Monitoring program provides operational remote sensing support and analysis services to help meet internal and interagency programmatic assessment and monitoring needs, such as this existing vegetation mapping project. GTAC is the principal provider of remote sensing technical expertise and map production techniques for this effort. The Center has assisted in this effort in all aspects: data collection, remote sensing analyses, image segmentation, image analysis, field reference data protocol and sample design, map filtering, map production, draft map reviews, and final report development.

The IWFIA unit operates under technical guidance from the Office of the Deputy Chief for Research and Development, located in Washington, DC, and under administrative guidance from the Director of the Rocky Mountain Research Station located in Fort Collins, Colorado.

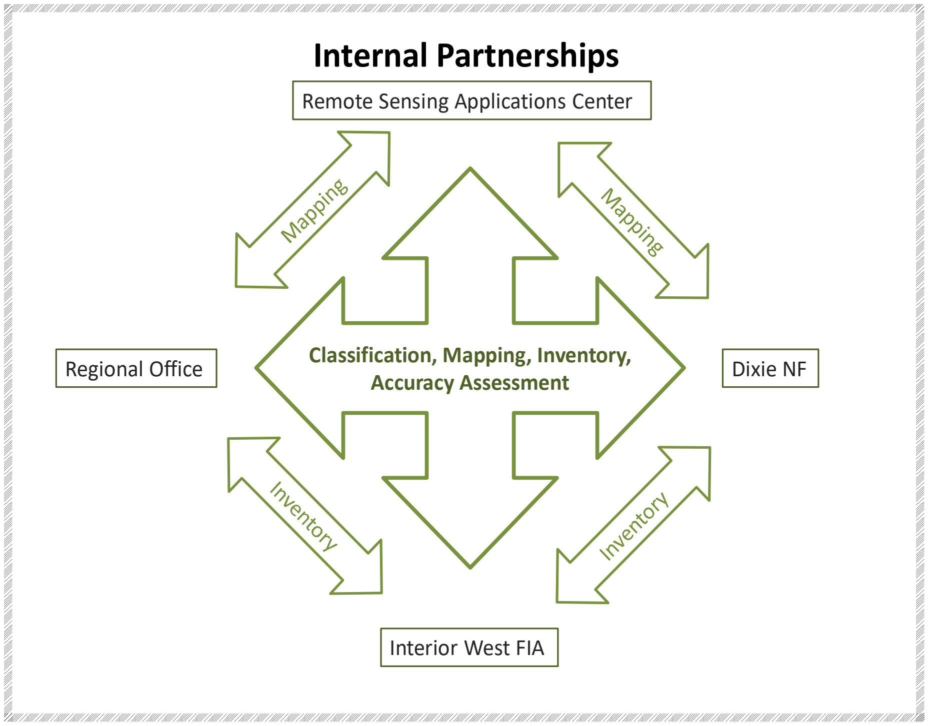

Figure 2: Partnerships developed for the classification, mapping, inventory, and accuracy assessment conducted on the DNF.

This research unit provides ongoing support for the inventory aspects of the project: FIA inventory on forest land and all-condition inventory (ACI) on nonforest plots, contract inspections, data collections, database assistance, pre-field inspections, intensified inventory sample design, and accuracy assessment. Their participation ensures consistency and establishes credible and defensible inventory data to be used in conjunction with the derived map products.

Final Products

The final map products depict continuous land cover information for the entire project area including the DNF, Teasdale portion of the Fremont District on the Fishlake National Forest, and private land inholdings. Maps are formatted as a geodatabase, which is compatible with Forest Service corporate GIS software. The vegetation maps are consistent with mid-level mapping standards set forth in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015). In conformance with these standards, upland modeling units were aggregated up to 5 acres and riparian vegetation types were aggregated to 2 acres. Additional products include field-collected reference information and photographs, seasonal Landsat image mosaics and derived vegetation indices, topographic derivatives, climate data, surface information derived from IfSAR, fire history, and burn severity information.

Methods

The phases for this project included project planning, data acquisition and processing, classification development, segmentation, map unit legend design, reference data collection, modeling, draft map review and revision, and final map development (Figure 3). After the final maps were completed, an accuracy assessment, vegetation type map unit description, and dominance type descriptions were developed.

Maps depicting existing vegetation types, canopy cover, and tree size classes were developed using moderate and high resolution imagery, topographic data, ancillary GIS layers, field and photo-interpreted reference data, automated image segmentation, and data-mining classification techniques. The remotely sensed imagery assembled for this project included moderate and high resolution satellite and aerial imagery. Eleven Landsat scenes (30-meter spatial resolution) were assembled depicting spring, summer, and fall conditions. The high resolution imagery included 2011 and 2014 National Agricultural Imagery Program (NAIP) aerial photography (1-meter) and 2012 resource photography (half-meter). U.S. Geological Survey Digital Elevation Models (DEM) (10-meter) were compiled. Other ancillary GIS layers that were gathered include climate, land form, wildfire severity, Landfire existing vegetation type, National Land Cover Database 2011 (NLCD), GAP national land cover data, and interferometric synthetic aperture radar (IfSAR) data (Appendix A).

Vegetation indices and image transformations were generated from the Landsat and high resolution imagery and topographic information was derived from the digital elevation models (Appendix B). All imagery and topographic derived information were projected to a common geographic coordinate system (UTM, NAD83, and Zone 12 N). Modeling units (image segments) were developed using 2011 Landsat imagery, 2011 NAIP imagery, and a topographic derivative data layer.

Field sites were collected in homogeneous modeling units during the summers of 2013, 2014, and 2015 and information on vegetation composition, canopy cover, and tree size was recorded. Additional canopy cover reference information was obtained using photo interpretation methods.

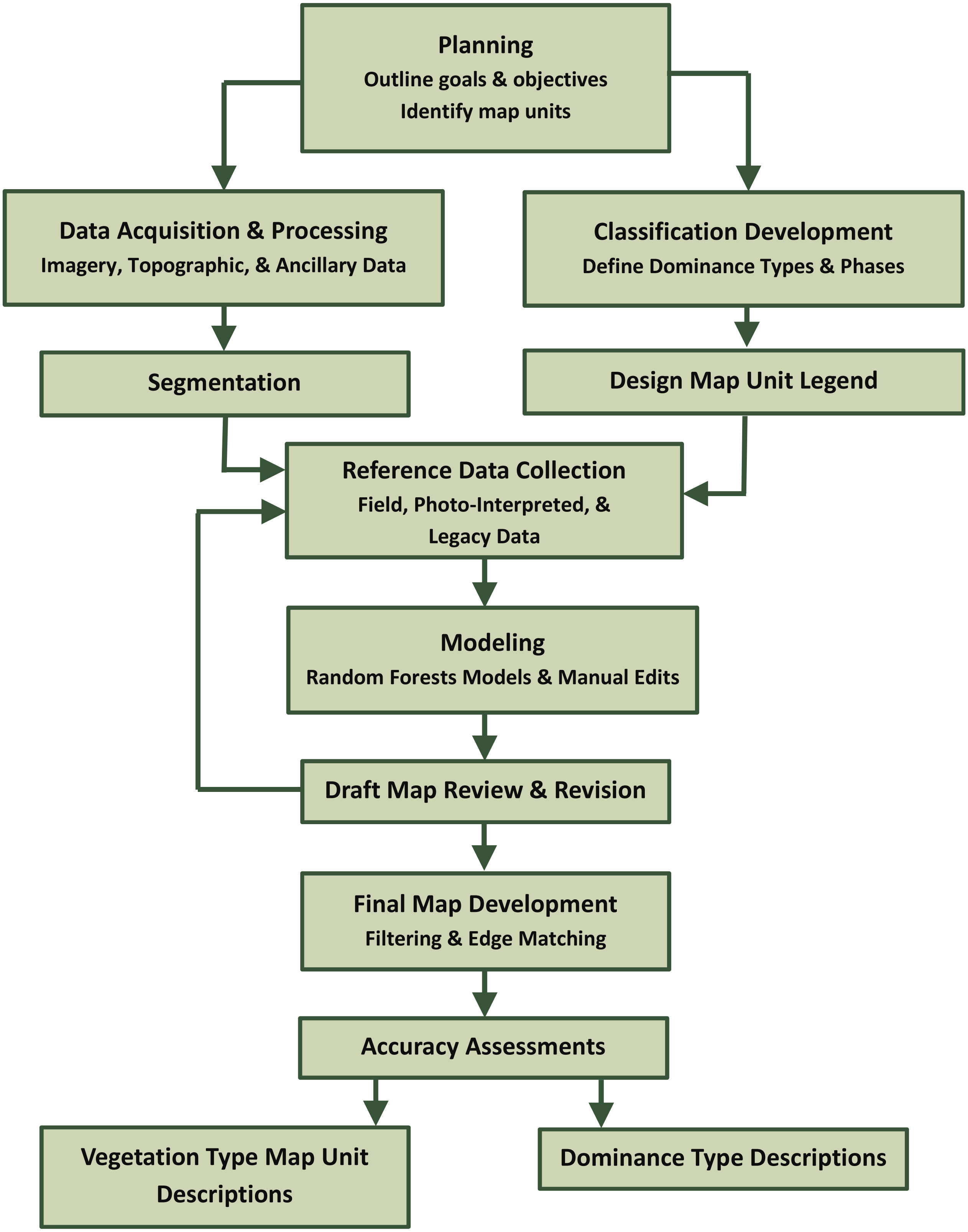

Figure 3: Project phases from project planning to descriptions of vegetation type map units and dominance types.

Map unit labels (vegetation type, canopy cover class, and tree size class) were assigned to the modeling units using Random Forests (Breiman 2001). Random Forests is a method of automated computer classification and regression that uses reference and geospatial data to develop decision trees. Each map (vegetation type, canopy cover class, and tree size class) was developed individually using distinct reference data sets and geospatial data layers.

Draft maps were distributed to DNF resource specialists for review and final revisions were made based on the feedback. Maps were completed by aggregating and filtering the modeling units to the minimum map feature size. Upland vegetation types were filtered to 5 acres, while riparian vegetation types were filtered to 2 acres. An accuracy assessment was conducted and descriptions of the vegetation type map units were written.

Project Planning

In 2013, staff of the DNF, Intermountain Regional Office, and GTAC met to discuss map unit design and prepare a project plan. Since one of the goals for the project was to provide a regionally cohesive map product, efforts were made to ensure that processes and spatial and thematic characteristics of the maps would fulfill regional requirements. A classification of dominance types and phases was developed to address forest information needs. These were combined into vegetation types that achieved a balance between map detail and accuracy within the allocated budget and time constraints. The final vegetation type map units conformed to the mid-level mapping standards referenced in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015), while the canopy cover and tree size map units were selected to represent the management needs of the Forest.

Vegetation Classification Development

The Intermountain Region's VCMQ program is designed to classify, map, and quantitatively inventory existing vegetation across the Region. At the regional level, existing plant communities are assigned to dominance types based on the most abundant species of the ecologically dominant life form (e.g., the most abundant tree species in forests or woodlands). This approach was decided upon by a council with representatives from each Forest in the Region.

At the Forest level, the regional dominance types may be subdivided into dominance type phases based on associated species of the same life form as the dominant species. Forests are able to define these phases to best meet their own information needs, as long as they nest within the regional dominance types.

An initial list of dominance types is compiled using Forest vegetation plot data and vegetation classification literature relevant to the Forest. The list is reviewed and augmented by Forest resource specialists and local contributors. The Forest specialists determine whether any dominance types need to be split into phases and how those should be defined. Rules for distinguishing phases are tested using the regional plot database and a taxonomic key to dominance types and phases is developed. In practice, phases have only been defined in forests and woodlands, not in shrublands or herblands.

Vegetation Type Map Units

Once the classification is developed, Forest and Regional specialists develop a map legend by determining which dominance types and phases should be mapped individually, and identifying which dominance types and phases can be combined. Overall map accuracy decreases as the number of map units increases; therefore, the team seeks to balance map detail versus map quality. This process is informed by applying the Forest dominance type key to FIA plot data and estimating the acreage of each type on the Forest. The initial map legend is complete when each dominance type and phase has been assigned to a map unit and included in the dominance type key. This process was followed to develop the dominance type classification and vegetation type map legend for the DNF (Tart et al. 2015; Appendix C). Data collected for classification of habitat and community types (Pfister 1972; Youngblood and Mauk 1985; Mueggler 1988; Padgett et al. 1989, West et al. 1998) and vegetation plot data collected by the Dixie National Forest, the Intermountain Regional Office, and the Grand Canyon Trust were used to compile a list of dominance types and test definitions of phases.

Structural Characteristics

Structural technical groups for tree size and tree and shrub cover were identified by DNF resource specialists to meet business information requirements specified in the land and resource management plans (Forest Plans). Tree size and canopy cover technical groups were established to represent a diversity of vegetation structure and density classes appropriate for informing the management and maintenance of physical and biological processes. The identified classes facilitate the assessment and monitoring of forest and nonforest (rangeland) vegetation, ecological patterns and processes, and wildlife habitat.

Tree Size Class

Tree size class or tree diameter class is any interval into which a range of tree diameters may be divided for classification (Helms 1998). Tree size is represented by the plurality of a given class forming the uppermost canopy layer as viewed from above. Tree size classes (Table 1) for the Conifer Forest and Deciduous Forest vegetation group map units and the Woodland vegetation group map unit differ in individual diameter class breaks. Forest species are measured using diameter at breast height (DBH) (4.5 feet above the ground) and designated woodland species (Table 2) are measured using diameter at root collar (DRC). Specific procedures used for measuring DRC are found in the Field Reference Data Collection Guide (Appendix D).

Table 1: Tree size map classes represented by diameter at breast height (DBH) for Conifer Forest and Deciduous Forest vegetation group map units, and by diameter at root collar (DRC) for Woodland vegetation group map units.

Forest Tree Size DBH (in)	Code	Woodland Tree Size DRC (in)	Code
0 – 4.9”	FS1	0 – 11.9”	WS1
5 – 11.9”	FS2	12 – 17.9”	WS2
12 – 17.9”	FS3	≥ 18”	WS3
18 – 23.9”	FS4		
≥ 24”	FS5		

Table 2: Designated woodland species measured by diameter at root collar (DRC).

Symbol	Scientific Name	Common Name
ACGR3	*Acer grandidentatum*	bigtooth maple
CELE3	*Cercocarpus ledifolius*	curlleaf mountain mahogany
JUOS	*Juniperus osteosperma*	Utah juniper
JUSC2	*Juniperus scopulorum*	Rocky Mountain juniper
PIED	*Pinus edulis*	two-needle pinyon
PIMO	*Pinus monophylla*	singleleaf pinyon
PRGL2	*Prosopis glandulosa*	honey mesquite
QUGA	*Quercus gambelii*	Gambel oak

Tree and Shrub Canopy Cover Class

Canopy cover from above represents the total non-overlapping canopy in a delineated area as viewed from above (Nelson et al. 2015). Overlapping canopy not visible from above is not assessed or counted. Map classes representing total tree and total shrub cover from above are listed in Table 3. Additional assessment was completed on the tree canopy cover by further splitting those classes into either forest or woodland canopy cover classes. These alternative cover estimates were derived by classifying either forest (conifer forest or deciduous forest) or woodland map groups into their corresponding canopy cover classes (based on its total canopy cover value).

Table 3: Map classes for total tree, forest tree, woodland tree, and shrub canopy cover as viewed from above.

Total Tree Canopy Cover	Code	Forest Tree Canopy Cover	Code	Woodland Tree Canopy Cover	Code	Shrub Canopy Cover	Code
10 – 19%	TC1	10 – 19%	FC1	10 – 19%	WC1	10 – 24%	SC1
20 – 39%	TC2	20 – 39%	FC2	20 – 49%	WC2	25 – 34%	SC2
40 – 49%	TC3	40 – 59%	FC3	≥ 50%	WC3	≥ 35%	SC3
50 – 59%	TC4	≥ 60%	FC4				
≥ 60%	TC5						

Geospatial Data Acquisition and Processing

Geospatial data acquisition is a major activity in most vegetation mapping efforts that use digital image processing methods. This activity involved assembling remotely sensed images of various spatial and spectral resolutions and an array of geospatial data (Appendix A). A requirement of the mapping process was that any data layer used must be available across the entire DNF to ensure consistency. Data used included imagery from the National Agriculture Imagery Program (NAIP), topographic data in the form of Digital Elevation Models (DEMs), burn severity information from the Monitoring Trends in Burn Severity (MTBS) program, surface climate conditions data generated by the Daily Surface Weather and Climatological summaries (Daymet), interferometric synthetic aperture radar (IfSAR) data, and 11 orthorectified Landsat 8 OLI satellite images from 2013 and 2014. In addition, enterprise data such as USFS administrative boundaries, land ownership, roads, trails, hydrology, and vegetation maps developed in 2011 were provided by the DNF.

For modeling purposes only, the DNF administrative boundary was buffered by 0.25 mile to account for edge effects that can occur along the clipped edge of some topographic and image data sources that may negatively impact the classification models. The buffered area was not included in the final map deliverables. Private and national park lands completely contained within the Forest were included in the project area to maintain spatial contiguity and are part of the final map deliverables. However, no reference data were gathered within these areas or lands outside the Forest boundary.

All geospatial data, including ancillary GIS layers, remotely sensed images, and topographic layers, were projected to the UTM Zone 12, GRS 1980, NAD83 coordinate system and clipped to the buffered project area.

Imagery

All Landsat imagery was co-registered and obstructions (e.g., haze, clouds, cloud shadows) were removed and replaced to develop three seamless seasonal mosaics: spring, summer, and fall. A regression technique was used to replace clouds and cloud shadows and create seamless mosaics between neighboring Landsat scenes. Model II regression is a statistical technique that uses a common area between two images (i.e., overlap between adjacent Landsat scenes) to develop a regression model for each of the spectral bands on the image. The regression equation is then used to “fit” the target image to the reference image by adjusting the pixel values in the non-overlap areas to facilitate the creation of a seamless mosaic between images. Two spectral transformations (Tasseled Cap Transformation and Principal Component Analysis) and one spectral index (Normalized Difference Vegetation Index (NDVI)) were produced from the final Landsat mosaics. An additional time series raster was produced to exploit the seasonal trends (speed, magnitude, and longevity of green-up and senescence) that occur between different vegetation communities. This layer was created using Landsat scenes from 2010-2015, Tasseled Cap Transformations, and harmonic regression equations.

The 2011 and 2014 1-meter NAIP images were resampled to 10 meters and mosaicked. This step increased the processing efficiency of image segmentation by reducing the resulting segment file size while still maintaining image resolution appropriate for mid-level mapping. NDVIs were produced using the visible and near infrared bands.

Digital Elevation Models (DEMs) and Topographic Derivatives

Topographic derivatives including three slope and aspect based products (slope, slope-aspect (cos), and slope-aspect (sin)), were developed from the 10-meter DEM (Ruefenacht 2014), as well as heatload, trishade, and valleybottom. Such topographic models are used in the modeling process to depict environmental parameters that help predict vegetation cover types.

IfSAR Data

Interferometric synthetic aperture radar (IfSAR) data estimates vegetation height by taking the difference between two radar returns with different wavelengths. One wavelength returns to the sensor after contact with the ground, and the other wavelength returns to the sensor after coming in contact with vegetation. IfSAR difference products were used for the mapping of tree size class, since it correlates with tree height. Unfortunately, IfSAR data is inconsistent across mountainous terrain where steep slopes prevent the radar data from being acquired. Consequently, ifSAR data was not used to map tree size for these areas, instead traditional predictor layers were used.

Segmentation

Image segmentation is the process of partitioning digital imagery into spatially cohesive polygonal segments (modeling units) that represent discrete areas or objects on a landscape (Ryherd and Woodcock 1996). The goal of developing segments is to simplify complex images comprised of millions of pixels into more meaningful and mappable objects. Excluding water bodies, the final segments (modeling units) ranged in size from 0.19 to 411 acres with an average size of approximately 3.3 acres.

Modeling units were produced using Trimble eCognition's multi-resolution segmentation algorithm (Figure 4). This algorithm is a bottom-up segmentation technique, whereby pixels are recursively merged together based on user-defined heterogeneity thresholds to form discrete image objects. The input data layers used to generate segments included the resampled NAIP imagery (raw bands and NDVI), Landsat imagery (1st principal component) and trishade topographic data. There are four primary parameters within eCognition's multi-resolution segmentation algorithm that control the spatial and spectral quality of the resultant segments: layer weights, scale, shape, and compactness. Layer weights control the relative influence that each of the raster data layers have on the segmentation process (Appendix E).

The majority of the influence was given to the 10-meter NAIP imagery. While all layers contribute valuable information to the segmentation process, the "texture" of the higher-resolution, multi-spectral data is often most effective at distinguishing between distinct vegetation types and conditions.

Scale is a unit-less parameter that controls the amount of allowable heterogeneity within segments. Scale parameters can range from 1 to infinity, where the low end would delineate polygons only around identical pixels and the high end would result in the entire study area delineated as a single polygon. As such, scale can also be seen as a proxy control for segment size. A high scale parameter means more heterogeneity is allowed within segments and will ultimately result in larger relative segment sizes. Conversely, a small scale parameter means less heterogeneity is allowed within segments, so smaller segments will result. A scale parameter of 16 was used for the DNF segmentation. The appropriate scale factor was determined by experimentation and previous experience with other forests.

The shape parameter controls the type of heterogeneity contained within the resultant segments. It is a relative value that caters to the desire for resultant segments to be controlled by spatial homogeneity (shape) and/or spectral homogeneity (color). The values range from 0.0 (a low shape parameter/high color parameter) to 0.9 (a high shape parameter/low color parameter). Segments created with a low shape parameter will have very spectrally homogeneous segments, but less compactness or smoothness of the resultant segments. Conversely, a very high shape parameter will result in segments that have very smooth, compact shapes, but more variance of spectral and topographic pixel values. For the DNF segmentation, a shape parameter of 0.1 was used, which emphasizes spectral and topographic homogeneity over smoothness and compactness of segment shapes.

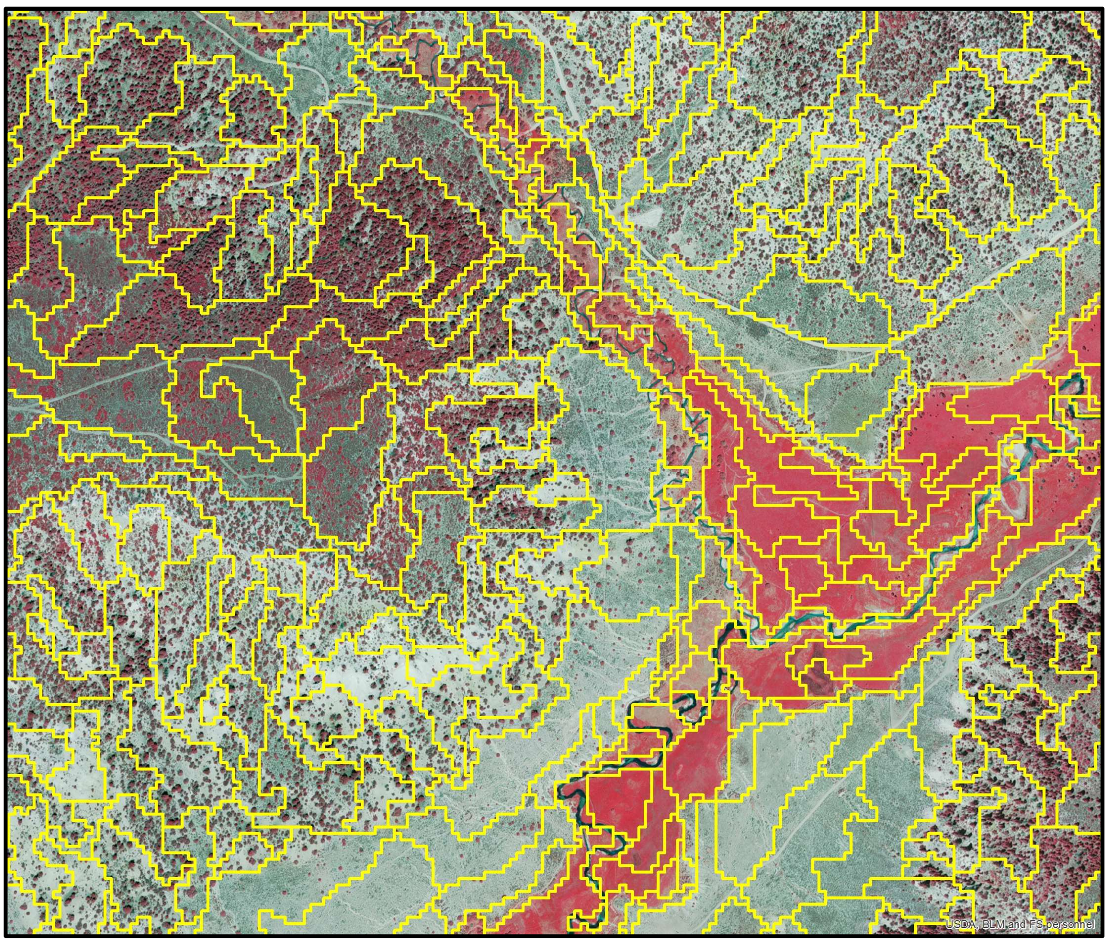

Figure 4: An example of modeling units generated using eCogniton software overlaid on false color 1-meter 2012 resource imagery.

Similar to the shape parameter, the compactness parameter actually weighs the balance between two opposing spatial qualities: compactness and smoothness. Compactness can be described as the ratio between the area of a given segment and the area of the smallest bounding box of that segment. A very compact segment (e.g., a circular or square segment) will have a ratio that approaches 1, while a segment with low compactness (e.g., an oblong or linear segment) will have a value that approaches 0. Smoothness can be described as the ratio between the length of a segment's boundary and its area. A very smooth segment will have a short border relative to its area, whereas an irregular segment will have a lengthy border relative to its area. The value of the compactness parameter ranges from 0.0 (low compactness/high smoothness) to 1.0 (high compactness/low smoothness). For the DNF segmentation, a compactness parameter of 0.6 was used, which equally balances the shape and compactness of segments.

In addition to the base parameters described above, GTAC developed additional components to the segmentation rule set, including the definition of a minimum mapping feature (MMF) and associated MMF filtering techniques, and an "object smoothing" process that sends the raw segments through a majority filter-based re-shaping tool that results in smoother, more spatially consistent and functional modeling units.

Reference Data Collection

Vegetation plot data were assembled and aerial photo interpretation was conducted to obtain a reference data set representative of the map units (vegetation type, canopy cover, and tree size class) depicted on the final maps. Reference data are intended to represent a statistically robust sample of broader vegetation conditions across the entire study area. They are used both as training data in model development and to assist with image interpretation. For this project, three types of reference data were used: legacy vegetation plot data, newly collected field reference data, and photo-interpreted data.

Legacy Vegetation Plot Data

Existing information on vegetation composition and structure was reviewed for use in the mapping process. Rangeland monitoring sites, collected in 2004 through 2012, were provided to GTAC with GPS coordinates. Common stand exam data and ifSAR data were also used to extract vegetation type and tree size information for an additional 299 sites. All legacy data underwent a rigorous QA/QC process using high resolution NAIP imagery. Each site was reviewed for segment homogeneity, if the site was relatively uniform in vegetation characteristics, and if the assigned vegetation group, vegetation type, and tree size class was appropriate.

Multiple legacy data sources and associated plot information were used for developing dominance type classifications and reference data for vegetation mapping (Table 4). Additionally, 321 FIA plots comprising 394 conditions were available for this study. These were used in developing the dominance type and the map legend but were not used as reference data for the mapping process. They were used to assess the overall accuracy of the map and to describe the composition of the final vegetation type map units. Over 340 supplemental field plots were also collected in 2015 that will be used to write map unit and dominance type descriptions.

Table 4: Legacy data sources and associated plot information used for vegetation mapping and developing dominance type classifications on the Dixie NF.

Data Set	Dominance Type Classification Plots	Map Reference Plots
Habitat Type Plots		
Pfister 1972	102	---
Youngblood and Mauk 1985	249	---
Community Type Plots		
Padget et al. 1989	89	---
Mueggler 1988	165	---
West et al. 1998	15	---
Other Plots		
Dixie NF Monitoring	180	350
R4 Mahogany Plots	10	
Totals	**810**	**350**

Newly Collected Field Reference Data

Field reference data were collected to capture the variation of vegetation composition communities and structure classes across the project area. Field sites were selected using several criteria to ensure that representative vegetation conditions were sampled. First, sites were located in relatively homogeneous areas as perceived from high resolution aerial imagery. Second, sites were large enough (one acre or greater) to capture variation in the geospatial data to provide reasonable statistics for a particular sample. Third, sites were placed within 0.25 mile of a road or trail to facilitate accessibility in the field. In addition, spectral and topographic data and an existing landcover map were used to help capture the range of conditions anticipated to occur within the project area

Approximately 2,048 field sites were visited during the summer of 2013. Information on dominance type, vegetation type, percent canopy cover, and tree size was collected at each site. A 50-foot radius circular plot was established within the segment as identified on a plot map depicting high resolution aerial imagery and image segments. Field crews navigated to the given descriptive plot coordinates within each segment. The center of the plot and plot boundary in each cardinal direction from plot center was then marked. Because the map represents an overhead view, all vegetation within the plot area was assessed based on an aerial perspective from above the canopy. Overlapping canopy not visible from above was not assessed or counted as part of the estimates.

Ocular estimates of canopy cover for trees, shrubs, herbaceous and non-vegetated cover types were recorded for the plot totaling 100 percent. Based on these estimates, the vegetation formation for the site was determined using the vegetation key and up to the 5 most abundant species having greater than or equal to 5 percent cover was recorded for that formation. Based on the plot composition and cover estimates, a dominance type and corresponding vegetation type and vegetation group were assigned to the site using the vegetation keys and map unit cross-walk (Appendix C).

For forest and woodland sites, the percent visible cover from above of each tree size class was ocularly estimated by species and then totaled for each size class. Tree size was determined using DBH for all tree species except for woodland tree species. Tree size for woodland tree species was determined using DRC (Tables 1 and 2). The tree size class having the most abundant total canopy cover was used for assigning the forested plot to a tree size map unit.

For forest, woodland, and shrubland sites, total life form canopy cover was estimated to assign the plot to a tree or shrub canopy cover map unit. Upland forest and woodland sites were assigned to a tree canopy cover map unit. Shrub and riparian woody sites were assigned a shrub canopy cover map unit (Table 3). In addition to the ocular cover estimates, a transect intercept method was used at regular intervals for shrub plots to calibrate ocular estimates.

After descriptive plot information was collected, field crews navigated to given observation plot locations. Between three to nine field observation sites were collected to quickly acquire additional vegetation information within the extended vicinity of the field plot, including dominance type, vegetation type and group, canopy cover class, and tree size class. Additional information regarding field sampling procedures is discussed in the Field Reference Data Collection Guide (Appendix D).

Photo Interpretation

In addition to the field-collected data, aerial photo interpretation was conducted for discernable vegetation composition and structure characteristics to validate and supplement the field-based reference data set. All legacy and newly acquired field reference data were photo-interpreted to validate segment homogeneity and representativeness of the field calls for vegetation type and structure class. In addition, supplemental photo interpretation reference sites were acquired for classes not adequately represented in the legacy or newly acquired field sample data sets.

Photo-interpretation techniques were used to assign canopy cover for 1,000 randomly selected tree segments. Tree canopy cover was evaluated across the full extent of the modeling unit (segment) using high resolution imagery. Example segments, in which the canopy cover percent was established by multiple interpreters, were used to help calibrate individual interpretation. All sites were reviewed by two photo-interpreters to provide an impartial assessment. This process ensured more consistent tree canopy cover estimates, provided information for remote locations, and enabled the acquisition of an unbiased, random reference data set for modeling purposes.

Modeling

Modeling was the step in the mapping process that developed the statistical relationships between the reference data and the geospatial data. These statistical relationships were then applied to building a map. Each model output was carefully evaluated. To improve the model results, reference data were reevaluated, changes or additions were made, and an updated model was developed. This modeling procedure was repeated until the maps were considered satisfactory.

An important task in the modeling process was the development of draft maps to share with DNF resource specialists. This step allowed resource specialists to take maps into the field for verification, apply local knowledge, and make suggestions for improvements to the map products. This feedback allowed modelers to make map changes and improvements prior to final map delivery.

Vegetation Type Map

Vegetation types were mapped using a hierarchical approach. A mapping hierarchy determined the sequence in which models were run, and incorporated the vegetation types most difficult to separate (Figure 5). Broad life form types, such as tree and non-tree, were mapped first. These communities were subsequently divided into more distinct categories until the final vegetation types were mapped. There are several advantages to using this hierarchical approach. It enables a targeted review of maps at each level where conspicuous errors can be addressed at the upper levels of the hierarchy, and it provides additional reference sites for mapping the broad classes.

The mapping hierarchy was developed using a data clustering technique based on the relative separability of each vegetation type. Separability was determined by how well the spectral and ancillary data could distinguish between vegetation types. It is quantified by a value known as "entropy," which measures how well a model could be expected to separate vegetation types beyond random chance. Vegetation types with low entropy values are expected to be modeled poorly and vegetation types with high entropy values are expected to be modeled well. The mapping hierarchy was built from the bottom up by identifying and aggregating the least separable classes first.

A Random Forests model (Breiman 2001) was developed for each level of the mapping hierarchy, and the resulting output map was carefully evaluated. To correct inconsistencies, reference data were reevaluated, changes or additions were made, and an updated model was developed. This modeling procedure was repeated until the maps were considered satisfactory.

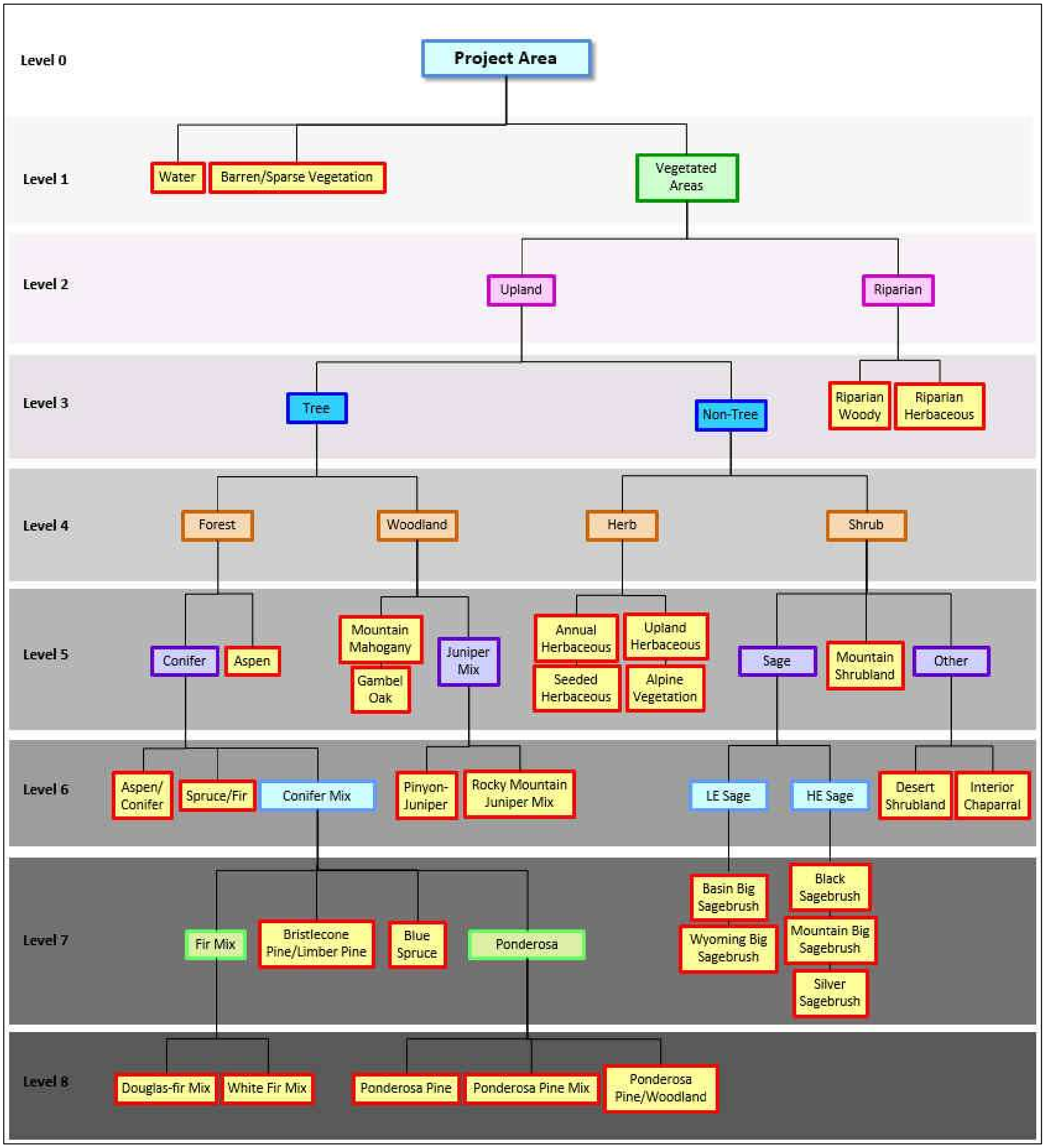

Figure 5: Vegetation type mapping hierarchy example used in the modeling process. Successive models were developed starting with level 1 (broad separation of land cover) and progressing to higher levels (more refined). At each level a separate map was developed and reviewed for accuracy. Yellow boxes depict vegetation type map units. LE = Low Elevation and HE = High Elevation. Land use types, agriculture and developed, were not included in the hierarchy because they were manually delineated using high resolution imagery.

Canopy Cover Map

Canopy cover was assigned to forest, woodland, and shrubland modeling units identified on the vegetation type map. Forest and woodland canopy cover was determined using photo-interpretation techniques, while shrubland canopy cover was assessed in the field.

To optimize modeling effectiveness, vegetation types were sorted into tree and shrubland lifeform categories (Table 5) and for each lifeform a Random Forests model was developed. Tree canopy cover was modeled continuously, while shrubland types were modeled to the canopy cover class. These maps were evaluated using the high resolution imagery and additional reference sites were added if necessary. An assessment of the final modeling results for tree canopy cover was conducted using an independent aerial photo-interpreted dataset (Appendix F).

Table 5: Canopy cover groups used for modeling canopy cover.

Canopy Cover Group	Vegetation Type
Tree	Aspen, Aspen/Conifer, Douglas-fir Mix, Ponderosa Pine, Ponderosa Pine Mix, Ponderosa Pine/Woodland, White Fir Mix, Spruce/Fir, Blue Spruce, Bristlecone Pine/Limber Pine, Mountain Mahogany, Pinyon-Juniper, Rocky Mountain Juniper Mix, and Gambel Oak.
Shrubland	Mountain Big Sagebrush, Wyoming Big Sagebrush, Basin Big Sagebrush, Silver Sagebrush, Black Sagebrush, Desert Shrubland, Interior Chaparral, Mountain Shrubland, and Riparian Woody.

Tree Size Map

Tree size was assigned to modeling units identified as forest or woodland vegetation types (Table 6). Diameter at breast height (DBH) was assigned to the forest types and diameter at root collar (DRC) was assigned to the woodland types. Vegetation height information derived from IfSAR data and Landsat seasonal coefficients that characterizes forest disturbance and/or recovery were used in addition to the customary geospatial predictors (Appendix G).

Table 6: Tree groups and the associated vegetation types used for tree size mapping.

Tree Size Groups	Vegetation Type
Forest	Aspen, Aspen/Conifer, Douglas-fir Mix, Ponderosa Pine, Ponderosa Pine Mix, Ponderosa Pine/Woodland, White Fir Mix, Spruce/Fir, Blue Spruce, and Bristlecone Pine/Limber Pine.
Woodland	Mountain Mahogany, Pinyon-Juniper, Rocky Mountain Juniper Mix, and Gambel Oak.

Draft Map Review and Revision

The draft vegetation type, canopy cover, and tree size maps were provided to local forest resource specialists for comment and review. Meetings were held in Cedar City, Utah, where the review process and associated materials were presented to the Forest staff and other parties (Appendix H). Digital maps using Webmap services were the primary review device. This was an opportunity for local experts to assess the map and give additional information to make improvements. All draft map review comments were compiled and reviewed by the vegetation mapping team, and the recommended changes were used to produce the final maps.

Final Map Development

Three final map products were produced for delivery: 1) vegetation type; 2) canopy cover class for trees and shrubs; and 3) tree size class. For the vegetation type map, segments were first dissolved to merge adjacent polygons of the same type. To achieve the minimum map feature (MMF) of 5 acres, with the exception of riparian woody and riparian herbaceous (2 acre MMF), segments below these thresholds were merged based on a set of rules developed by the RO and Dixie NF staffs (Appendix I). The rules followed logic based on similarities between adjacent polygons, so that neighbors were merged with the most similar type of vegetation. An example of this dissolving and filtering process is shown in Figure 6. For the canopy cover and tree size maps, segments were dissolved and merged using a similar process. For example, the first choice for filtering out a small TS1 map feature was to merge it with a neighboring TS2 map feature, since that is the most similar class.

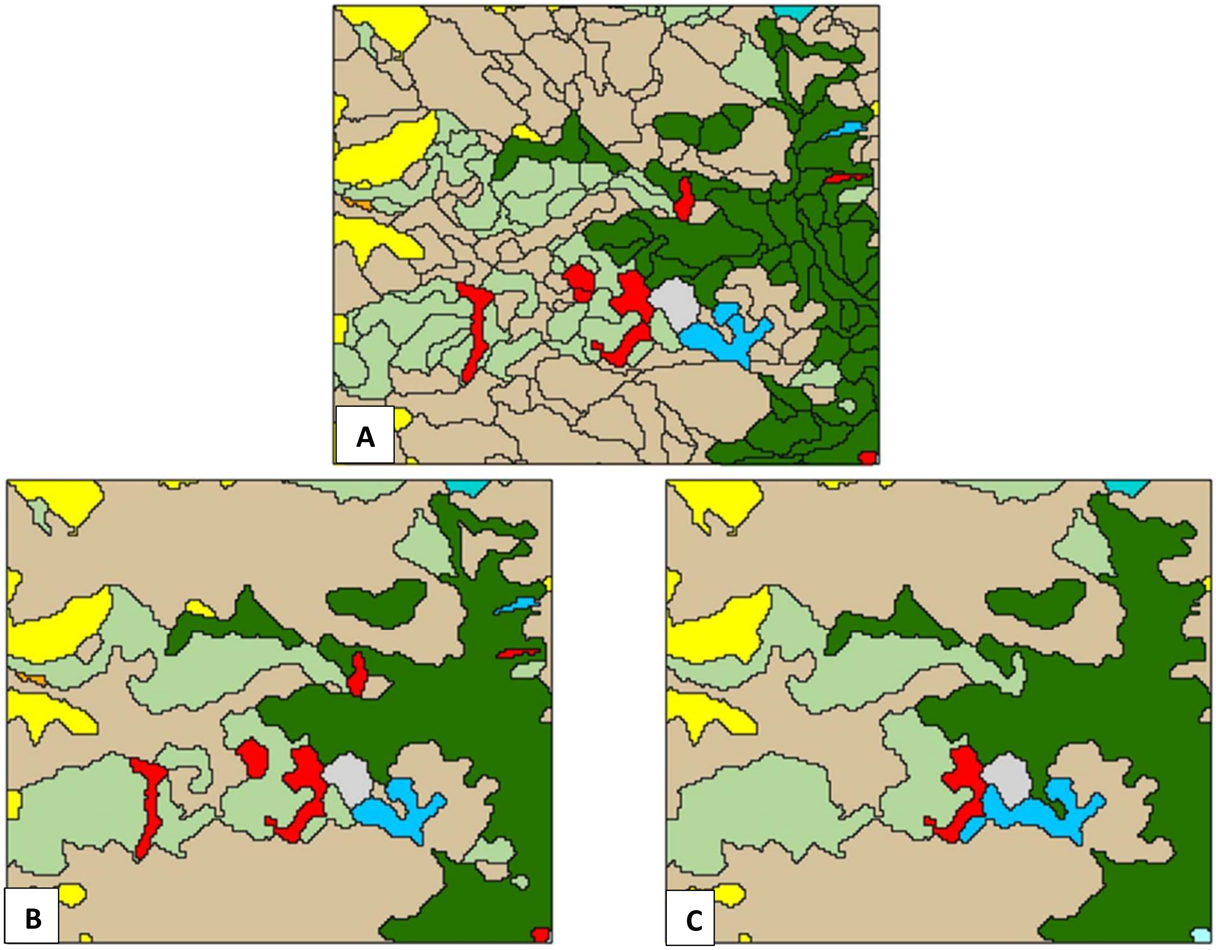

Figure 6: An example of the dissolving/merging and filtering process that was performed on the final maps. Image A shows the original vegetation type map with no dissolving or filtering. Image B illustrates the dissolving and merging of adjacent map features labeled with the same vegetation type. Image C illustrates the filtering process. Segments smaller than the designated minimum map feature size were merged with similar adjacent map features based on the filtering rule-set.

Map Products

The final map products provide for continuous land cover, vegetation type, tree size, and canopy cover information for the entire DNF. The final maps were formatted as a digital geodatabase, which is compatible with Forest Service corporate GIS software. Categories included: Vegetation Group and Vegetation Type, Canopy Cover Class, and Tree Size Class. The vegetation map is consistent with mid-level mapping standards set forth in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015). These minimum map feature standards were also maintained in the canopy cover and size class maps.

All mapped areas in the subsequent tables are based upon acreage values calculated in the Region 4 Albers Equal Area projection and the version of Automated Lands Project (ALP) Forest Service ownership that is currently archived in the project record. For area comparison purposes, the use of Region 4 Albers Equal Area projection was preferred over a UTM projection due to its more accurate representation of acreage values across the entire geographic area of Region 4. Changes in the ALP data set or using area calculations from other spatial references will result in variations of total acreages. Total values for many of these tables may not add up correctly due to rounding of their corresponding input values. Acreages for the Dixie National Forest include the Teasdale District.

Vegetation Type and Group

A total of 32 vegetation types comprising eight generalized groups were mapped (Table 7). These classes ranged from specific vegetation species (e.g., Ponderosa Pine) to vegetation communities (e.g., Mountain Shrubland) and more general land use types (e.g., Developed).

Table 7: Total acres and percent area of Vegetation Types by Vegetation Groups. Only National Forest System lands were included in the acreage calculations.

Vegetation Type	Area (ac)	% Area
Alpine		
Alpine Vegetation	19,877	1.1
Conifer Forest		
Ponderosa Pine/Woodland	126,958	6.7
Spruce/Fir	91,929	4.9
Ponderosa Pine Mix	90,031	4.8
Ponderosa Pine	89,456	4.7
Douglas-fir Mix	76,845	4.1
White Fir Mix	70,252	3.7
Bristlecone Pine/Limber Pine	11,027	0.6
Blue Spruce	516	0.0
Deciduous Forest		
Aspen/Conifer	152,527	8.1
Aspen	58,807	3.1
Herbland		
Upland Herbaceous	23,325	1.2
Annual Herbaceous	9,794	0.5
Seeded Herbaceous	4,973	0.3
Non-Vegetated/Sparse Vegetation		
Barren/Sparse Vegetation	53,202	2.8
Water	2,092	0.1
Developed	565	0.0
Agriculture	137	0.0
Riparian		
Riparian Woody	7,923	0.4
Riparian Herbaceous	7,114	0.4
Shrubland		
Mountain Big Sagebrush	86,043	4.6
Black Sagebrush	83,252	4.4
Wyoming Big Sagebrush	54,028	2.9
Mountain Shrubland	45,327	2.4
Silver Sagebrush	29,518	1.6
Interior Chaparral	20,559	1.1
Basin Big Sagebrush	15,844	0.8
Desert Shrubland	10,939	0.6
Woodland		
Pinyon-Juniper	496,568	26.3
Gambel Oak	100,912	5.4
Mountain Mahogany	43,219	2.3
Rocky Mountain Juniper Mix	1,838	0.1
Total	**1,885,395**	**100.0**

Tree and Shrub Canopy Cover

A canopy cover map was generated by independently processing tree and shrubland canopy cover (Table 8). All other areas were mapped as having no canopy cover. Canopy cover categories were assembled into a wall-to-wall map for the entire DNF.

Table 8: Total acres and percent area for each tree and shrub canopy cover class. Only National Forest System lands were included in the acreage calculations.

Tree Canopy Cover Class	Area (ac)	% Area
TC1 (10 - 19%)	242,739	17.2
TC2 (20 - 39%)	869,091	61.6
TC3 (40 - 49%)	188,507	13.4
TC4 (50 - 59%)	82,273	5.8
TC5 (≥ 60%)	28,274	2.0
Total	**1,410,884**	**100.0**

Shrub Canopy Cover Class	Area (ac)	% Area
SC1 (10 - 24%)	161,857	45.8
SC2 (25 - 34%)	125,002	35.4
SC3 (≥ 35%)	66,572	18.8
Total	**353,431**	**100.0**

Additional assessment was completed on the tree canopy cover by further splitting those classes into either forest or woodland canopy cover classes. These alternative cover estimates (Table 9) were derived by classifying either forest (conifer forest or deciduous forest) or woodland map groups into their corresponding canopy cover classes (based on its total canopy cover value).

Table 9: Total acres and percent area for each tree (based on dominant forest or woodland species). Only National Forest System lands were included in the acreage calculations.

Tree Canopy Cover Class	Area (ac)	% Area
FC1 (10 - 19%)	114,583	8.1
FC2 (20 - 39%)	417,635	29.6
FC3 (40 - 59%)	211,979	15.0
FC4 (≥ 60%)	24,150	1.7
WC1 (10 - 19%)	128,155	9.1
WC2 (20 - 49%)	494,333	35.0
WC3 (≥ 50%)	20,049	1.4
Total	**1,410,884**	**100.0**

Tree Size

A tree size map was generated for all areas identified as forest or woodland in the existing vegetation map. These lands were classified into one of five forest (timber) size classes or three woodland size classes (Table 10). All other areas were mapped as having no size class. The tree size class map was assembled into a complete coverage for each mapping region and mosaicked for the entire DNF.

Table 10: Total acres and percent area for each tree size class. Only National Forest System lands were included in the acreage calculations.

Tree Size DBH or DRC Class (in)	Area (ac)	% Area
FS1 (0 - 4.9" DBH)	52,222	2.8
FS2 (5 - 11.9" DBH)	434,104	23.0
FS3 (12 - 17.9" DBH)	210,062	11.1
FS4 (18 - 23.9" DBH)	66,406	3.5
FS5 (≥24" DBH)	5,552	0.3
WS1 (0 - 11.9" DRC)	560,444	29.7
WS2 (12 - 17.9" DRC)	71,223	3.8
WS3 (≥18" DRC)	10,870	0.6
NT (Non Tree)	474,511	25.2
Total	**1,885,395**	**100.0**

Accuracy Assessment

An accuracy assessment for a mapped product can be defined as a statistical summary or metric, usually presented as a table, comparing the mapped classes to reference data or “truth”. An accuracy assessment should provide objective information on the quality or reliability of the map, and can be used to determine the utility of the map and its associated risks with respect to specific applications (Nelson et al. 2015). Thus, it is important that the reference information used to conduct accuracy assessments be independent from the information used to produce the map and also be a reliable and unbiased source for representation of ground conditions.

Quantitative inventory data were used for the accuracy assessment on the DNF. This included the most current FIA, base-level, field-collected data available for each plot; consisting of a spatially-complete systematic grid sample for all forest and nonforest lands. This source data spanned a full cycle of ten years (2005-2014) of FIA annual inventory plots on the DNF. Systematic inventory plots provide a spatially balanced estimate of map unit (e.g., vegetation type, canopy cover class, and tree size class) proportions for a population. Below are more detailed discussions concerning: 1) the use of reference datasets for accuracy assessments, 2) the use of the map product from the accuracy assessment perspective, and 3) the accuracy assessment design.

Use of Reference Data Sets for Accuracy Assessments

Reference data is quantitative or qualitative information about ground features necessary to successfully complete a map accuracy assessment. Although the collection of field reference data is not required, some type of reference data is needed to help interpret and/or assess accuracy during a mapping project. Quantitative accuracy assessments usually depend on the collection of reference data, which is assumed to be known information of high accuracy (Brewer et al. 2005).

There is rarely a sufficient sample size to quantify all vegetation types occurring across a geographic area. Important types of naturally small extent, such as riparian communities, are rarely sampled by a systematic or random design. Inventory data, therefore, involves trade-offs between resolution and reliability. It is often necessary to generalize or aggregate vegetation types and/or structural classes in order to achieve the sample sizes needed to provide statistically reliable estimates of the amounts of those types or classes (Brewer et al. 2005).

When data collection protocols for accuracy assessment samples are similar to those of the training samples, then assigning the appropriate map unit label to an accuracy assessment sample is straightforward. If plot designs are dissimilar, then developing a crosswalk and reinterpreting or verifying plot information using high-resolution imagery, or conducting field visits may be necessary. When existing data, such as FIA data, is used to assess map accuracy, consideration should be given to address differences in data collection methods (Stehman and Czaplewski 1998). The following are some limitations that need to be considered when using FIA or other data not explicitly designed for accuracy assessments:

- Size of FIA plot vs. unit of evaluation for the map
- Nature of FIA condition boundaries vs. mapped polygon boundaries
- Vintage of field collected data of annual cycle vs. vintage of imagery
- Insufficient numbers of accuracy assessment sites for less common classes

One consideration when using FIA data is that it is typically collected on a ten year cycle by the Interior West FIA (IWFIA) unit, such that one-tenth of each state is sampled each year. As a result, the average measurement period for a ten year cycle of plot data would be about five years old (such as that for the DNF). An analyst must determine how well the remotely-sensed data used for modeling, which may have been taken during one or more years, will coincide temporally with ten years' worth of measurement dates for the plot data. Such differences may cause additional accuracy errors if there were significant disturbances in vegetation types or cover during that time.

Although the use of FIA data as a reference data set for accuracy assessments has its limitations, it also has many advantages. FIA data are a statistically robust, spatially distributed, unbiased sample that is updated annually over a ten year cycle. It has well-established and consistent data collection protocols that facilitate multi-temporal comparability and long-term usage. FIA data are also readily available to users.

FIA data can be used early in the classification scoping process to identify or distinguish rare (less than one percent of area on a Forest), uncommon (one to ten percent), and common (greater than ten percent) classes. Rare classes are typically too spatially-limited for normal mid-level mapping processes, and may need to be "burned in" (incorporated) later using local knowledge from Forest Service employees. This process can help make the mapping process more efficient by reducing the number of initial classes and/or the number of classes that may need further collapsing following an accuracy assessment based on too few samples. Other sources of reference information are often needed (e.g., intensified, stratified, or photo-interpreted data) for less common classes.

Use of Map Products

Map features (e.g., polygons) rarely have homogeneous characteristics; instead, they usually contain varying proportions of vegetation, structure, and cover class mixtures. Therefore, map products should be used within the context of the map unit and the associated dominance type descriptions.

The map assessment may identify map units with low accuracy. These map units may meet the desired thematic detail but not the desired thematic accuracy. By assessing the error structure relative to the mapping objectives and management questions, map units can be combined into new, more generalized map units that better meet accuracy requirements. Merging map units is not an edit or a correction to the final map; rather, this process is a generalization of the map legend to achieve an acceptable compromise between thematic detail and classification accuracy (Nelson et al. 2015).

Accuracy Assessment Design

The three basic components of an accuracy assessment are: sample design, response design, and the analysis protocol (Stehman and Czaplewski 1998). The sample design determines the plot design and the distribution of sites across the landscape. The response design determines how the sites are labeled or assigned to map units. The analysis protocol summarizes the results of information obtained from the sampling and response designs.

Sample design and sample size (number of samples) are important considerations for an efficient accuracy assessment. The *sample design* should be statistically and scientifically valid. The sampling unit (i.e., polygon or point) should be identified early in the process since it affects much of the plot design. While training data used for producing a map may be collected according to a preferential or representative sampling scheme (purposive sampling), data used for an accuracy assessment should be collected using an unbiased approach where samples have a known probability of selection (Stehman and Czaplewski 1998). The number of sample sites should be large enough to be statistically sound but not larger than necessary for the sake of efficiency. The need for statistical validity is often balanced with practical considerations, such as time and budget constraints (Nelson et al. 2015).

The *response design* includes procedures for collecting the accuracy assessment samples and protocols for assigning a map unit label to each accuracy assessment sample (Stehman and Czaplewski 1998). If an existing data set is used, then the information needs to be deemed sufficient for assigning a map unit label. Additional information or interpretations may be needed as well.

The *analysis protocol* summarizes the results of information obtained from the sampling and response designs (Stehman and Czaplewski 1998). A primary objective of an accuracy assessment is to quantify the level of agreement between mapped and observed attributes. This is most often performed for classified (categorical) maps by creating an error matrix, and deriving the accuracies from that matrix. The error matrix is the standard way of presenting results of an accuracy assessment (Story and Congalton 1986). This matrix is a cross-tabulation table (array) that shows the number of reference sites found in every combination of reference data category and map unit category. Agreement can also be measured by comparing the similarity of the mapped and observed proportions of the attributes within the mapped area.

Quantitative Inventory

Quantitative vegetation inventory consists of applying an objective set of sampling methods to quantify the amount, composition, condition, and/or productivity of vegetation within specified limits of statistical precision. To be most useful, a quantitative inventory must have a statistically valid sample design, use unbiased sampling methods, and provide both population and reliability estimates (Brewer et al. 2005).

Phase 2 FIA Base-level Inventory

The FIA program of the USDA Forest Service has been in continuous operation since 1930. Their mission is to conduct and continuously update a comprehensive inventory and analysis of the present and prospective conditions of the renewable resources of the forests and rangelands of the United States. This national program consists of four regional FIA units. The IWFIA unit, part of the Rocky Mountain Research Station, conducts inventories throughout National Forest System Regions 1, 2, 3 and 4.

Forest Lands

Although FIA's mission includes rangeland assessments, it was only funded to conduct forest land inventories. The Phase 2 forest inventory consists of permanently establishing field sampled plots distributed across each state with a sample intensity of about one plot per 6,000 acres. Field data are typically collected only on plot locations where forest land is present. In general, forest land has at least ten percent canopy cover of live tally tree species of any size or has had at least ten percent canopy cover of live tally species in the past; based on the presence of stumps, snags, or other evidence. Each plot consists of a cluster of four subplots that fall within a 144-foot radius circle based on the plot center spread out over approximately 1.5 acres. Most Phase 2 data are related to tree and understory vegetation components of the forest. Plots are distributed across all ownerships throughout the United States; therefore, there are a number of plots in proportion to the extent of a vegetation type on the landscape.

For more details on the national FIA program visit http://www.fia.fs.fed.us/ or for the IWFIA program at http://www.fs.fed.us/rm/ogden/.

All Condition Inventory

The USFS Intermountain Region (Region 4) has entered into an agreement with IWFIA to conduct an "All Condition Inventory" (ACI) on Region 4 National Forest System (NFS) lands, which is a base-level, quantitative inventory that collects similar vegetation information on both forest and nonforest conditions throughout the Region. ACI was initiated as a joint effort by FIA and the USFS Northern Region (Region 1), in which the protocol was adapted and expanded to meet Region 4 needs. As an extension of the grid-based forest land inventories that IWFIA conducts on all ownerships throughout the Interior West states, ACI will result in a consistent and unbiased wall-to-wall inventory on all Region 4 NFS forest and nonforest lands. A nonforest condition includes all lands not considered a forest condition by FIA's definition of forested lands. Thus, the Northern and Intermountain Regions have collaborated with IWFIA to conduct a seamless inventory with the same data collection protocols on all NFS lands regardless of the presence or absence of tree cover.

Methods

In general, quantitative inventory data from FIA plots can be used for many assessments or as complementary information for other projects. Mid-level vegetation mapping typically produces three layers of information: dominance type, canopy cover, and tree size. Since the inventory data are a true sample (systematic and random) of these characteristics across the landscape (e.g., a national forest, county, or state), the data can be used in ways that complement the mapping process, as an independent data set to assess the accuracy of the maps, or both. For mid-level mapping purposes, there are several ways in which the inventory data can be used:

1. Understanding the proportional distributions of forest dominance types, tree sizes and canopy cover across a map project area for map unit design and intermediate map evaluation purposes
2. Designed-based (e.g., FIA plots) vs. model-based area estimate comparisons of the final map products (non-site-specific)
3. Site-specific accuracy assessment

The methods used for data preparation and classification, non-site-specific area estimate comparison, and site-specific accuracy assessment are discussed below for this project using FIA base-level plot data. The set of FIA base-level plots used for this accuracy assessment are referred to in the subsequent accuracy assessment subsections of this report as “inventory” plots.

Data Preparation and Classification

The first step in the data preparation process was acquiring data. Before classification began, it was necessary to query data from IWFIA’s regional database, join the proper tables, and calculate variables used in this process. Quality control checks were run on previously populated and vetted statewide national databases to assure that plot-level and condition-level estimates (e.g., live basal area per acre estimates, understory vegetation species, and lifeform cover estimates) were correct.

The next step was assigning dominance types to the plot/condition-level data (some plots have multiple conditions) in conjunction with the classification criteria outlined in the DNF Existing Vegetation Keys (Appendix C). This complicated step involved separating plots and their plot conditions into many categories in order to use the appropriate available information for a particular condition’s characteristics. The FIA plot layout and an example scenario where more than one condition exists on a plot are illustrated in Appendix J.

Species-level canopy cover data were available for all lifeforms except trees. A variable collected on all plots “total live crown cover for all tree species” was used to determine necessary thresholds for forest and woodland dominance types. Basal area (BA) by species was used to calculate total crown cover by tree species, and then used within the key.

The following lists summarize the primary steps involved in assigning vegetation dominance types, tree size, and crown cover.

Vegetation dominance type steps included:

- Calculate live BA per acre estimates by species
- Convert to percentages of total live BA by species
- Identify species with plurality of percent live BA
- Use live BA percentages as a surrogate in the classification key for identifying species that are the most abundant in terms of relative cover
- Where necessary in classification key, use total cover to convert to absolute cover
- Determine general plot vegetation characteristics based upon vegetation groups and allocate into classes

- Based on plot and plot/condition information, assign the appropriate dominance type, vegetation type, and vegetation group according to classification key for each plot/condition
- Determine if plot data are relevant due to potential disturbance since plot measurement. If they are not relevant, determine another method of assigning dominance type information (imagery, plot photos, notes, etc.) so that plot information is current with map information

Tree Size steps included:

- Calculate live BA per acre estimates by diameter class and plot/conditions
- Convert to percentages of total live BA by diameter class and species
- Identify diameter class with plurality of percent live BA
- Assign diameter classes to plot/conditions
- Determine if plot data are relevant due to potential disturbance since plot measurement. If they are not relevant, determine another method of assigning tree size information (imagery, plot photos, notes, etc.) so that plot information is current with map information

Canopy cover steps included:

- Use total live tree cover (greater than 10 percent) attribute to determine forest and woodland conditions
- If total live tree cover is less than 10 percent, then use understory vegetation cover estimates by lifeform and species to determine nonforest cover classes
- Determine if plot data are relevant due to potential disturbance since plot measurement. If they are not relevant, determine another method of assigning crown or shrub cover information (imagery, plot photos, notes, etc.) so that plot information is current with map information

Non-Site-Specific Accuracy Assessment

A non-spatial comparison of design-based (inventory) vs. model-based (mapped) area outputs is one approach of assessing a final map. Such a comparison was, in-part, the reason that the Forest Service management decision appeal was affirmed in the Mission Brush Case (Lands Council vs. McNair 2008). Designed-based estimates such as those obtained by using FIA plot data provide an excellent source of accuracy assessment information since it is a true systematic random sample.

Stratification for Area Estimates

Area expansion factors are generated for each inventory plot/condition, which signifies the area that an inventory plot represents at the population level. The stratification process is an important step in determining area estimates from inventory data as it provides an area representation from which area expansions can be determined. A stratification crosswalk was used for the DNF to classify plots into generalized categories based upon their map-assigned strata (Table 11). Vegetation groups were classed into one of ten strata, based upon their vegetation characteristics. Some vegetation groups with relatively large acreages were given their own strata layer, which typically assists in the inventory estimation process.

These data were considered a legitimate, unbiased sample because the inventory plots were spatially-distributed, unbiased estimates, and all data collection protocols were consistent (whether forest or nonforest). There were a total of 374 plot/conditions used for the area estimation from a total of 317 inventory plot locations (non-sampled plot/conditions were not considered in the area estimation process). As part of the plot data collection protocol, conditions are mapped and sampled separately for each plot since they are considered an area of relatively uniform ground cover (i.e., homogeneous vegetation cover), which allows area weights to be assigned using condition proportions. Based upon the area of the strata and the distribution of plots, an area expansion factor was applied to each plot/condition based upon the strata value.

Table 11: Inventory plots were grouped into generalized map strata using their vegetation map unit and the following crosswalk. These general strata classifications help inform the inventory estimation process by assigning plots to strata. Six map units (Rocky Mountain Juniper Mix, Bristlecone Pine/Limber Pine, Blue Spruce, Agriculture, Developed, and Water) were omitted from this table since they had zero acres (i.e., no FIA plot intersected these map units).

STRATA	Vegetation Map Unit	Acres
Pinyon-Juniper_mix	Pinyon-Juniper	498,406
Ponderosa_Pine_mix	Ponderosa Pine/Woodland	138,365
	Ponderosa Pine Mix	88,199
	Ponderosa Pine	79,881
Sage_mix	Black Sagebrush	121,252
	Mountain Big Sagebrush	64,760
	Basin Big Sagebrush	33,069
	Wyoming Big Sagebrush	33,069
	Silver Sagebrush	16,534
Conifer_mix	Spruce/Fir	99,604
	White Fir Mix	79,372
	Douglas-fir Mix	71,591
Aspen_mix	Aspen/Conifer	151,199
	Aspen	60,136
Woodland_mix	Gambel Oak	112,288
	Mountain Mahogany	31,843
Shrubland_mix	Mountain Shrubland	34,144
	Interior Chaparral	25,608
	Desert Shrubland	17,072
Herbland_Alpine_mix	Upland Herbaceous	17,837
	Alpine Vegetation	17,837
	Seeded Herbaceous	13,378
	Annual Herbaceous	8,918
Barren_Sparse_Veg	Barren/Sparse Vegetation	55,996
Riparian_mix	Riparian Woody	7,519
	Riparian Herbaceous	7,519
Total		**1,885,395**

Site-Specific Accuracy Assessment

Another use for a quantitative inventory (e.g., FIA plots) is for conducting site-specific accuracy assessments on existing vegetation mid-level map products. The use of all plots was necessary so that the systematic, unbiased nature of the grid was not compromised. This assessment was completed by comparing the center subplot centroid location of an FIA plot (Appendix J) to the spatially-coincident location of a mapped polygon feature.

It was determined that to best portray map accuracy, the assessment would be performed on the final map features, and not the intermediate modeled segments, which serve as the building blocks for the final map product. This resulted in polygons that were at least the same size but more often larger than assessment segments, which allowed a larger percentage of plots to fit entirely within an evaluation unit, which reduced the number of plots that potentially straddled segments. Consequently, some polygons were relatively large. Due to the inherent differences between the inventory sample design and map characteristics, the inventory sample design (e.g., size of plot), the field data collection protocols, and the defining attributes (forest type, tree size, tree cover density, etc.) associated with inventory vegetation condition boundaries were often not in complete alignment with the size or characteristics of the mid-level mapped polygon boundaries.

As noted in the "Data Preparation and Classification" section, FIA plot data were evaluated to determine if they were still relevant due to potential disturbances (primarily stand-altering wildfires) since plot measurement occurred, or before plot measurement occurred for fire disturbances after 2011, which was the earliest primary remotely-sensed imagery date used for producing the map (Appendix A). After obtaining fire history data, it was determined that 53 FIA plot/conditions were within the burn perimeters of major wildfires for the DNF. From those 53 plot/conditions, additional inspection was performed to compare fire disturbance year against both plot measurement year and imagery date (i.e., plots that were significantly disturbed by fire between the timeframe of plot measurement and imagery date were analyzed further). It was determined that five plot/conditions were altered enough by fire disturbance to categorize them as "not relevant". Consequently, the corresponding data (vegetation types, tree sizes, cover estimates, etc.) for these five plot/conditions were updated with additional, more relevant data (imagery, plot photos, field crew notes, etc.) so that plot information would be current with map information (i.e., both remotely-sensed data and plot data were again in sync regarding the fire disturbance).

Prior accuracy assessments used an involved process of analyzing inventory plots against map polygons by applying decision rules regarding the use of plots based upon their location within a polygon and/or near a polygon edge. For the DNF assessment, it was decided to objectively use the subplot center location without any adjustments. This process allows for a more objective and repeatable accuracy assessment.

Results

Non-Site-Specific Accuracy Assessment

Classification and stratification of inventory plot/conditions for generating area estimates was performed, resulting in area estimates for vegetation group, vegetation type, tree size class (forest and woodland), and canopy cover class (tree and shrub). Total values of area estimates for many of these tables may not add up correctly due to rounding of their corresponding input values.

Area Estimates Based on Inventory Plots

The source data set for this analysis was obtained from approximately ten years (2005 to 2014) of FIA data; including All Condition Inventory (ACI) data, which were gathered to gain a representation of nonforest plots. There were a total of 374 plot/conditions available for area estimation from a total of 317 inventory plot locations. When plots have more than one vegetation condition, condition-level plot data was used for area estimates. While the area classification focused on the condition level data, the site-specific accuracy assessment focused on plot level information and its spatial relationship to the mapped polygons.

Summarized inventory data results for predicted area, percent area, and number of plot/conditions by five map attributes (vegetation group, vegetation type, tree size class, tree canopy cover class, and shrub canopy cover class) are presented in the following sections.

Vegetation Group Area Estimates

Area estimates for eight vegetation group categories on the DNF are presented in Table 12. Approximately 75 percent of the DNF is in forest and woodland groups, while about 25 percent are in nonforest groups. The Woodland group is the largest with nearly 38 percent total area, followed by the Conifer Forest group covering 25 percent. The Shrubland group is 12 percent, while the remaining groups are less than ten percent of the area. The DNF had relatively few inventory plot/conditions representing riparian (three) or alpine (two) vegetation groups.

Table 12: Inventory-estimated area (acres), percentage of total area, and number of FIA plot/conditions listed by both forest/nonforest and vegetation group categories for the DNF.

Vegetation Group	Area (ac)	% Total Area	Number of Plot/Conditions
Forest and Woodland			
Woodland	710,716	37.7	133
Conifer Forest	470,726	25.0	90
Deciduous Forest	228,527	12.1	42
Forest and Woodland Total	**1,409,968**	**74.8**	**265**
Nonforest			
Shrubland	226,251	12.0	48
Non-Vegetated/Sparse Vegetation	129,638	6.9	34
Herbland	99,880	5.3	22
Riparian	10,739	0.6	3
Alpine	8,918	0.5	2
Nonforest Total	**475,426**	**25.2**	**109**
Total	**1,885,395**	**100.0**	**374**

Vegetation Type Area Estimates

Area estimates for 28 vegetation type categories on the DNF are presented in Table 13. Pinyon-Juniper vegetation type covered the largest area with nearly 29 percent of the DNF (by acres), followed by Aspen/Conifer (nine percent), Barren/Sparse Vegetation (seven percent), Spruce/Fir (six percent) and White Fir Mix (five percent). The remaining vegetation types each composed less than five percent of the total area. Fourteen vegetation types also had less than ten classified inventory samples each, which reflects the relative scarcity of occurrence of those types across the DNF. Vegetation types without any inventory samples (Agriculture, Developed, Desert Shrubland and Blue Spruce) were not included in this table.

Table 13: Inventory-estimated area (acres), percentage of total area, and number of plot/conditions by both forest/nonforest and vegetation type categories for the DNF. Vegetation types without inventory samples (Agriculture, Developed, Desert Shrubland, and Blue Spruce) were not listed.

Vegetation Type	Area (ac)	% Total Area	Number of Plot/Conditions
Forest and Woodland			
Pinyon-Juniper	542,738	28.8	100
Aspen/Conifer	172,219	9.1	27
Spruce/Fir	106,747	5.7	21
White Fir Mix	101,247	5.4	19
Ponderosa Pine	91,042	4.8	17
Gambel Oak	76,889	4.1	14
Ponderosa Pine/Woodland	71,615	3.8	15
Rocky Mountain Juniper Mix	59,453	3.2	13
Aspen	56,308	3.0	15
Douglas-fir Mix	53,097	2.8	9
Ponderosa Pine Mix	35,274	1.9	6
Mountain Mahogany	31,635	1.7	6
Bristlecone Pine/Limber Pine	11,703	0.6	3
Forest and Woodland Total	**1,409,968**	**74.8**	**265**
Nonforest			
Barren/Sparse Vegetation	123,818	6.6	32
Upland Herbaceous	66,644	3.5	16
Mountain Shrubland	54,367	2.9	12
Black Sagebrush	52,449	2.8	11
Mountain Big Sagebrush	46,231	2.5	11
Wyoming Big Sagebrush	32,017	1.7	6
Interior Chaparral	26,651	1.4	4
Seeded Herbaceous	18,507	1.0	3
Annual Herbaceous	14,729	0.8	3
Riparian Herbaceous	9,270	0.5	2
Basin Big Sagebrush	9,025	0.5	3
Alpine Vegetation	8,918	0.5	2
Water	5,820	0.3	2
Silver Sagebrush	5,511	0.3	1
Riparian Woody	1,468	0.1	1
Nonforest Total	**475,426**	**25.2**	**109**
Total	**1,885,395**	**100.0**	**374**

Tree Size Class Area Estimates

Area estimates for nine tree size classes on the DNF are presented in Table 14 Tree size class area was estimated for forest species (FS1-FS5), woodland species (WS1-WS3) and non tree (NT) categories. Non Tree was the most common class (NT, 25 percent), followed by Woodland Size Class 1 (WS1, over 21 percent), which represents the 0 - 11.9" DRC diameter class. The most common forest class was Forest Size Class 2 (FS2, 5 - 11.9" DBH), which covers 19 percent of the DNF. Tree size classes less than 12" diameter (FS1, FS2, WS1) spanned about half (42 percent) of the total area, while those classes with 18" or larger diameters (FS4, FS5, WS3) accounted for 17 percent.

Table 14: Inventory-estimated area (acres), percentage of total area, and number of plot/conditions by tree size classes for forest species (FS1-FS5), woodland species (WS1-WS3), and non tree (NT) for the DNF.

Tree Size Code	Tree Size Class DBH or DRC (in)	Area (ac)	% Total Area	Number of Plot/Conditions
Forest				
FS1	0 - 4.9" DBH	35,723	1.9	10
FS2	5 - 11.9" DBH	364,963	19.4	64
FS3	12 - 17.9" DBH	157,679	8.4	31
FS4	18 - 23.9" DBH	82,624	4.4	17
FS5	≥ 24" DBH	58,264	3.1	10
Woodland				
WS1	0 - 11.9" DRC	399,573	21.2	74
WS2	12 - 17.9" DRC	128,572	6.8	26
WS3	≥ 18" DRC	182,571	9.7	33
Non Tree				
NT	Non Tree	475,426	25.2	109
Total		**1,885,395**	**100.0**	**374**

Canopy Cover Class Area Estimates

Area estimates for nine canopy cover classes on the DNF are presented in Table 15. Canopy cover area was estimated for both tree and shrubland canopies. The tree cover classes (TC) were primarily dominated by Pinyon-Juniper, Aspen/Conifer, Spruce/Fir, White Fir Mix and Ponderosa Pine vegetation types, while the shrubland cover classes (SC) were mostly comprised of Mountain Shrubland, Black Sagebrush, Mountain Big Sagebrush and Wyoming Big Sagebrush (Table 13). The most prevalent cover class was TC2 at nearly 32 percent total area, followed by

NT/NS (Non Tree/ Non Shrub) at 13 percent. The cover classes of TC3, TC4 and TC5 are each around 12 percent of the DNF, while the remaining cover classes are below ten percent. Tree cover classes make up almost 75 percent of the total area, while shrubland cover classes encompass about 12 percent. The primary reason for the large representation of areas in the tree cover classes is the prevalence of Pinyon-Juniper vegetation type across the DNF.

Table 15: Inventory-estimated area (acres), percentage of total area, and number of plot/conditions by tree and shrub canopy cover classes for the DNF.

Canopy Cover Code	Canopy Cover Class	Area (ac)	% Total Area	Number of Plot/Conditions
Tree				
TC1	10 - 19%	144,160	7.6	32
TC2	20 - 39%	601,978	31.9	113
TC3	40 - 49%	229,879	12.2	40
TC4	50 - 59%	224,757	11.9	40
TC5	≥ 60%	209,194	11.1	40
Shrub				
SC1	10 - 24%	155,636	8.3	34
SC2	25 - 34%	24,875	1.3	5
SC3	≥ 35%	47,209	2.5	10
Non Tree/Non Shrub				
NT/NS	Non Tree/Non Shrub	247,707	13.1	60
Total		**1,885,395**	**100.0**	**374**

In addition, canopy cover estimates based on the alternative canopy cover procedure were derived for tree (based on dominant forest or woodland species) and shrubland canopies (Table 16). The most prevalent cover class was WC2 with 26 percent total area, followed by FC3 and NT/NS at 13 percent, then FC2 with 11 percent. The remaining classes were each ten percent or less total area. Forest cover classes make up 37 percent of the total area, while woodland classes span almost 38 percent and shrubland classes encompass about 12 percent.

Table 16: Inventory-estimated area (acres), percentage of total area, and number of plot/conditions for tree (based on dominant forest or woodland species) and shrub canopy cover classes on the DNF.

Canopy Cover Code	Canopy Cover Class	Area (ac)	% Total Area	Number of Plot/Conditions
Forest				
FC1	10 - 19%	66,452	3.5	14
FC2	20 - 39%	221,047	11.7	43
FC3	40 - 59%	259,134	13.7	47
FC4	≥ 60%	152,619	8.1	28
Woodland				
WC1	10 - 19%	77,708	4.1	18
WC2	20 - 49%	494,158	26.2	89
WC3	≥ 50%	138,850	7.4	26
Shrub				
SC1	10 - 24%	155,636	8.3	34
SC2	25 - 34%	24,875	1.3	5
SC3	≥ 35%	47,209	2.5	10
Non Tree/Non Shrub				
NT/NS	Non Tree/Non Shrub	247,707	13.1	60
Total		**1,885,395**	**100.0**	**374**

Comparisons of Mapped to Inventory Area Estimates

In general, map units with many categories such as vegetation type tend to have more discrepancies between the mapped area estimates and field sampled occurrences. This is probably due to more and finer thresholds hindering recognition of class spectral signatures, and may also be due in part to limitations in the number of accuracy assessment sites available from quantitative inventory plots.

Vegetation Group Comparisons

An examination was performed to compare inventory-derived estimates and mapped area acreages for the eight vegetation groups of the DNF (Table 17 and Figure 7). The Woodland vegetation group composes more than 34 percent of map area and 37 percent of inventory area. The Conifer Forest group spanned nearly 30 percent of map area and 25 percent of inventory area. Agreements between the map and inventory area estimates for most vegetation groups were relatively close (Figure 7). The largest discrepancy between inventory and mapped area was exhibited in the Shrubland class (six percent difference), followed by the Conifer Forest class (four percent difference). The remaining vegetation groups were all less than four percent difference in area estimates for the DNF. Discussions regarding inventory confidence interval estimates and an error matrix component of this report will further evaluate these acreage differences.

Table 17: Mapped versus inventory-based estimates of area by existing vegetation groups for the DNF. Acreage and Percent Differences are based on the difference of total area between mapped and inventory estimates. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Veg Group Code	Vegetation Group Class	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
W	Woodland	642,537	34.1	710,716	37.7	-68,179	-3.6
C	Conifer Forest	557,013	29.5	470,726	25.0	86,287	4.5
S	Shrubland	345,508	18.3	226,251	12.0	119,257	6.3
D	Deciduous Forest	211,334	11.2	228,527	12.1	-17,193	-0.9
N	Non-Vegetated/ Sparse Veg.	55,996	3.0	129,638	6.9	-73,642	-3.9
H	Herbland	38,093	2.0	99,880	5.3	-61,787	-3.3
A	Alpine	19,877	1.1	8,918	0.5	10,959	0.6
R	Riparian	15,038	0.8	10,739	0.6	4,299	0.2
Total		**1,885,395**	**100.0**	**1,885,395**	**100.0**	**n/a**	**n/a**

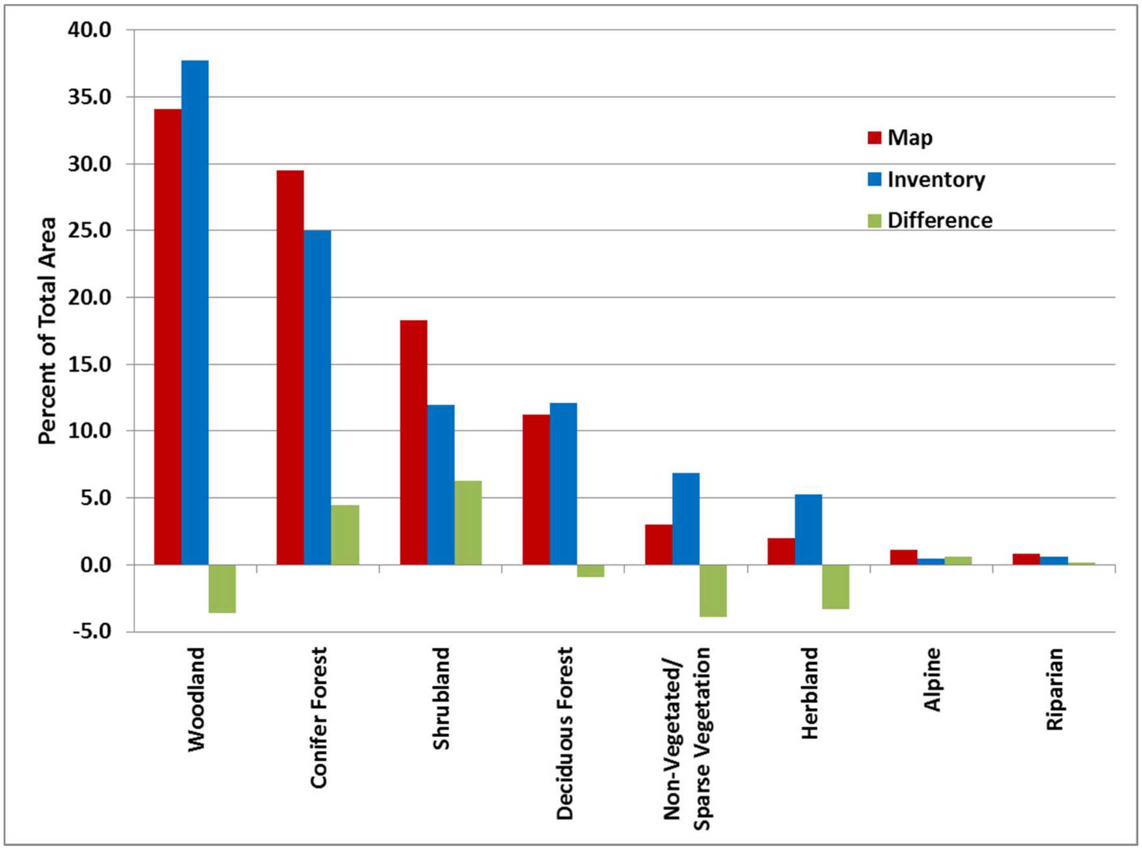

Figure 7: Comparison of mapped and inventory-based estimates of area as a percentage of total area, by vegetation group on the DNF. A positive difference indicates mapped acres exceed inventory acres for that group, while a negative difference shows that inventory acres exceed mapped acres.

Confidence Interval (95 Percent Standard Error) for Vegetation Groups

Using the Forest Inventory Estimation for Analysis tool (FIESTA) (Frescino et al. 2012), it is possible to generate 95 percent standard error values around area estimates of sampled inventory data. By definition, these standard error values represent a 95 percent statistical likelihood that the true value of the estimate ranges within the bounds of the confidence intervals. However, standard error values are highly influenced by sample size. In some cases, map classes are not represented well within the inventory data, which may result in relatively large confidence intervals. The FIESTA-based estimates are more appropriate for classes with high sampled area representations. The bounding values give a better idea of where the area estimates should fall, which also informs the accuracy assessment of the maps.

Area estimates from the map product for three vegetation groups (Deciduous Forest, Alpine and Riparian) were within their corresponding 95 percent confidence interval values based on their inventory-based estimates (Figure 8). The remaining five vegetation groups fell outside their corresponding confidence interval values, although the Woodland and Herbland groups were relatively close. Overall, there was still relatively good agreement between the map-based and inventory-based area estimates, with less than three percent average difference in total area across the eight vegetation groups of the DNF. The error matrices presented later in this report may assist in determining where confusion among vegetation groups might have occurred during the mapping process.

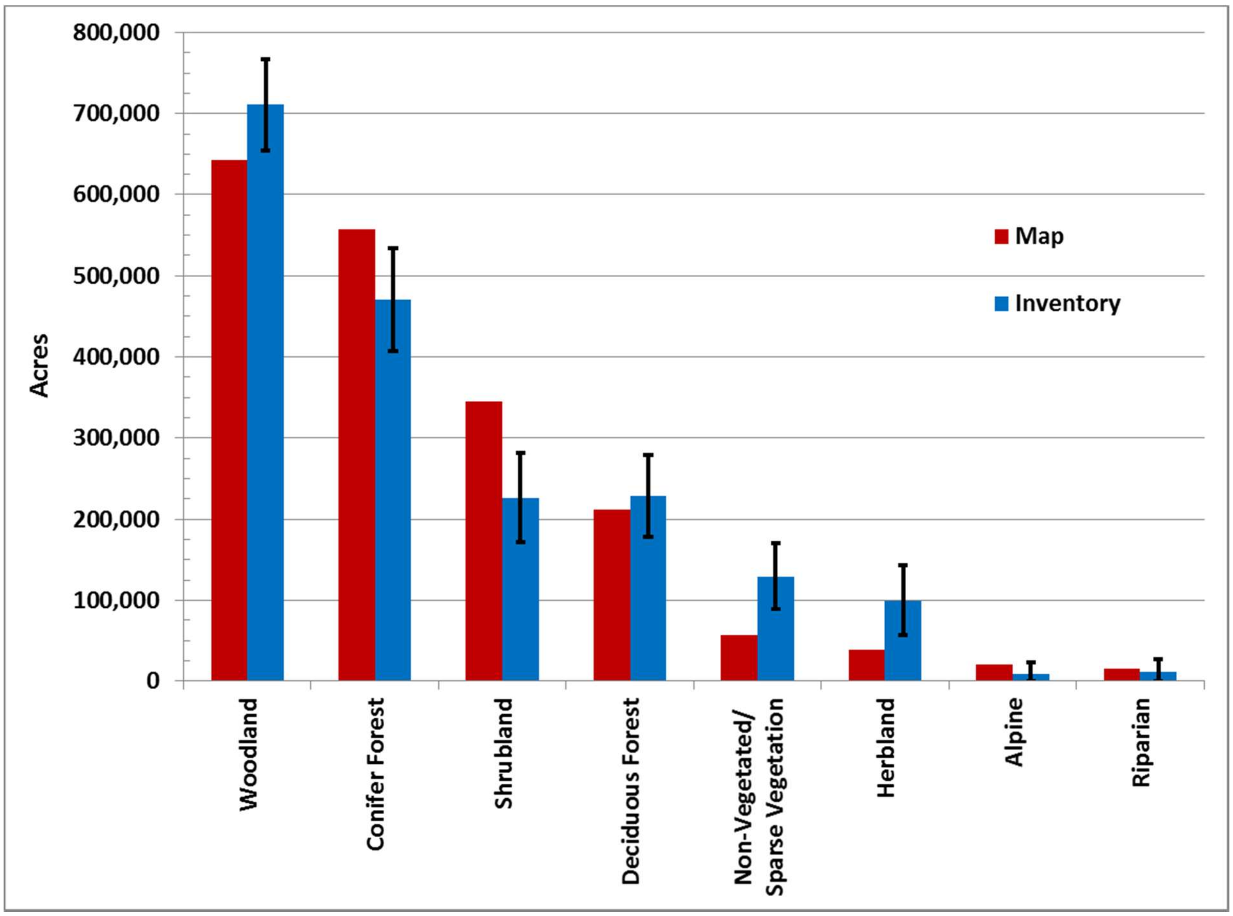

Figure 8: Comparison of mapped and inventory-based estimates of area by vegetation group on the DNF. The 95 percent standard error bars, as derived from the FIESTA program, were added to the inventory-based estimate.

Vegetation Type Comparisons

Vegetation type area estimates were compared between mapped and inventory-predicted areas (Table 18 and Figure 9). Note that the vegetation type which covers the largest amount of map acres (i.e., Pinyon-Juniper) encompass 26 percent of the total map area, and is less than three percent total area than its corresponding inventory area, which demonstrates relatively good agreement for the largest vegetation type by this modeling procedure.

The largest difference in percent area for all vegetation types was Barren/Sparse Vegetation, which was predicted almost four percent less area on the map than when compared to the inventory (Table 18, Figure 9 and Figure 10). The second largest difference was Rocky Mountain Juniper Mix, which was predicted by three percent less area on the map than the inventory. There are multiple vegetation types with disagreements between the map and inventory-based estimates of area. But overall, the proportion of these differences does not seem very significant compared to the magnitude of the acreage amounts. Note that Agriculture, Developed, Desert Shrubland, and Blue Spruce vegetation types did not have any inventory samples, and consequently do not have any associated inventory acres.

As for the Woodland group, those four vegetation types (i.e., Mountain Mahogany, Gambel Oak, Pinyon-Juniper, and Rocky Mountain Juniper Mix) had a respectable overall agreement between the map predictions (34 percent) and inventory estimates (37 percent), with less than four percent difference combined. Also, those eight vegetation types that compose the Conifer Forest group (i.e., Bristlecone Pine/Limber Pine, Douglas-fir Mix, Spruce/Fir, Blue Spruce, Ponderosa Pine, Ponderosa Pine Mix, Ponderosa Pine/Woodland, and White Fir Mix) had a similar overall agreement between the map predictions (29 percent) and the inventory estimates (25 percent), with less than five percent difference combined. However, when the vegetation types for the Woodland and Conifer Forest groups are combined, their overall agreement between map and inventory estimates is about one percent.

In general, comparisons of map units with less than ten inventory plot/conditions are typically not recommended as it may produce unreliable inventory-based area estimates. A more appropriate technique may be to combine some of these map units, when appropriate, so they are represented by a larger number of inventory plot/conditions. Misclassifications and confusion areas will be delineated in the error matrix portion of the report.

Table 18: Mapped versus inventory-based estimates of area by existing vegetation types on the DNF. Acreage and Percent Differences are based on the difference of total area between mapped and inventory estimates. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres. Vegetation classes are sorted by descending map acres.

Vegetation Class	Code	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
Pinyon-Juniper	PJ	496,568	26.3	542,738	28.8	-46,170	-2.5
Aspen/Conifer	AS/C	152,527	8.1	172,219	9.1	-19,692	-1.0
Ponderosa Pine/Woodland	PP/WD	126,958	6.7	71,615	3.8	55,343	2.9
Gambel Oak	GO	100,912	5.4	76,889	4.1	24,023	1.3
Spruce/Fir	SF	91,929	4.9	106,747	5.7	-14,818	-0.8
Ponderosa Pine Mix	PPmix	90,031	4.8	35,274	1.9	54,757	2.9
Ponderosa Pine	PP	89,456	4.7	91,042	4.8	-1,586	-0.1
Mountain Big Sagebrush	MSB	86,043	4.6	46,231	2.5	39,812	2.1
Black Sagebrush	BLSB	83,252	4.4	52,449	2.8	30,803	1.6
Douglas-fir Mix	DFmix	76,845	4.1	53,097	2.8	23,748	1.3
White Fir Mix	WFmix	70,252	3.7	101,247	5.4	-30,995	-1.7
Aspen	AS	58,807	3.1	56,308	3.0	2,499	0.1
Wyoming Big Sagebrush	WSB	54,028	2.9	32,017	1.7	22,011	1.2
Barren/Sparse Vegetation	BR/SV	53,202	2.8	123,818	6.6	-70,616	-3.8
Mountain Shrubland	MS	45,327	2.4	54,367	2.9	-9,040	-0.5
Mountain Mahogany	MM	43,219	2.3	31,635	1.7	11,584	0.6
Silver Sagebrush	SSB	29,518	1.6	5,511	0.3	24,007	1.3
Upland Herbaceous	UHE	23,325	1.2	66,644	3.5	-43,319	-2.3
Interior Chaparral	CHAP	20,559	1.1	26,651	1.4	-6,092	-0.3
Alpine Vegetation	ALP	19,877	1.1	8,918	0.5	10,959	0.6
Basin Big Sagebrush	BSB	15,844	0.8	9,025	0.5	6,819	0.3
Bristlecone Pine/Limber Pine	BC/LM	11,027	0.6	11,703	0.6	-676	0.0
Desert Shrubland	DSH	10,939	0.6	0	0.0	10,939	0.6
Annual Herbaceous	AHE	9,794	0.5	14,729	0.8	-4,935	-0.3
Riparian Woody	RW	7,923	0.4	1,468	0.1	6,455	0.3
Riparian Herbaceous	RHE	7,114	0.4	9,270	0.5	-2,156	-0.1
Seeded Herbaceous	SHE	4,973	0.3	18,507	1.0	-13,534	-0.7
Water	WA	2,092	0.1	5,820	0.3	-3,728	-0.2
Rocky Mountain Juniper Mix	RMJmix	1,838	0.1	59,453	3.2	-57,615	-3.1
Developed	DEV	565	0.0	0	0.0	565	0.0
Blue Spruce	BS	516	0.0	0	0.0	516	0.0
Agriculture	AGR	137	0.0	0	0.0	137	0.0
Total		**1,885,395**	**100.0**	**1,885,395**	**100.0**	**n/a**	**n/a**

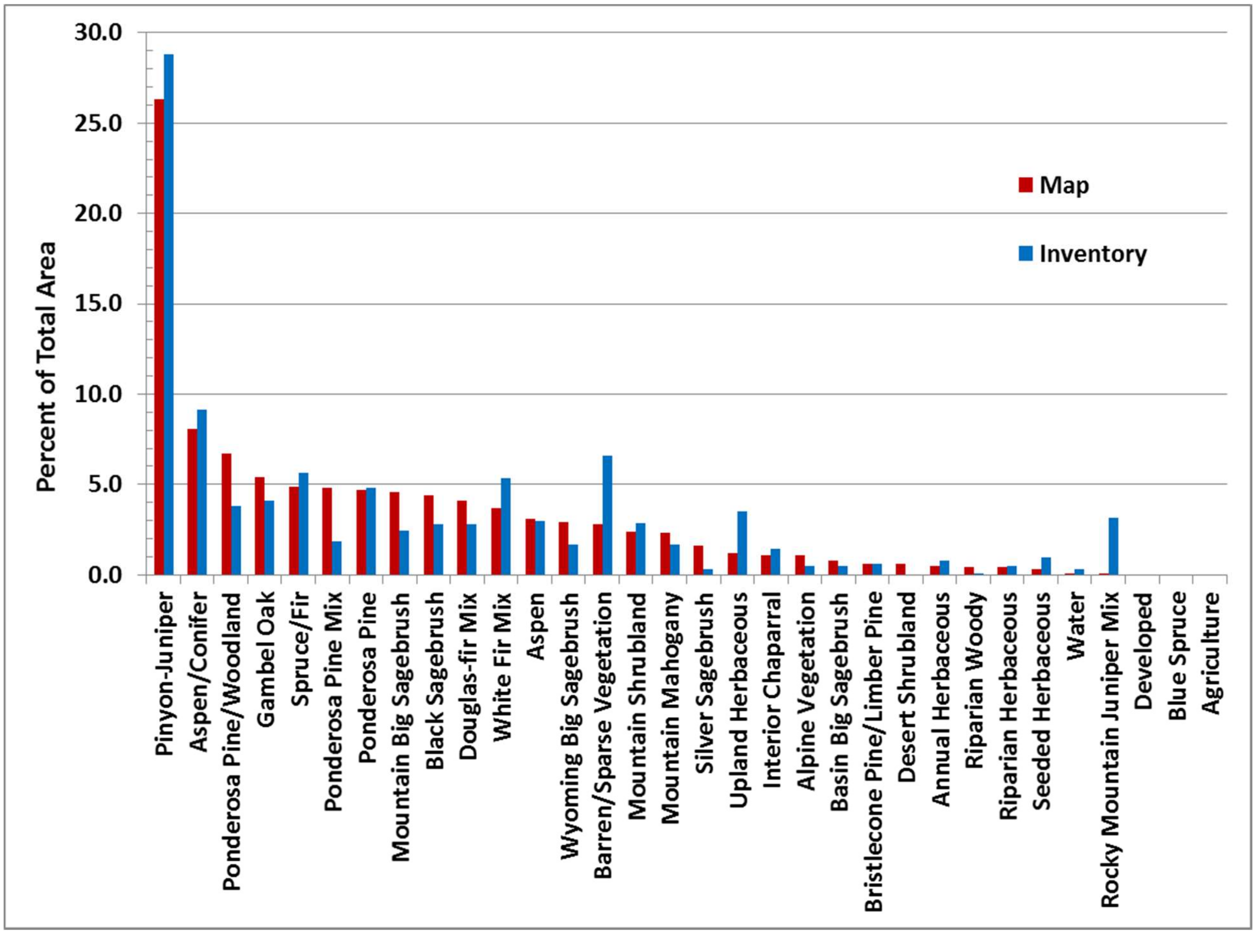

Figure 9: Comparison of mapped and inventory-based estimates of area as a percentage of total area by vegetation type for the DNF.

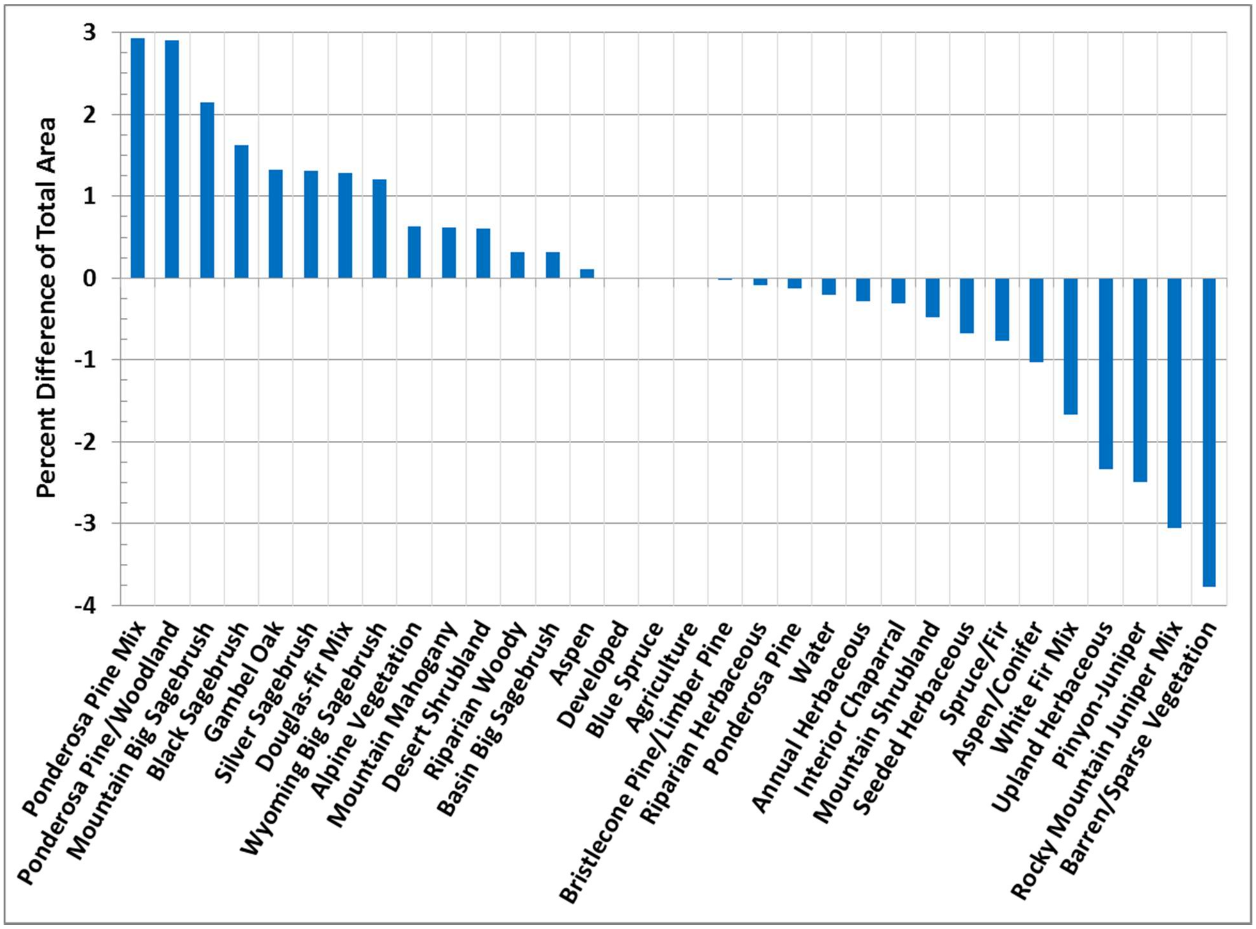

Figure 10: Comparison of mapped and inventory-based estimates of area as a difference in percentage of total area by vegetation type for the DNF**.** A positive difference indicates mapped acres exceed inventory acres for that type, while a negative difference shows that inventory acres surpass mapped acres.

Confidence Interval (95 Percent Standard Error) for Vegetation Types

Using the FIESTA tool to derive 95 percent standard error intervals from the inventory-based area estimates for vegetation types shows some strengths and weaknesses of the mapping process when additional vegetation types are introduced into the modeling process. Comparisons between the mapped areas to their inventory-based confidence intervals are shown in Figure 11.

The mapped areas of eight vegetation types (i.e., Ponderosa Pine/Woodland, Ponderosa Pine Mix, Mountain Big Sagebrush, Barren/Sparse Vegetation, Silver Sagebrush, Upland Herbaceous, Riparian Woody and Rocky Mountain Juniper Mix) fell outside their corresponding 95 percent standard error intervals, while the remaining vegetation types (20) were within their respective error intervals. Agriculture, Developed, Desert Shrubland and Blue Spruce types did not have any inventory samples, and consequently do not have any associated error bars. In addition, only three of the 12 largest vegetation types (each over three percent of the mapped area) fell outside their corresponding error intervals. Moreover, only one of the four largest types (each over five percent of the mapped area) fell outside their respective intervals. The two largest vegetation types (almost 38 percent of the map area) were both within their 95 percent standard error intervals.

Although a higher proportion of vegetation types were within their respective error intervals (62 percent for vegetation types versus 37 percent for vegetation groups), it would also seem that some types were having some difficulty being classified correctly by the modeling process. There are seven vegetation types (i.e., Ponderosa Pine Mix, Ponderosa Pine/Woodland, Mountain Big Sagebrush, Upland Herbaceous, Pinyon-Juniper, Rocky Mountain Juniper Mix, Barren/Sparse Vegetation) that have two percent or greater difference between map and inventory acres (Table 18 and Figure 10), of which all but one (Pinyon-Juniper) fell outside their respective error interval (Figure 11). There may also be some modeling "confusion" between the Rocky Mountain Juniper Mix, Pinyon-Juniper, Ponderosa Pine/Woodland and/or Ponderosa Pine Mix types, as some of those types included mixtures, which potentially may be more troublesome to classify based somewhat on their similar spectral signatures. But overall, there seems to be relatively good agreement between the map and inventory area estimates of vegetation types for the DNF.

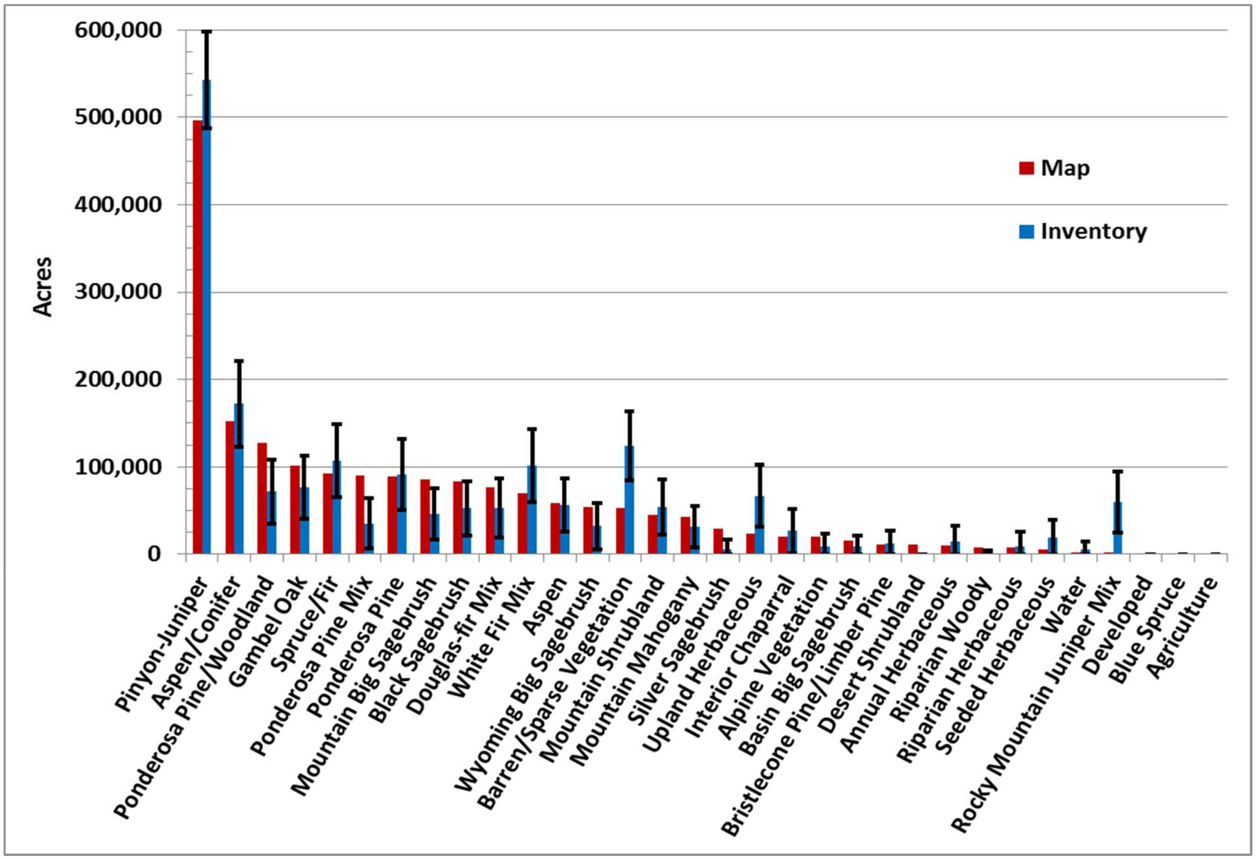

Figure 11: Comparison of mapped and inventory-based estimates of area by vegetation type for the DNF. The 95 percent standard error bars were derived from the inventory-based estimates using FIESTA. No error bars were created for Desert Shrubland, Developed, Blue Spruce or Agriculture, since no FIA plots were sampled in these vegetation types.

Tree Size Class Comparisons

Map and inventory-based estimates of areas for different forest and woodland tree size (diameter) classes were compared for the DNF (Table 19 and Figure 12). The map and inventory acres for the NT (Non Tree) class were virtually identical, which is very impressive for a class that covers such a large area (approximately 25 percent) of the DNF. The WS1 (0 - 11.9” DRC) class was the largest among tree map estimates, with nearly 30 percent of the total area. The next largest class was FS2 (5 - 11.9” DBH) with 23 percent, followed by FS3 (12 - 17.9” DBH) with 11 percent. These three tree size classes account for over 63 percent of the map estimates for total area, while the remaining five tree size classes (each below four percent map area) when combined are 11 percent. From Figure 12, the map acres tend to be less than the inventory acres for the larger diameter classes (i.e., FS4, FS5, WS2 and WS3), while the map acres are more than the inventory acres for those two most prevalent diameter classes for the DNF (i.e., FS2 and WS1). The diameter classes having the least agreement between map acres and inventory acres were WS3 (-9.1%) and WS1 (8.5%), while the remaining classes were each within four percent difference.

Table 19: Mapped and inventory-based estimates of area by forest and woodland tree diameter classes for the DNF. Acreage and Percent Differences are based on the difference of total area between mapped and inventory estimates. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Tree Size Code	Tree Size Class DBH or DRC (in)	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
FS1	0 - 4.9" DBH	52,222	2.8	35,723	1.9	16,499	0.9
FS2	5 - 11.9" DBH	434,104	23.0	364,963	19.4	69,141	3.6
FS3	12 - 17.9" DBH	210,062	11.1	157,679	8.4	52,383	2.7
FS4	18 - 23.9" DBH	66,406	3.5	82,624	4.4	-16,218	-0.9
FS5	≥ 24" DBH	5,552	0.3	58,264	3.1	-52,712	-2.8
WS1	0 - 11.9" DRC	560,444	29.7	399,573	21.2	160,871	8.5
WS2	12 - 17.9" DRC	71,223	3.8	128,572	6.8	-57,349	-3.0
WS3	≥ 18" DRC	10,870	0.6	182,571	9.7	-171,701	-9.1
NT	Non Tree	474,511	25.2	475,426	25.2	-915	0.0
Total		**1,885,395**	**100.0**	**1,885,395**	**100.0**	**n/a**	**n/a**

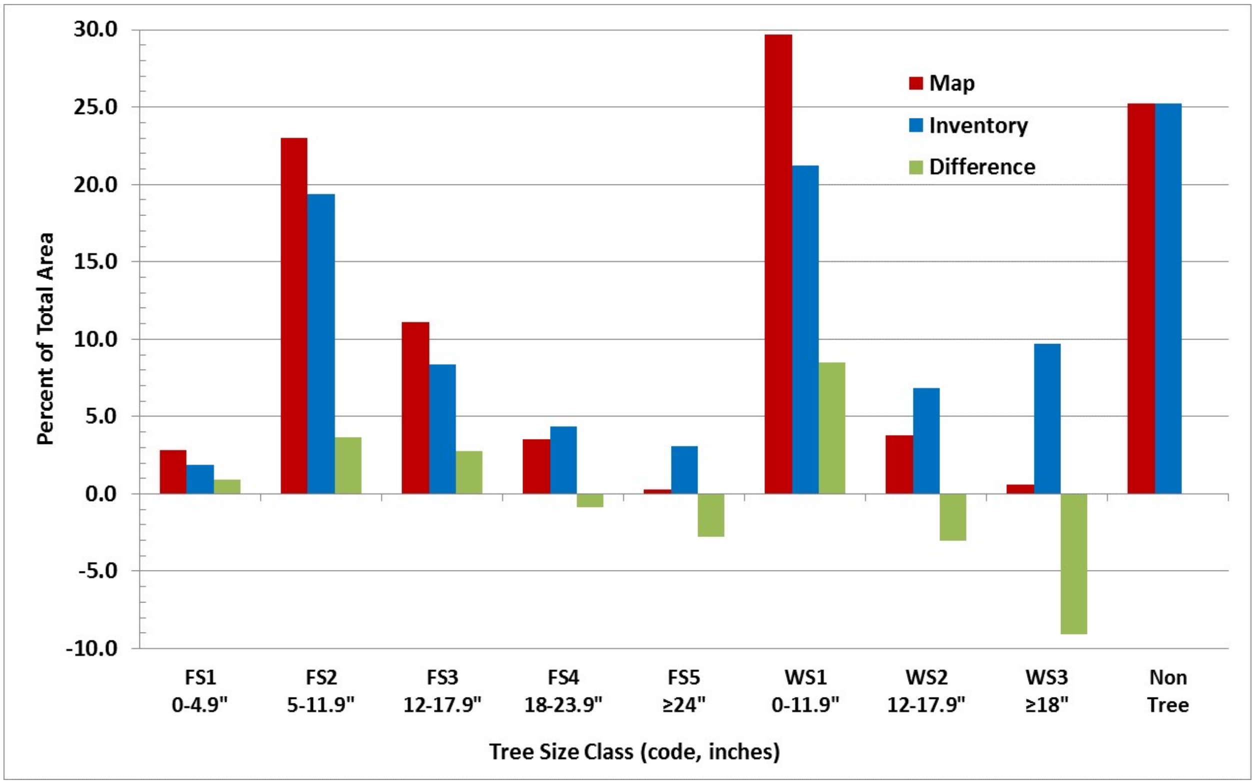

Figure 12: Comparison of mapped and inventory-based estimates of area as a percentage of total area by forest and woodland tree size classes for the DNF. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Confidence Interval (95 Percent Standard Error) for Tree Size Class

FIESTA-based estimates of 95 percent standard error intervals were generated around the inventory-based area estimates for each of the nine tree size classes. The mapped areas of six tree size classes (FS2, FS3, FS5, WS1, WS2 and WS3) fell outside their corresponding 95 percent standard error intervals, while the three remaining classes (FS1, FS4 and Non Tree) were within their respective error intervals (Figure 13). However, most of the tree size classes were either within or relatively close in agreement between map acres and the standard error intervals from the inventory-based area estimates. As shown in Figure 13, all of the tree size classes were either inside or relatively close to the error intervals except for WS1 and WS3, which had an 8.5 and 9.1 percent difference, respectively, in their estimates (Table 19). This was primarily due to the relatively high map estimate for WS1 (560,444 acres) compared to its inventory-based estimate (399,573 acres), and the relatively low map estimate for WS3 (10,870 acres) related to its inventory-based estimate (182,571 acres). It is essential to recognize the limitations of mapping and assessing tree size classes, such as estimating tree size from aerial imagery or sampling errors associated with measuring size classes in the field.

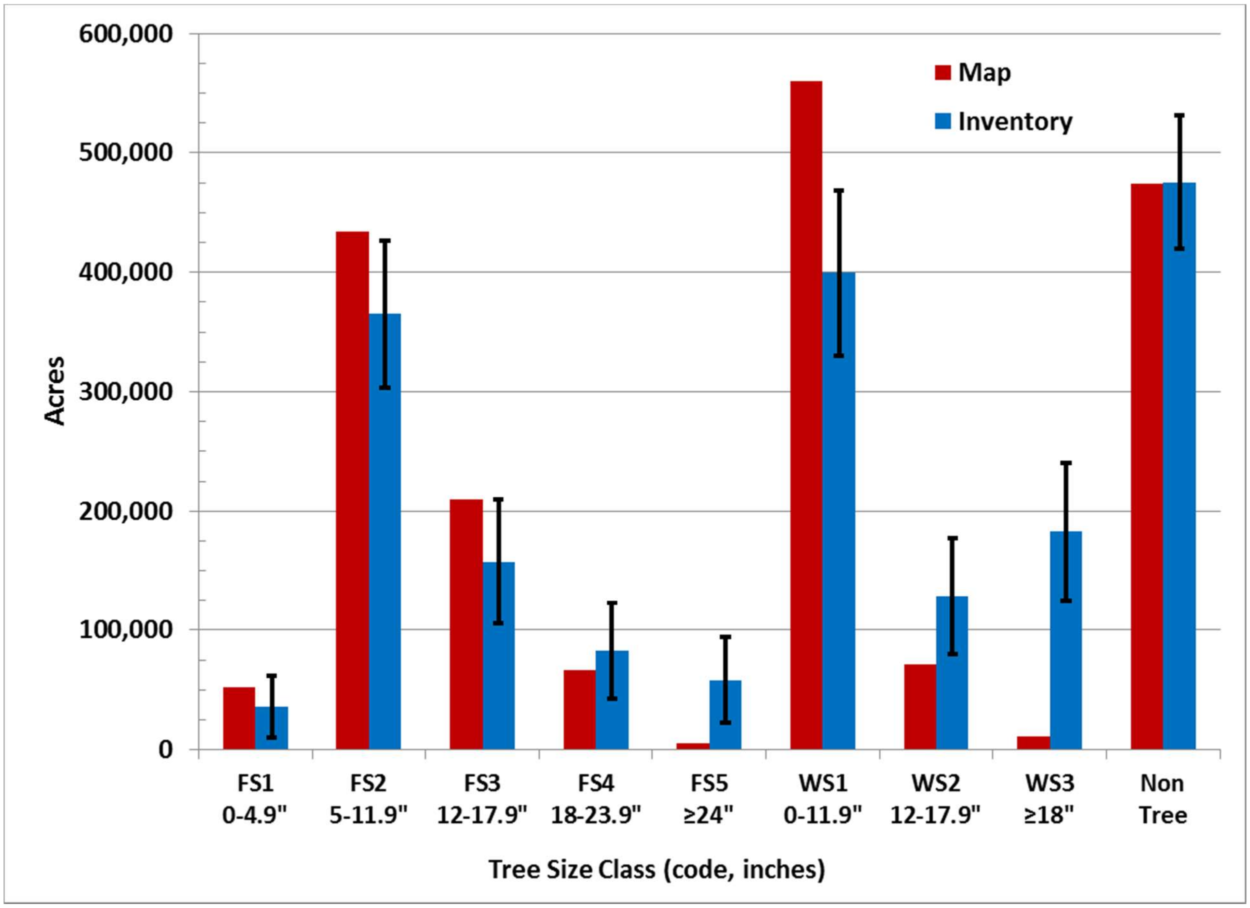

Figure 13: Comparison of mapped and inventory-based estimates of area by tree size classes for the DNF, with 95 percent standard error bars generated from the inventory-based estimates using FIESTA.

Tree Canopy Cover Comparisons

Besides tree size classes, map and inventory-based estimates of areas by different tree canopy cover classes were compared as well (Table 20 and Figure 14). The TC2 (20 - 39%) class had the largest difference (14.2 percent) between map and inventory estimates, with the map-based estimate (869,091 acres) being more than the inventory-based value (601,978 acres). The more dense tree canopy cover classes produced the next largest area differences, with both TC5 (≥ 60%) and TC4 (50 - 59%) having -9.6 and -7.5 percent differences, respectively. The remaining tree canopy cover classes were in relatively good agreement between their map and inventory area estimates (each less than six percent difference). The map-based estimates seemed to be over-predicting for the less dense tree cover classes (TC1 and TC2), while under-predicting for the more dense classes (TC4 and TC5). Perhaps the modeling procedure is estimating areas that might be difficult to classify into the most prevalent cover class, such as what seemed to be the case with TC2 (20 - 39%). Nevertheless, the map and inventory acres for the NT (Non Tree) canopy had a 0.0 percent acreage difference, which is notable for a class that covers such a large area (approximately 25 percent) of the DNF.

Table 20: Mapped and inventory-based estimates of area by tree canopy cover class on the DNF. Acreage and Percent Differences are based on the difference of total area between mapped and inventory estimates. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Canopy Cover Code	Canopy Cover Class	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
TC1	10 - 19%	242,739	12.9	144,160	7.6	98,579	5.3
TC2	20 - 39%	869,091	46.1	601,978	31.9	267,113	14.2
TC3	40 - 49%	188,507	10.0	229,879	12.2	-41,372	-2.2
TC4	50 - 59%	82,273	4.4	224,757	11.9	-142,484	-7.5
TC5	≥ 60%	28,274	1.5	209,194	11.1	-180,920	-9.6
NT	Non Tree	474,511	25.2	475,426	25.2	-915	0.0
Total		**1,885,395**	**100.0**	**1,885,395**	**100.0**	**n/a**	**n/a**

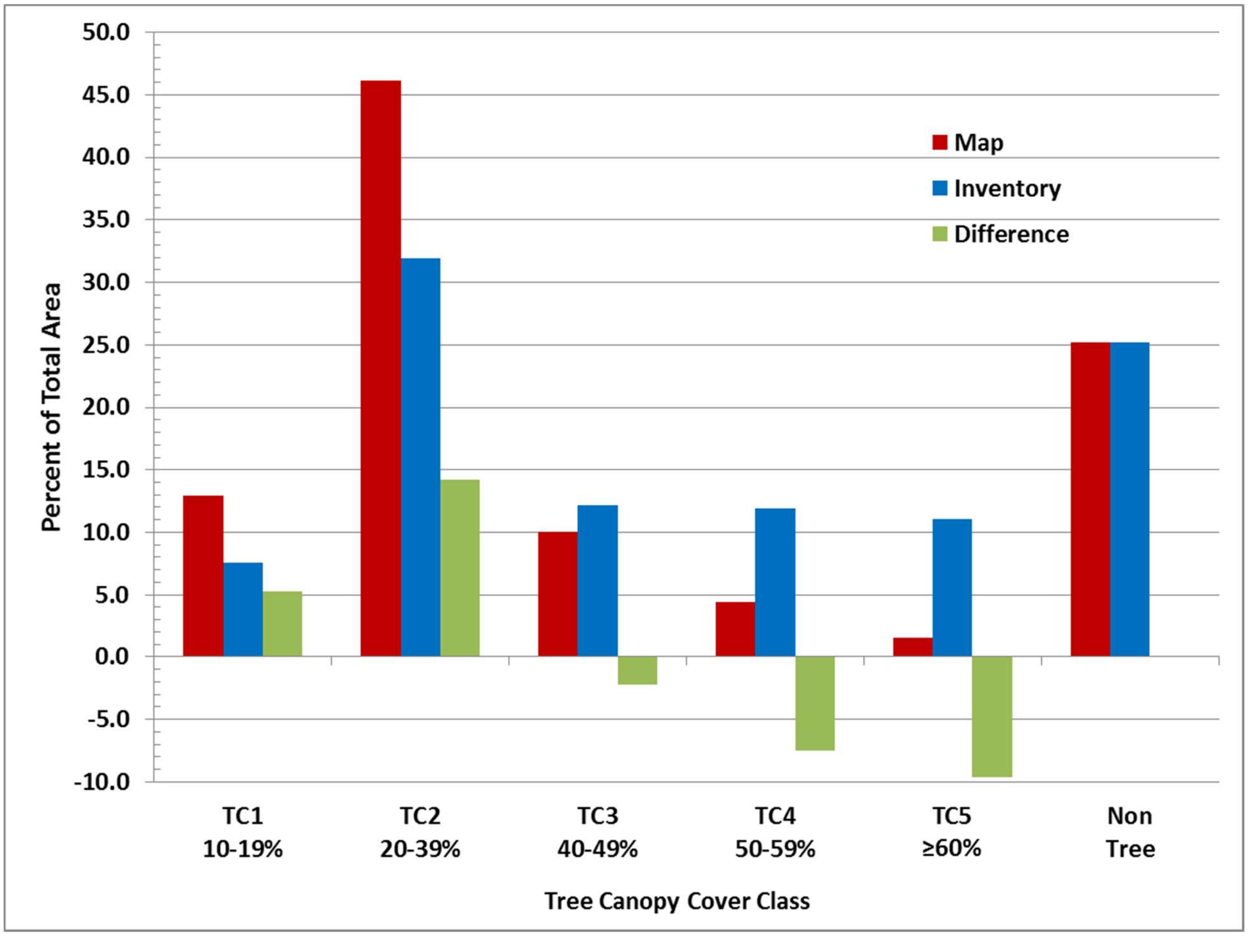

Figure 14: Comparison of mapped and inventory-based estimates of area as a percentage of total area by tree canopy cover classes for the DNF. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Canopy cover estimates based on the alternative canopy cover procedure were also constructed for tree (based on dominant forest or woodland species) and shrubland canopies (Table 21 and Figure 15). The FC2 (20 - 39%) class had the largest difference (10.5 percent) between map and inventory estimates, with the map-based estimate (417,635 acres) being almost twice the inventory-based value (221,047 acres). The more dense canopy cover classes produced the next largest area differences, with both FC4 (≥ 60%) and WC3 (≥ 50%) having -6.8 and -6.3 percent differences, respectively. All the remaining tree canopy cover classes were in relatively good agreement between their map and inventory area estimates (each less than three percent difference). Figure 15 suggests the map-based estimates seemed to be over-predicting the less dense cover classes (FC1, FC2 and WC1), while under-predicting the denser classes (FC3, FC4 and WC3). However, the two most widespread classes (WC2 and NT) both had a 0.0 percent acreage difference, which is remarkable given these two classes combined comprise over half (51 percent) the area of the DNF.

Table 21: Mapped and inventory-based estimates of area by tree canopy cover class (based on dominant forest or woodland species) on the DNF. Acreage and Percent Differences are based on the difference in percentages of total area between mapped and inventory estimates. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Canopy Cover Code	Canopy Cover Class	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
FC1	10 - 19%	114,583	6.1	66,452	3.5	48,131	2.6
FC2	20 - 39%	417,635	22.2	221,047	11.7	196,588	10.5
FC3	40 - 59%	211,979	11.2	259,134	13.7	-47,155	-2.5
FC4	≥ 60%	24,150	1.3	152,619	8.1	-128,469	-6.8
WC1	10 - 19%	128,155	6.8	77,708	4.1	50,447	2.7
WC2	20 - 49%	494,333	26.2	494,158	26.2	175	0.0
WC3	≥ 50%	20,049	1.1	138,850	7.4	-118,801	-6.3
NT	Non Tree	474,511	25.2	475,426	25.2	-915	0.0
Total		**1,885,395**	**100.0**	**1,885,395**	**100.0**	**n/a**	**n/a**

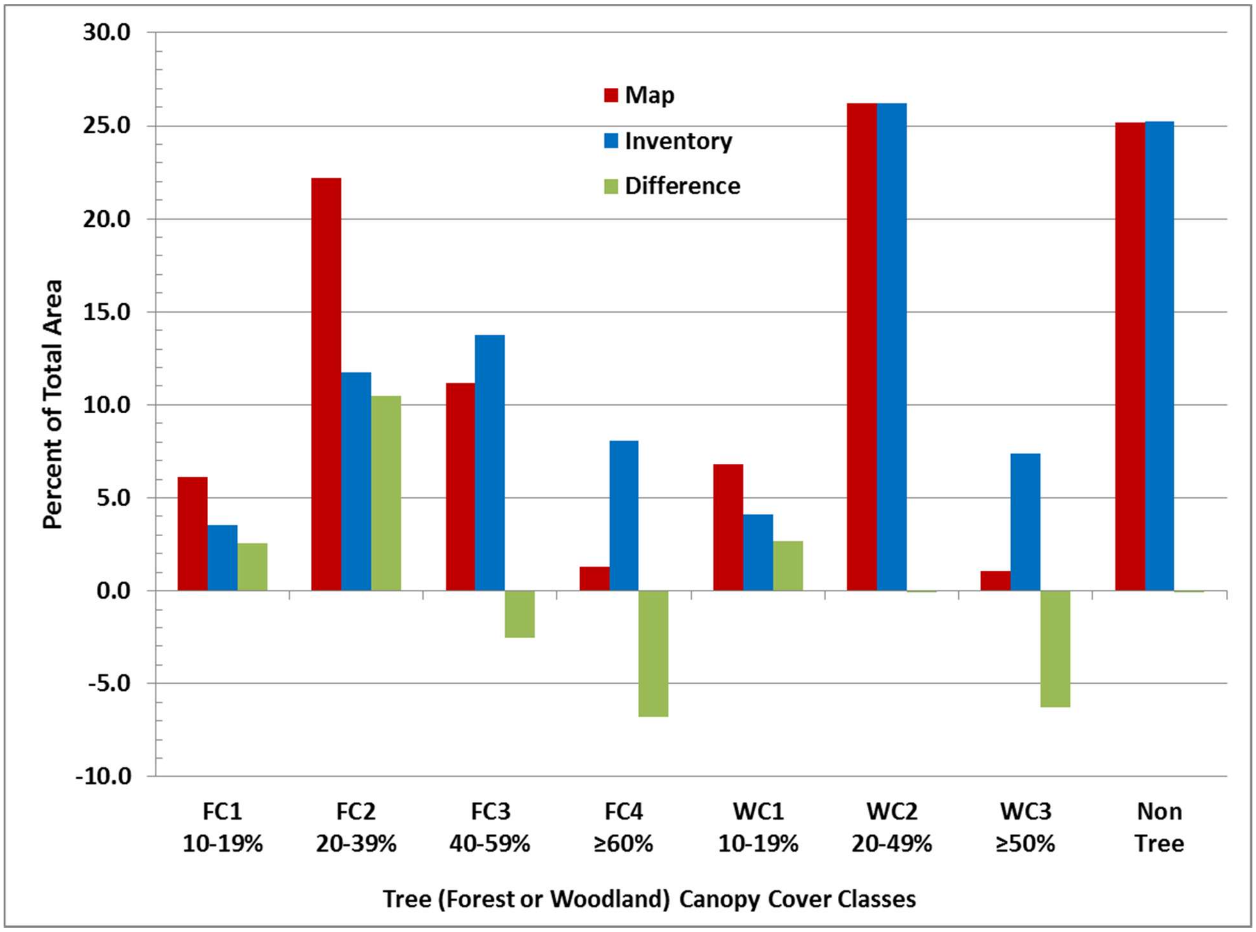

Figure 15: Comparison of mapped and inventory-based estimates of area as a percentage of total area by tree canopy cover classes (based on dominant forest or woodland species) for the DNF. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Shrub Canopy Cover Comparisons

In addition to area by tree canopy cover, map and inventory-based estimates of areas for different shrub cover classes were also evaluated (Table 22 and Figure 16). A large majority of the shrub canopy cover area estimates from the map were slightly over-predicting compared to their respective classes for the inventory-based estimates, with the Non Shrub class being the exception. Area estimates for SC1 (10 - 24%) and SC3 (≥ 35%) cover classes were relatively close between map and inventory-based values (one percent or less), while SC2 (25 - 34%) and NS (Non Shrub) had somewhat larger differences (over five percent). But overall, there was relatively good agreement between the map and inventory-based estimates of shrub cover classes.

Table 22: Mapped and inventory-based estimates of area by shrub canopy cover class for the DNF. Acreage and Percent Differences are based on the difference in percentages of total area between mapped and inventory estimates. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Canopy Cover Code	Canopy Cover Class	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
SC1	10 - 24%	161,857	8.6	155,636	8.3	6,221	0.3
SC2	25 - 34%	125,002	6.6	24,875	1.3	100,127	5.3
SC3	≥ 35%	66,572	3.5	47,209	2.5	19,363	1.0
NS	Non Shrub	1,531,963	81.3	1,657,675	87.9	-125,712	-6.6
Total		**1,885,395**	**100.0**	**1,885,395**	**100.0**	**n/a**	**n/a**

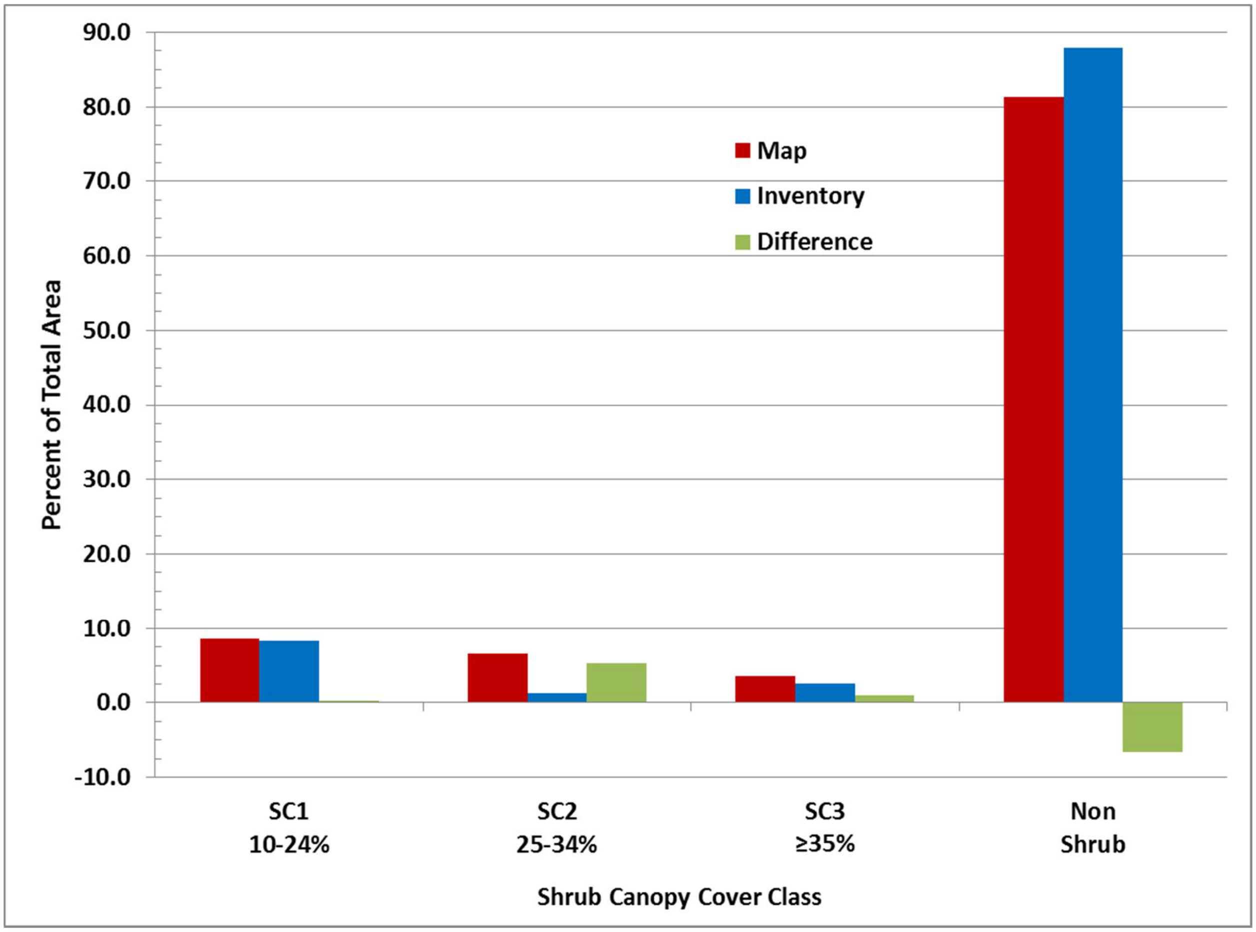

Figure 16: Comparison of mapped and inventory-based estimates of area as a percentage of total area by shrub canopy cover classes for the DNF. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Confidence Interval (95 Percent Standard Error) for Canopy Cover Class

FIESTA estimates of 95 percent standard error confidence intervals for the inventory-based area estimates were created for each tree and shrub canopy cover class (Figure 17). The three canopy cover classes (map-based estimates) within their corresponding 95 percent error bars from the inventory-based estimates were TC3 (40 - 49%), SC1 (10 - 24%) and SC3 (≥ 35%), each with a 2.2 percent or less difference in total area estimates. The remaining cover classes were typically further outside their error bars, ranging from 5.3 percent to 14.2 percent differences in estimates (Tables 20 and 22). Overall, the tree canopy cover class map estimates generally fared worse than the shrub estimates for being within their respective error intervals.

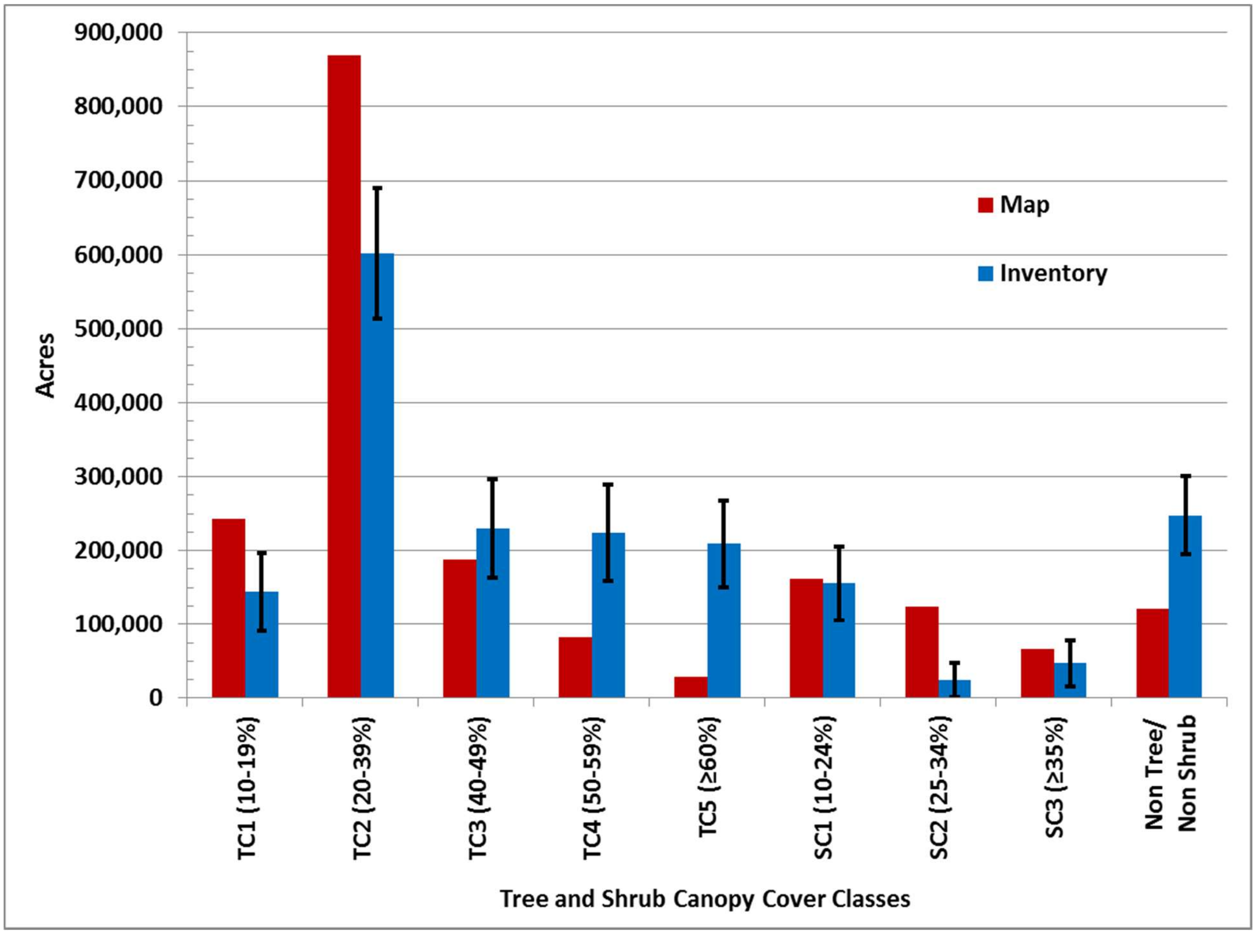

Figure 17: Comparison of mapped and inventory-based estimates of area by canopy cover class for the DNF, with 95 percent standard error bars generated from the inventory-based estimates using FIESTA.

FIESTA estimates of 95 percent standard error confidence intervals for the inventory-based area estimates based on the alternative canopy cover procedure were also developed for each tree (based on dominant forest or woodland species) and shrub canopy cover class (Figure 18). The four canopy cover classes (map-based estimates) within their corresponding 95 percent error bars from the inventory-based estimates were FC3 (40 - 59%), WC2 (20 - 49%), SC1 (10 - 24%) and SC3 (≥ 35%), each with a 2.5 percent or less difference in total area estimates. The remaining cover classes were typically further outside their error bars, ranging from 2.6 percent to 10.5 percent differences in estimates (Tables 21 and 22). While the most prevalent canopy cover class (WC2, 20 - 49%) was within its respective error interval (0.0% difference), the denser cover classes of forest (FC4, -6.8%) and woodland (WC3, -6.3%) as well as FC2 (10.5%) and NT/NS (-6.7%) appear well-outside their error intervals (Figure 18).

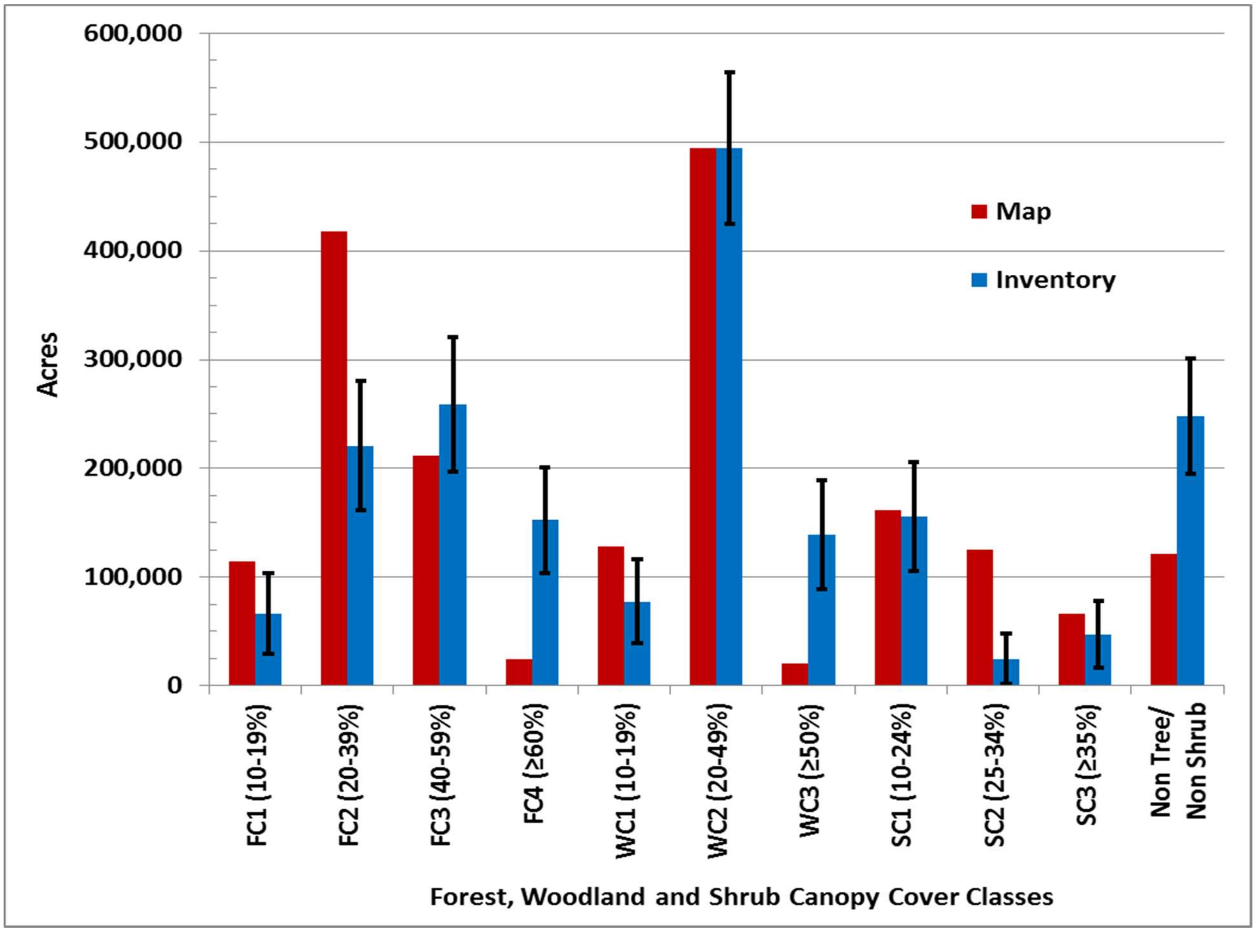

Figure 18: Comparison of mapped and inventory-based estimates of area by canopy cover class (tree cover classes based on dominant forest or woodland species) for the DNF, with 95 percent standard error bars generated from the inventory-based estimates using FIESTA.

Site-Specific Accuracy Assessment

Accuracy assessments are an essential part of any modeling or remote sensing project; not only for comparing different mapping methods and sensors, but also for providing information on the reliability and usefulness of those techniques for a particular application. Most importantly, accuracy assessments provide guidance in the decision making process by providing a measure of reliability for the mapped classes, as well as allowing users to understand a map's limitations (Nelson et al. 2015).

Error Matrix

The error (confusion) matrix is a standard tool used for presenting results of an accuracy assessment. In general, it is a square array where both the classified reference (observed) and image (mapped) data are ordered and compared for class agreement on the diagonally intersected cells; typically rows in the matrix represent the classified image data while columns represent the observed data (Story and Congalton 1986). The error matrix can be used to determine the accuracy of classes and any degree of confusion between classes.

The vegetation group error matrix for the DNF is presented in Table 23, with the *observed* classes (FIA inventory plots) in the columns and the *mapped* classes (modeled results) in the rows. For accuracy assessment purposes, only the condition-level data from the center subplot of an FIA plot (Appendix J) was used, since it corresponds to the actual coordinates used when intersecting an FIA plot against mapped values. As a result, a total of 317 FIA plot/conditions were available for the following accuracy assessment tables, instead of the 374 sampled plot/conditions previously stated (e.g., some FIA plots had multiple-conditions per plot or did not have a center subplot accessible to field crews). The highlighted diagonal cells tally the number of inventory plots that are in agreement with the intersected mapped classes. Percent class accuracies are calculated by dividing the number of correct classifications (diagonal cells) by each class total.

The overall accuracy for an error matrix is determined by summing the number of correct classifications (diagonal cells) and dividing that sum by the total number of observations (FIA plot/conditions in this case). While the overall accuracy summarizes the actual agreement between map and inventory classifications, the Kappa statistic indicates the difference between the observed accuracy and the amount of agreement due to random chance. Consequently, the Kappa statistic may provide a meaningful measure of agreement between the map and inventory classifications without chance. The Kappa statistic (K) for an error matrix is calculated by the following formula (Lillesand and Kiefer 1994):

$$K = (\text{observed accuracy - chance agreement}) / (1 - \text{chance agreement})$$

There are two main types of accuracies generated for each class in an error matrix: a *user's* and *producer's* accuracy. A user's accuracy indicates errors of commission, where a class has been mapped in places where it does not exist. A producer's accuracy indicates errors of omission, where a class has not been mapped where it exists on the ground. A user's accuracy value reflects how useful some map product might be for a given user, while a producer's accuracy typically indicates how well some map product represents field samples on the ground. It is generally assumed that at least ten observations per class is needed to have a meaningful value. A "not applicable" (n/a) status was used to indicate when information for a certain cell calculation is not available, which is primarily due to the absence of inventory plots for a specific row or column in the error matrix.

Vegetation Group Accuracies

As shown in Table 23, the vegetation group with the highest producer's accuracy, and having at least 10 plot/conditions per group, was the Conifer Forest group (85 percent). The Woodland group was similar with 82 percent, followed by the Shrubland group at 81 percent. The Deciduous Forest group followed with an accuracy of 61 percent, while Herbland and Non-Vegetated/Sparse Vegetation groups had lower accuracies. Both Alpine and Riparian groups were at 100 percent producer's accuracy, but with a very small number of plot/conditions (2 and 1, respectively).

The Woodland group had the highest user's accuracy at 94 percent, which was the highest class accuracy shown in Table 23 (for groups with at least 10 plot/conditions), followed by the Non-Vegetated/Sparse Vegetation group (with only 9 plot/conditions) at 89 percent. The Conifer Forest (71 percent) and Deciduous Forest (71 percent) groups had slightly lower accuracies, while the remaining groups were at 50 percent or less.

Some issues related to mapping involve separating "fuzzy" categorical boundaries between different mapping groups. Generally, it is difficult to accurately separate groups within transition zones. In addition, inventory plots and vegetation group polygons may encompass multiple vegetation groups, leading to additional confusion. The overall classification accuracy for the eight vegetation groups was 74 percent, while the average producer's accuracy was 71 percent and average user's accuracy was 65 percent. The Kappa statistic was 66 percent.

Table 23: Error matrix for vegetation groups on the DNF. FIA plots were used as an independent source to evaluate the classification accuracies of the modeled map classes. Overall classification accuracy across eight vegetation groups was 74 percent, while average producer's accuracy was 71 percent and average user's accuracy was 65 percent. The Kappa statistic was 66 percent.

		INVENTORY PLOTS									
	Map Group	Woodland	Conifer Forest	Shrubland	Deciduous Forest	Herbland	Non-Vegetated/ Sparse Vegetation	Alpine	Riparian	Total	User's % Accuracy
MAP CLASS	**Woodland**	**101**	3	1		1	2			108	**94**
	Conifer Forest	14	**68**	2	10	1	1			96	**71**
	Shrubland	7	3	**29**	3	10	6			58	**50**
	Deciduous Forest		5	2	**22**	1	1			31	**71**
	Herbland			2		**4**	3			9	**44**
	Non-Vegetated/Sparse Veg	1					**8**			9	**89**
	Alpine		1			1		**2**		4	**50**
	Riparian				1				**1**	2	**50**
	Total	123	80	36	36	18	21	2	1	**317**	**65**
	Producer's % Accuracy	**82**	**85**	**81**	**61**	**22**	**38**	**100**	**100**	**71**	**74**

Vegetation Type Accuracies

Accuracy assessment results typically decrease when the complexity of mapping more refined classes occurs. The overall classification accuracies for 29 vegetation types (Table 24) should consequently be lower than that for eight vegetation groups (Table 23). As expected, accuracies decline due, in part, to a larger number of classes and distinctions made to account for a greater variety of vegetation types. The overall accuracy for the 29 vegetation types was 53 percent, while average producer's accuracy was 41 percent and average user's accuracy was 38 percent. Zero plots/conditions existed for Agriculture, Developed, and Blue Spruce; therefore, those types did not affect and were not included in the overall classification accuracy. The Kappa statistic was 48 percent.

The vegetation types listed in Table 24 were ordered and shaded by their corresponding vegetation groups (Table 23), so that any misclassifications within members of an individual vegetation group could be easily detected. For example, the four vegetation types within the Woodland vegetation group (Mountain Mahogany, Gambel Oak, Pinyon-Juniper and Rocky Mountain Juniper Mix) were grouped together and have a light-brown shading in Table 24. Those plot misclassifications within this Woodland group "box" could be considered as having a reasonable justification of being misclassified by being within the same vegetation group. Alternatively, misclassifications of plots along the columns of those woodland types, but outside this Woodland group "box", are probably not as easily justified and may indicate some modeling deficiency that needs further review.

Pinyon-Juniper vegetation type had the highest number of inventory plots (95), with a producer's accuracy of 81 percent and user's accuracy of 90 percent. The modeling process seemed to perform well for this vegetation type. The next most numerous vegetation type was Aspen/Conifer (27 plots), which had a producer's accuracy of 59 percent but a user's accuracy of 73 percent. This difference in producer and user accuracy values may indicate potential confusion among other types (primarily Spruce/Fir, Aspen, Douglas-fir Mix, Ponderosa Pine Mix, Ponderosa Pine and White Fir Mix). The remaining vegetation types with ten or more samples were Barren/Sparse Vegetation (19 plots), Spruce/Fir (17 plots), White Fir Mix (17 plots), Ponderosa Pine (15 plots), Ponderosa Pine/Woodland (14 plots), Gambel Oak (12 plots), Upland Herbaceous (12 plots) and Rocky Mountain Juniper Mix (11 plots).

For producer's accuracy values, vegetation types with 50 percent accuracy or more included: Pinyon-Juniper (81 percent), Black Sagebrush (78 percent), Gambel Oak (67 percent), Aspen/Conifer (59 percent), Spruce/Fir (53 percent), Wyoming Big Sagebrush (50 percent), Alpine Vegetation (100 percent, two plots), Silver Sagebrush (100 percent, one plot) and Riparian Herbaceous (100 percent, one plot). For the user's accuracy, vegetation types with 50 percent accuracy or more were: Pinyon-Juniper (90 percent), Barren/Sparse Vegetation (89 percent, nine plots), Mountain Shrubland (75 percent, four plots), Aspen/Conifer (73 percent), Spruce/Fir (56 percent), White Fir Mix (54 percent), Wyoming Big Sagebrush (50 percent, six plots), Upland Herbaceous (50 percent, four plots), Alpine Vegetation (50 percent, four plots) and Riparian Herbaceous (100 percent, one plot). The map modeling process seemed to do very well classifying Pinyon-Juniper (90 percent) and Barren/Sparse Vegetation (89 percent, nine plots), which likely have a distinct signature within the imagery when compared to other types. Those vegetation types with fewer than ten plots were noted since they have the potential to obtain relatively high accuracies if only a few plots are correctly classified and plots from other types are not mistakenly classified into that particular type.

A map modeling process may be evaluated by reviewing how the model mapped an individual vegetation type. For example, the Pinyon-Juniper type had the highest number of plots (95) in the FIA data set, with 77 of those plots correctly classified by the model. The Pinyon-Juniper type also had a producer's accuracy of 81 percent and user's accuracy of 90 percent. However, by reviewing the Inventory Plots/Pinyon-Juniper column, there were several other modeled vegetation types that overlap with Pinyon-Juniper plots. Some of the map unit classes that were confused, but perhaps reasonably misclassified by being within the same vegetation group (note the light-brown Woodland group "box"), included Gambel Oak (four plots) and Mountain Mahogany (two plots). Also, the Ponderosa Pine/Woodland type (five plots) could also be reasonably misclassified due to its woodland component, even though it is within the Conifer Forest group. An argument could likewise be made that both Ponderosa Pine Mix (two plots) and Ponderosa Pine (one plot) types from the Conifer Forest group could also be readily mistaken, due in part to their typically open, park-like stands found in many Ponderosa Pine forests. Some map unit classes that were perhaps not reasonably misclassified as Pinyon-Juniper included Black Sagebrush (two plots), Interior Chaparral (one plot) and Barren/Sparse Vegetation (one plot).

A similar evaluation could be done while looking along the Map Class/Pinyon-Juniper row, where there are several other vegetation classes with inventory plots whose coordinates intersected within the modeled Pinyon-Juniper vegetation type. Some inventory plot classes that were located within the modeled Pinyon-Juniper vegetation type, which could reasonably be misclassified by being within the same vegetation group (note the light-brown Woodland group "box"), were Rocky Mountain Juniper Mix (three plots) and Gambel Oak (one plot). As mentioned above, the Ponderosa Pine/Woodland type (two plots) could also be realistically misclassified due to its woodland component. Some map unit classes that were perhaps not practically misclassified as Pinyon-Juniper consisted of Barren/Sparse Vegetation (two plots) and Annual Herbaceous (one plot). A map user may compare other map classes in a similar manner to determine the level of agreement between a specific modeled map class and its corresponding FIA plot data. A user may also compare producer versus user accuracy values for a specific vegetation type to analyze similarities or differences between the two accuracy values.

It should also be noted that there are several class accuracies with either a 100 percent or zero percent accuracy (Table 24). This is commonly found where there are very few plots within an individual vegetation class. A better representation of model performance might be gained for such cases by collapsing similar vegetation types so that some minimum number of plots (perhaps at least ten plots) were available for each class. For example, the herbaceous vegetation types of Annual Herbaceous (three plots), Seeded Herbaceous (three plots) and Upland Herbaceous (12 plots) could be combined into a single "Herbaceous" class that would then contain 18 plots.

Tree Size Class Accuracies

For the various tree size classes (excluding the Non Tree class), the WS1 (0 - 11.9" DRC) class had the highest producer's accuracy (81 percent) and second highest user's accuracy (59 percent) for the DNF (Table 25). Next, the FS2 (5 - 11.9" DBH) class had the second highest producer's accuracy (78 percent) and highest user's accuracy (63 percent), while the remaining classes were all 50 percent or less.

The modeling process for the larger-sized tree size classes performed below the overall classification accuracy (59 percent). For example, the producer's accuracy values for those tree size classes 18" or larger were seven percent or less (FS4 (18 - 23.9" DBH) at seven percent, FS5 (≥ 24.0" DBH) at zero percent and WS3 (≥ 18" DRC) at three percent). Moreover, the user's accuracy values for those classes were not much better (FS4 (18 - 23.9" DBH) at ten percent, FS5 (≥ 24.0" DBH) at zero percent (zero plots) and WS3 (≥ 18" DRC) at 50 percent (two plots)). Overall, the modeling process seemed to underestimate most tree size classes and tended to predict diameter values closer to their prevalent class, as the FS2 (5 - 11.9") and WS1 (0 - 11.9") classes contained the most numerous number of plots for forest and woodland species, respectively.

Table 24: Error matrix for vegetation types on the DNF. FIA plots were used as a validation data set to produce the classification accuracies of the modeled map unit classes. Overall classification accuracy across 29 vegetation types was 53 percent, while average producer's accuracy was 41 percent, and average user's accuracy was 38 percent. No entries were created for Developed, Blue Spruce or Agriculture vegetation types (all have zero acres for both map class and inventory acres) to simplify this table. The Kappa statistic was 48 percent.

INVENTORY PLOTS

MAP CLASS

Map Unit	Alpine Vegetation	Riparian Herbaceous	Riparian Woody	Annual Herbaceous	Seeded Herbaceous	Upland Herbaceous	Desert Shrubland	Wyoming Big Sagebrush	Basin Big Sagebrush	Black Sagebrush	Mountain Big Sagebrush	Silver Sagebrush	Interior Chaparral	Mountain Shrubland	Mountain Mahogany	Gambel Oak	Pinyon-Juniper	Rocky Mountain Juniper Mix	Aspen	Aspen/Conifer	Ponderosa Pine/Woodland	Ponderosa Pine	Ponderosa Pine Mix	Douglas-fir Mix	White Fir Mix	Spruce/Fir	Bristlecone Pine/Limber Pine	Barren/Sparse Vegetation	Water	Total	User's % Accuracy
Alpine Vegetation	**2**					1																				1				**4**	**50**
Riparian Herbaceous		**1**																												**1**	**100**
Riparian Woody																			1											**1**	**n/a**
Annual Herbaceous					1																							1		**2**	**0**
Seeded Herbaceous								1	1																			1		**3**	**0**
Upland Herbaceous				1		**2**																							1	**4**	**50**
Desert Shrubland					1																							1		**2**	**n/a**
Wyoming Big Sagebrush								**3**		1						1												1		**6**	**50**
Basin Big Sagebrush								1						1		1		1				1						1		**6**	**0**
Black Sagebrush					1	4		1		**7**	2			1			2					1		1				2		**22**	**32**
Mountain Big Sagebrush				1		2				1	**3**			2					3											**12**	**25**
Silver Sagebrush						1					1	**1**																		**3**	**33**
Interior Chaparral													**1**				1											1		**3**	**33**
Mountain Shrubland														**3**		1														**4**	**75**
Mountain Mahogany															**2**		2								1					**5**	**40**
Gambel Oak													1		3	**8**	4	1												**17**	**47**
Pinyon-Juniper				1												1	**77**	3			2							2		**86**	**90**
Rocky Mtn. Juniper Mix																														**0**	**0**
Aspen						1					1			1					**4**	1								1		**9**	**44**
Aspen/Conifer																			1	**16**				2		3				**22**	**73**
Ponderosa Pine/Wdlnd.													2				5	2			**6**	6	2		1		1			**25**	**24**
Ponderosa Pine																	1	2		1	3	**6**		1						**14**	**43**
Ponderosa Pine Mix																	2	1		2	3	1	**2**	1	3		1			**16**	**13**
Douglas-fir Mix																		1		2			2	**1**	5	1				**12**	**8**
White Fir Mix																				1				2	**7**	3				**13**	**54**
Spruce/Fir						1														4				1		**9**			1	**16**	**56**
Bristlecone/Limber Pine																														**0**	**0**
Barren/Sparse Veg.																	1											**8**		**9**	**89**
Water																														**0**	**0**
Total	**2**	**1**	**0**	**3**	**3**	**12**	**0**	**6**	**1**	**9**	**7**	**1**	**4**	**8**	**5**	**12**	**95**	**11**	**9**	**27**	**14**	**15**	**6**	**9**	**17**	**17**	**2**	**19**	**2**	**317**	**38**
Producer's % Accuracy	**100**	**100**	**n/a**	**0**	**0**	**17**	**n/a**	**50**	**0**	**78**	**43**	**100**	**25**	**38**	**40**	**67**	**81**	**0**	**44**	**59**	**43**	**40**	**33**	**11**	**41**	**53**	**0**	**42**	**0**	**41**	**53**

Neither DBH nor DRC diameter values are readily determinable using imagery from above; therefore, class separation relies heavily on shared spectral characteristics of similarly sized classes. It is generally more difficult to remotely-estimate tree diameters for woodland species (compared to forest species), since their tree form typically does not fit into a consistent diameter-to-crown ratio. In addition to diameter ranges, some degree of confusion can also be attributed to misclassification between forest and woodland species as well. Overall classification accuracy across all nine tree size classes was 59 percent, while average producer's accuracy was 37 percent and average user's accuracy was 38 percent. The Kappa statistic was 49 percent.

Table 25: Error matrix for tree size classes on the DNF. FIA plots were used as a validation data set to produce the classification accuracies for the modeled tree size map classes. Overall classification accuracy across nine tree size classes was 59 percent, while average producer's accuracy was 37 percent, and average user's accuracy was 38 percent. The Kappa statistic was 49 percent.

		INVENTORY PLOTS										
	Tree Size Class (DBH or DRC, inches)	**FS1 (0 - 4.9" DBH)**	**FS2 (5 - 11.9" DBH)**	**FS3 (12 - 17.9" DBH)**	**FS4 (18 - 23.9" DBH)**	**FS5 (≥ 24.0" DBH)**	**WS1 (0 - 11.9" DRC)**	**WS2 (12 - 17.9" DRC)**	**WS3 (≥ 18" DRC)**	**Non Tree**	**Total**	**User's % Accuracy**
MAP CLASS	**FS1 (0 - 4.9" DBH)**	**1**	1	1						3	6	**17**
	FS2 (5 - 11.9" DBH)	1	**45**	9	4	2	5	2	1	3	72	**63**
	FS3 (12 - 17.9" DBH)		7	**13**	8	6		2	2	1	39	**33**
	FS4 (18 - 23.9" DBH)		2	3	**1**	1			2	1	10	**10**
	FS5 (≥ 24.0" DBH)										0	**0**
	WS1 (0 - 11.9" DRC)			1	1	1	**55**	14	19	3	94	**59**
	WS2 (12 - 17.9" DRC)						3	**4**	5		12	**33**
	WS3 (≥ 18" DRC)								**1**	1	2	**50**
	Non Tree	4	3	1			5	3		**66**	82	**80**
	Total	6	58	28	14	10	68	25	30	78	**317**	**38**
	Producer's % Accuracy	**17**	**78**	**46**	**7**	**0**	**81**	**16**	**3**	**85**	**37**	**59**

Canopy Cover Class Accuracies

The overall classification accuracy across nine canopy cover classes was 41 percent, while average producer's accuracy was 35 percent and average user's accuracy was 39 percent for the DNF (Table 26). The Kappa statistic was 26 percent. For the various percent canopy cover classes, the TC2 (20 - 39%) class had the highest producer's accuracy (72 percent) and most abundant class (103 of 317 plots). The remaining classes had 50 percent or less producer's accuracy values and fewer numbers of plots (42 or less). For the user's percent accuracy values, the Non Tree/Non Shrub class had the highest value (83 percent), followed by TC5 (≥ 60%) at 75 percent (4 plots) and TC2 (20 - 39%) at 49 percent. The remaining classes had 38 percent or less user's accuracy values with relatively fewer plot counts as compared to TC2 (152 plots). This is also supported by Table 15, which shows the TC2 (20 - 39%) class as the most prevalent class by area (about 32 percent) for the DNF.

The modeling process for denser tree canopy cover classes appeared to be a challenging prospect. The producer's accuracy values for tree canopy cover of 40 percent or more were 16 percent or less (TC3 (40 - 49%) at 16 percent, TC4 (50 - 59%) at eight percent and TC5 (≥ 60%) at nine percent). The user's accuracy values for those classes were somewhat improved (TC3 (40 - 49%) at 18 percent, TC4 (50 - 59%) at 25 percent and TC5 (≥ 60%) at 75 percent (four plots)). Following review of Table 26, it appears that denser tree cover classes were typically underestimated toward the most abundant class of TC2 (20 - 39%).

It is also generally accepted that canopy cover classes can be classified more precisely than tree size (diameter) classes when using remotely-sensed imagery. However, when comparing canopy cover (Table 26) and tree size (Table 25) accuracies (average producer's, average user's and overall classification), it seems that tree size was modeled more successfully than canopy cover for the DNF. Perhaps combining some classes so that ten or more plots per class are available for modeling purposes might increase these accuracy values. Besides canopy cover class breakpoints, some degree of confusion can also be credited to misclassification between tree and shrub species as well.

Table 26: Error matrix for canopy cover classes on the DNF. FIA plots were used as a validation data set to produce the classification accuracies for the modeled canopy cover map classes. Overall classification accuracy across nine canopy cover classes was 41 percent, while average producer's accuracy was 35 percent, and average user's accuracy was 39 percent. The Kappa statistic was 26 percent.

		INVENTORY PLOTS										
	Canopy Class (percent cover)	TC1 (10 – 19%)	TC2 (20 - 39%)	TC3 (40 - 49%)	TC4 (50 - 59%)	TC5 (≥ 60%)	SC1 (10 - 24%)	SC2 (25 - 34%)	SC3 (≥ 35%)	Non Tree/ Non Shrub	Total	User's % Accuracy
MAP CLASS	TC1 (10 - 19%)	**10**	15	4	1		2			2	34	**29**
	TC2 (20 - 39%)	10	**74**	27	23	11	1		1	5	152	**49**
	TC3 (40 - 49%)		4	**6**	10	12		1			33	**18**
	TC4 (50 - 59%)		1	1	**3**	7					12	**25**
	TC5 (≥ 60%)				1	**3**					4	**75**
	SC1 (10 - 24%)	2	3				**9**	1	1	8	24	**38**
	SC2 (25 - 34%)	3	1				9	**2**	2	7	24	**8**
	SC3 (≥ 35%)	1	3			1	2		**3**	1	11	**27**
	Non Tree/Non Shrub		2				2			**19**	23	**83**
	Total	26	103	38	38	34	25	4	7	42	**317**	**39**
	Producer's % Accuracy	**38**	**72**	**16**	**8**	**9**	**36**	**50**	**43**	**45**	**35**	**41**

For comparison purposes, the overall classification accuracy across 11 canopy cover classes based on the alternative canopy cover procedure was 46 percent, while average producer's accuracy was 39 percent and average user's accuracy was 45 percent for the DNF (Table 27). The Kappa statistic was 38 percent.

For the various canopy cover classes, the FC2 (20 - 39%) class had the highest producer's accuracy (73 percent), followed by WC2 (20 - 49%) with 69 percent which also had the most abundant class (85 of 317 plots). The remaining classes had 50 percent or less producer's accuracy values and fewer numbers of plots (43 or less). For the user's percent accuracy values, the Non Tree/Non Shrub class had the highest value (83 percent), followed by FC4 (≥ 60%) at 75 percent (4 plots). Both WC2 (20 - 49%) and WC3 (≥ 50%, 3 plots) were at 67 percent, trailed by FC3 (40 - 59%) at 43 percent. The remaining classes had 38 percent or less user's accuracy values with relatively fewer plot counts as compared to WC2 (88 plots) and FC2 (71 plots). This is also supported by Table 16, which shows the WC2 (20 - 49%) class as the most prevalent class by area (26 percent) for the DNF.

The modeling process for denser tree canopy cover classes seemed to have mixed results. The producer's accuracy values for FC4 (≥ 60%) was 12 percent (25 plots), while WC3 (≥ 50%) was nine percent (23 plots). However, the user's accuracy values for these classes was better (FC4 (≥ 60%) at 75 percent (four plots) and WC3 (≥ 50%) at 67 percent (three plots)).

Overall, the classification accuracy using the alternative canopy cover procedure across 11 canopy cover classes was 46 percent, while its average producer's accuracy was 39 percent and average user's accuracy was 45 percent (Table 27). When compared to the classification accuracy using nine classes listed in Table 26, there was generally a five percent increase in agreement when using the alternative canopy cover procedure.

Table 27: Error matrix for canopy cover classes (tree cover classes based on dominant forest or woodland species) on the DNF. FIA plots were used as a validation data set to produce the classification accuracies for the modeled canopy cover map classes. Overall classification accuracy across 11 canopy cover classes was 46 percent, while average producer's accuracy was 39 percent, and average user's accuracy was 45 percent. The Kappa statistic was 38 percent.

		INVENTORY PLOTS												
	Canopy Class (percent cover)	**FC1 (10 – 19%)**	**FC2 (20 - 39%)**	**FC3 (40 - 59%)**	**FC4 (≥ 60%)**	**WC1 (10 – 19%)**	**WC2 (20 – 49%)**	**WC3 (≥ 50%)**	**SC1 (10 - 24%)**	**SC2 (25 - 34%)**	**SC3 (≥ 35%)**	**Non Tree/ Non Shrub**	**Total**	**User's % Accuracy**
MAP CLASS	**FC1 (10 - 19%)**	**3**	4	1		2	4		2			1	17	**18**
	FC2 (20 - 39%)	5	**27**	23	5		5	2	1			3	71	**38**
	FC3 (40 - 59%)		2	**15**	16			1		1			35	**43**
	FC4 (≥ 60%)			1	**3**								4	**75**
	WC1 (10 - 19%)					**5**	11					1	17	**29**
	WC2 (20 - 49%)			3		5	**59**	18			1	2	88	**67**
	WC3 (≥ 50%)						1	**2**					3	**67**
	SC1 (10 - 24%)	1	1			1	2		**9**	1	1	8	24	**38**
	SC2 (25 - 34%)	2	1			1			9	**2**	2	7	24	**8**
	SC3 (≥ 35%)		1		1	1	2		2		**3**	1	11	**27**
	Non Tree/Non Shrub		1				1		2			**19**	23	**83**
	Total	11	37	43	25	15	85	23	25	4	7	42	**317**	**45**
	Producer's % Accuracy	**27**	**73**	**35**	**12**	**33**	**69**	**9**	**36**	**50**	**43**	**45**	**39**	**46**

Conclusions for Accuracy Assessment

Since its inception in the early 1980s, thematic accuracy assessment of remote sensing data has consistently been a particularly challenging portion of the mapping process. Despite its critical importance, there are a wide variety of data types and methods that can be used to attain relatively similar goals. Although a number of definitive standards have been adopted throughout the remote sensing community over the years, there still remains a great degree of uncertainty to the question of how best to perform a reliable, repeatable, and realistic accuracy assessment.

Although optimum reference datasets for accuracy assessment would be designed specifically for use with the final map product, this is often very cost prohibitive and time-consuming. The use of inventory data, such as FIA, involves trade-offs between resolution and reliability. FIA data provide a statistically robust, spatially distributed, unbiased sample that is readily available as a source of information that can serve as a base-level accuracy assessment for mid-level mapping. When used for accuracy assessments, consideration should be given to address differences in the sample design and data collection methods compared with the map products.

It was initially thought that the DNF mid-level map product may have had a worse accuracy assessment when compared to other R4 Forests, due to its relatively higher percentage of woodland forests (which may likely be more difficult to map relative to conifer or deciduous forests). Those mapping issues, however, were overcome as the DNF accuracy assessment results were in-line with assessments recently conducted on mid-level mapping projects from other Region 4 Forests.

Project Data Files

Feature Class and Layer Files

The existing vegetation polygon feature class and its Federal Geographic Data Committee (FGDC)-compliant metadata are stored and maintained in ESRI geodatabase format within individual forest Enterprise Geodatabase schemas at the Forest Service Enterprise Data Center. This feature class containing a union of vegetation type, tree and shrub cover class, and tree size class serves as the authoritative source data. It is recommended that the feature class be accessed by Forest Service users through Citrix using ESRI ArcGIS software applications to optimize performance (https://apps.fs.fed.us/Citrix/auth/login.aspx). Geodatabase Feature classes and ArcGIS layer files (*.lyr) containing polygon-feature symbology for vegetation type, cover class, and tree size class can be accessed through Citrix from ArcGIS applications at T:\FS\Reference\GIS\r04_dif\LayerFile. More information on procedures for accessing geospatial data through Citrix at the Data Center can be found at: http://fsweb.egis.fs.fed.us/EGIS_tools/GettingStartedEDC.shtml.

Ancillary and Intermediate Data

All other data related to this project, including ancillary and intermediate geospatial data, reference site information, and supporting documentation are stored and archived as the trusted source data set on the Intermountain Regional Office local Network Attached Storage (NAS) device and tape backup system. Assistance in accessing the authoritative source data through Citrix or obtaining a copy of ancillary and intermediate data sets may be facilitated by Regional Office project partners.

Conclusion

The status and condition of existing vegetation on the DNF is a critical factor for many of its land-management decisions. When used in conjunction with the associated maps, taxonomic keys, data, and map unit descriptions, this document provides the foundation for supporting applicable land management decisions using the best-available science. Since these products reflect 2013-2014 conditions, land managers should develop a strategy for maintaining their initial investment in the future. Maintenance and future updates will keep the vegetation map current and useful as vegetation disturbances, treatments, or gradual changes occur over time.

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Appendices

Appendix A: Acquired Geospatial Data for Mapping

Geospatial Data	Source	Use
Landsat 5 TM – June & July 2011	USGS GloVis	Segmentation
Landsat 8 OLI – May 2013 & 2014, June 2013 & 2014, September & October 2013 & 2014	USGS GloVis	Modeling
NAIP 2011 (1-meter)	USDA Farm Service Agency	Modeling & Segmentation
NAIP 2014 (1-meter)	USDA Farm Service Agency	Modeling
Dixie Resource Photography 2012 (.5-meter)	USDA Farm Service Agency	Photo-Interpretation
Digital Elevation Model (DEM)	i-cubed DataDoors	Modeling & Segmentation
Administrative boundary	Dixie NF	Identify project area
Land ownership	Dixie NF	Field site selection
Roads & trails	Dixie NF	Field site selection
Hydrology	Dixie NF	Field site selection
Existing vegetation types	Dixie NF	Modeling & Field site selection
Gap Landcover	USGS Gap Analysis Program	Modeling & Field site selection
Landfire Existing Vegetation Type	Landscape Fire and Resource Management Planning Tools	Modeling & Field site selection
Geology	Dixie NF	Modeling
Fire severity & burn perimeters	MTBS	Modeling

Climate – average temperature	Daymet	Modeling
Climate – growing days	Daymet	Modeling
Climate – total precipitation	Daymet	Modeling
Climate – frequency precipitation	Daymet	Modeling
IfSAR	Intermap Technologies	Tree size modeling

Appendix B: Vegetation Indices, Transformations, and Topographic Derivatives

Geospatial Data	Source	Use
Landsat 5 TM – Principal Components (3)	Erdas model	Segmentation
Landsat 5 TM – Tasseled Cap	Erdas model	Segmentation
Landsat 8 OLI – NDVI	Customized model	Modeling
Landsat 8 OLI – Principal Components (3)	Customized model	Modeling
Landsat 8 OLI – Tasseled Cap	Customized model	Modeling
Landsat 8 OLI – Seasonal Coefficients	Customized model	Modeling
NAIP 2011 – NDVI	Customized model	Modeling & Segmentation
NAIP 2014 – NDVI	Customized model	Modeling
Slope (degrees)	Customized model	Modeling
Aspect	Customized model	Field site selection
Slope-Aspect (Cos)	Customized model	Modeling
Slope-Aspect (Sin)	Customized model	Modeling
Heatload	Customized model	Modeling
Valleybottom	Customized model	Modeling
Trishade	Customized model	Segmentation

Appendix C: Existing Vegetation Keys

Dixie National Forest &
Teasdale Portion of the Fremont District on the Fishlake National Forest

DRAFT Vegetation Keys

11/1/2016

Dave Tart, Rose Lehman, Mark Madsen, Jim Gerleman, Marisa Anderson

NOTE: These keys apply only to existing vegetation for mid-level mapping, not potential or historical vegetation.

R4 Key to Vegetation Formations

This key does not apply to lands used for agriculture or urban/residential development. It applies only to natural and semi-natural vegetation dominated by vascular plants. Semi-natural vegetation includes planted vegetation that is not actively managed or cultivated.

All cover values in the key to formations are absolute cover, not relative cover, for the life form. See Appendix A for a discussion of absolute versus relative cover. In this key, tree cover includes both regeneration and overstory sized trees, so that young stands of trees are classified as forest.

First, identify the R4 Vegetation Formation of the plot, stand, or polygon using the key below. Vegetation Type Map Units (Map Unit) are defined in Appendix B.

			Key or Dominance Type	Map Unit
1a		All vascular plants total < 1% canopy cover……...……..	**Non-Vegetated (p.24)**	
1b		All vascular plants total ≥ 1% canopy cover……………	2	
	2a	All vascular plants total < 10% canopy cover…………	**Sparse Vegetation**	**BR/SV**
	2b	All vascular plants total ≥ 10% canopy cover…………	3	
3a		Trees total ≥ 10% canopy cover………………………...	4	
3b		Trees total < 10% canopy cover………………………...	5	
	4a	Stand located above continuous forest line and trees stunted (< 5m tall) by harsh alpine growing conditions..	**Shrubland Key (p.11)**	
	4b	Stand not above continuous forest line; trees not stunted……………………………………………………..…	**Forest & Woodland Key (p.2)**	
5a		Shrubs total ≥ 10% canopy cover………..………………	**Shrubland Key (p.11)**	
5b		Shrubs total < 10% canopy cover……………………..……	6	
	6a	Herbaceous vascular plants total ≥ 10% canopy cover..	7	
	6b	Herbaceous vascular plants total < 10% canopy cover..	8	
7a		Total cover of graminoids ≥ total cover of forbs……….	**Grassland Key (p.15)**	
7b		Total cover of graminoids < total cover of forbs……..…	**Forbland Key (p.19)**	
	8a	Trees total ≥ 5% canopy cover…………………...……....	**Sparse Tree (SP TREE)**	**BR/SV**
	8b	Trees total < 5% canopy cover………………………......	9	
9a		Shrubs total ≥ 5% canopy cover………………………..	**Sparse Shrub (SP SHRUB)**	**BR/SV**
9b		Shrubs total < 5% canopy cover………………………....	10	
	10a	Herbaceous vascular plants total ≥ 5% canopy cover...	**Sparse Herbaceous(SP HERB)**	**BR/SV**
	10b	Herbaceous vascular plants total < 5% canopy cover...	**Sparse Vegetation (SP VEG)**	**BR/SV**

Forest and Woodland Key

Dominance Types (d.t.) and DT Phases (d.t.p.)

Instructions:

1. Preferably, plots or polygons should be keyed out based on overstory canopy cover (trees forming the upper or uppermost canopy layer) by tree species.
2. Plots or polygons lacking such data or lacking an overstory layer should be keyed out using total cover by species.
3. If a plot or polygon does not key out using overstory cover, then it may be keyed using total tree cover.
4. If two trees are equally abundant, the species encountered first in the key is recorded as the most abundant.
5. If a tree species is not listed, then consult with the Regional Ecologist to assign a dominance type and map unit.

			DT or DT Phase Code	Map Unit	Veg Group
1a		Narrowleaf cottonwood is the most abundant tree species………	**POAN3 d.t.**	**RW**	**R**
1b		Narrowleaf cottonwood not the most abundant tree species…….	**2**		
	2a	Fremont cottonwood is the most abundant tree species………...	**POFR2 d.t.**	**RW**	**R**
	2b	Fremont cottonwood is not the most abundant tree species…….	**3**		
3a		Thinleaf alder is the most abundant tree species……………...…..	**ALINT d.t.**	**RW**	**R**
3b		Thinleaf alder is not the most abundant tree species……….…...	**4**		
	4a	Water birch is the most abundant tree species…………………..…..	**BEOC2 d.t.**	**RW**	**R**
	4b	Water birch is not the most abundant tree species……………......	**5**		
5a		Velvet ash is the most abundant tree species…………………..….	**FRVE2 d.t.**	**RW**	**R**
5b		Velvet ash is not the most abundant tree species………………...	**6**		
	6a	Boxelder is the most abundant tree species……………………….....	**ACNE2 d.t.**	**RW**	**R**
	6b	Boxelder is not the most abundant tree species…………….……	**7**		
7a		Russian olive is the most abundant tree species………………..…	**ELAN d.t.**	**RW**	**R**
7b		Russian olive is not the most abundant tree species………………	**8**		
	8a	Five-stamen tamarisk is the most abundant species……………..	**TACH2 d.t.**	**RW**	**R**
	8b	Five-stamen tamarisk is not the most abundant species……...…	**9**		
9a		Smallflower tamarisk is the most abundant species………………	**TAPA4 d.t.**	**RW**	**R**
9b		Smallflower tamarisk is not the most abundant species…………..	**10**		
	10a	Saltcedar (tamarisk) is the most abundant species………………	**TARA d.t.**	**RW**	**R**
	10b	Saltcedar (tamarisk) is not the most abundant species…………..	**11**		
11a		Blue spruce is the most abundant tree species............................	**12**		
11b		Blue spruce is not the most abundant tree species......................	**22**		
	12a	Blue spruce ≥ 75% relative canopy cover.....................................	**PIPU-PIPU d.t.p.**	**BS**	**C**
	12b	Blue spruce < 75% relative cover cover.......................................	**13**		
13a		Narrowleaf cottonwood is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover…………	**PIPU-POAN3 d.t.p.**	**BS**	**C**

			DT or DT Phase Code	Map Unit	Veg Group
13b		Narrowleaf cottonwood is not the second most abundant tree species and/or it and blue spruce total < 65% relative canopy cover……………………………………………………………….	**14**		
	14a	Quaking aspen is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover....................................	**PIPU-POTR5 d.t.p.**	**AS/C**	**D**
	14b	Quaking aspen is not the second most abundant species and/or it and blue spruce total < 65% relative canopy cover……………..	**15**		
15a		Ponderosa pine is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover..............................	**PIPU-PIPO d.t.p.**	**BS**	**C**
15b		Ponderosa pine is not the second most abundant species and/or it and blue spruce total < 65% relative canopy cover……………..	**16**		
	16a	Douglas-fir is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover....................................	**PIPU-PSME d.t.p.**	**BS**	**C**
	16b	Douglas-fir is not the second most abundant tree species and/or it and blue spruce total < 65% relative canopy cover……………..	**17**		
17a		White fir is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover..	**PIPU-ABCO d.t.p.**	**BS**	**C**
17b		White fir is not the second most abundant tree species and/or it and blue spruce total < 65% relative canopy cover………………..	**18**		
	18a	Engelmann spruce is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover..............................	**PIPU-PIEN d.t.p.**	**BS**	**C**
	18b	Engelmann spruce is not the second most abundant species and/or it and blue spruce total < 65% relative canopy cover……..	**19**		
19a		Subalpine fir is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover....................................	**PIPU-ABLA d.t.p.**	**BS**	**C**
19b		Subalpine fir is not the second most abundant species and/or it and blue spruce total < 65% relative canopy cover………………..	**20**		
	20a	Another forest species is the second most abundant tree species; it and blue spruce ≥ 65% relative canopy cover……….	**PIPU mix d.t.p.**	**BS**	**C**
	20b	Another forest species is not the second most abundant tree species…………………………………………………………………	**21**		
21a		A woodland species is the second most abundant tree species; it and blue spruce total ≥ 65% relative canopy cover……….……	**PIPU-WD d.t.p.**	**BS**	**C**
21b		A woodland species is not the second most abundant tree species…………………………………………………………………	**PIPU d.t.**	**BS**	**C**
	22a	Quaking aspen is the most abundant tree species.......................	**23**		
	22b	Quaking aspen is not the most abundant tree species.................	**37**		
23a		Quaking aspen ≥ 75% relative canopy cover…………..…………	**POTR5-POTR5 d.t.p.**	**AS**	**D**
23b		Quaking aspen < 75% relative canopy cover…………..…………	**24**		
	24a	Ponderosa pine is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover.........................	**POTR5-PIPO d.t.p.**	**AS/C**	**D**
	24b	Ponderosa pine is not the second most abundant tree species and/or it and quaking aspen total < 65% relative canopy cover….	**25**		

			DT or DT Phase Code	Map Unit	Veg Group
25a		Douglas-fir is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover................................	**POTR5-PSME d.t.p.**	**AS/C**	**D**
25b		Douglas-fir is not the second most abundant tree species and/or it and quaking aspen total < 65% relative canopy cover…………	**26**		
	26a	White fir is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover................................	**POTR5-ABCO d.t.p.**	**AS/C**	**D**
	26b	White fir is not the second most abundant tree species and/or it and quaking aspen total < 65% relative canopy cover……………	**27**		
27a		Engelmann spruce is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover………………….	**POTR5-PIEN d.t.p.**	**AS/C**	**D**
27b		Engelmann spruce is not the second most abundant tree species and/or it and quaking aspen total < 65% relative canopy cover………………………………………………………………… .	**28**		
	28a	Subalpine fir is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover................................	**POTR5-ABLA d.t.p.**	**AS/C**	**D**
	28b	Subalpine fir is not the second most abundant tree species and/or it and quaking aspen total < 65% relative canopy cover….	**29**		
29a		Blue spruce is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover................................	**POTR5-PIPU d.t.p.**	**AS/C**	**D**
29b		Blue spruce is not the second most abundant tree species and/or it and quaking aspen total < 65% relative canopy cover….	**30**		
	30a	Another forest species is the second most abundant species; it and quaking aspen ≥ 65% relative canopy cover………………….	**POTR5 mix d.t.p.**	**AS/C**	**D**
	30b	Another forest species is not the second most abundant species……………………………………………………………….	**31**		
31a		Curlleaf mountain mahogany is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover……	**POTR5-CELE3 d.t.p.**	**AS**	**D**
31b		Curlleaf mountain mahogany is not the second most abundant tree and/or it and quaking aspen < 65% relative canopy cover….	**32**		
	32a	Rocky Mountain juniper is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover……..	**POTR5-JUSC2 d.t.p.**	**AS/C**	**D**
	32b	Rocky Mountain juniper is not the second most abundant tree and/or it and quaking aspen < 65% relative canopy cover………	**33**		
33a		Utah Juniper, Twoneedle pinyon and/or singleleaf pinyon species is/are the second most abundant tree species………..….	**POTR5-PJ d.t.p.**	**AS/C**	**D**
33b		Utah Juniper, Twoneedle pinyon and/or singleleaf pinyon species is not the second most abundant tree species………..….	**34**		
	34a	Gambel oak is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover……………………...…..	**POTR5-QUGA d.t.p.**	**AS**	**D**
	34b	Gambel oak is not the second most abundant tree and/or it and quaking aspen < 65% relative canopy cover………………………	**35**		
35a		Bigtooth maple is the second most abundant tree species; it and quaking aspen ≥ 65% relative canopy cover……………………...…..	**POTR5-ACGR3 d.t.p.**	**AS**	**D**

			DT or DT Phase Code	Map Unit	Veg Group
35b		Bigtooth maple is not the second most abundant tree and/or it and quaking aspen < 65% relative canopy cover…………………	**36**		
	36a	Another woodland species is the second most abundant tree species; it and quaking aspen total ≥ 65% relative canopy cover…………………………………………………………….......	**POTR5 d.t.**	**AS**	**D**
	36b	A woodland species is not the second most abundant tree species………………………………………………………….………	**POTR5 d.t.**	**AS**	**D**
37a		Great Basin bristlecone pine is the most abundant tree species...	**PILO d.t.**	**BC/LM**	**C**
37b		Great Basin bristlecone pine is not the most abundant tree species…………………………………………………………………	**38**		
	38a	Limber pine is the most abundant tree species……………………	**PIFL2 d.t.**	**BC/LM**	**C**
	38b	Limber pine is not the most abundant tree species……………..…	**39**		
39a		Ponderosa Pine is the most abundant tree species.....................	**40**		
39b		Ponderosa Pine is not the most abundant tree species...............	**47**		
	40a	Ponderosa Pine ≥ 75% relative canopy cover..............................	**PIPO-PIPO d.t.p.**	**PP**	**C**
	40b	Ponderosa Pine < 75% relative canopy cover..............................	**41**		
41a		Quaking aspen is the second most abundant tree species; it and Ponderosa Pine ≥ 65% relative canopy cover..............................	**PIPO-POTR5 d.t.p.**	**AS/C**	**D**
41b		Quaking aspen is not the second most abundant tree species and/or it and ponderosa pine total < 65% relative canopy cover...	**42**		
	42a	Douglas-fir is the second most abundant tree species; it and ponderosa Pine ≥ 65% relative canopy cover..............................	**PIPO-PSME d.t.p.**	**PPmix**	**C**
	42b	Douglas-fir is not the second most abundant tree species and/or it and ponderosa pine total < 65% relative canopy cover………..	**43**		
43a		White fir is the second most abundant tree species; it and ponderosa pine ≥ 65% relative canopy cover..............................	**PIPO-ABCO d.t.p.**	**PPmix**	**C**
43b		White fir is not the second most abundant tree species and/or it and ponderosa pine total < 65% relative canopy cover……..……	**44**		
	44a	Another forest species is the second most abundant species; it and ponderosa pine ≥ 65% relative canopy cover…………………	**PIPO mix d.t.p.**	**PPmix**	**C**
	44b	Another forest species is not the second most abundant species.	**45**		
45a		Rocky Mountain juniper is the second most abundant tree species; it and ponderosa pine total ≥ 65% relative canopy cover………………………………………………………………… .	**PIPO-JUSC2 d.t.p.**	**PP/WD**	**C**
45b		Rocky Mountain juniper is not the second most abundant tree species and/or it and ponderosa pine total < 65% relative canopy cover...	**46**		
	46a	Another woodland species is the second most abundant tree species; it and ponderosa pine total ≥ 65% relative canopy cover………..………………………………………….…………… .	**PIPO-WD mix d.t.p.**	**PP/WD**	**C**
	46b	A woodland tree species is not the second most abundant species……………………………………………………….........…. .	**PIPO d.t.**	**PPmix**	**C**

			DT or DT Phase Code	Map Unit	Veg Group
47a		Douglas-fir is the most abundant tree species..............................	**48**		
47b		Douglas-fir is not the most abundant tree species........................	**57**		
	48a	Douglas-fir ≥ 75% relative canopy cover………...……...................	**PSME-PSME d.t.p.**	**DFmix**	**C**
	48b	Douglas-fir < 75% relative cover cover…………………..................	**49**		
49a		Quaking aspen is the second most abundant tree species; it and Douglas-fir ≥ 65% relative canopy cover………………..................	**PSME-POTR5 d.t.p.**	**AS/C**	**D**
49b		Quaking aspen is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover………	**50**		
	50a	Ponderosa pine is the second most abundant tree species; it and Douglas-fir ≥ 65% relative canopy cover...............................	**PSME-PIPO d.t.p.**	**DFmix**	**C**
	50b	Ponderosa pine is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover…….	**51**		
51a		White fir is the second most abundant tree species; it and Douglas-fir ≥ 65% relative canopy cover......................................	**PSME-ABCO d.t.p.**	**DFmix**	**C**
51b		White fir is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover………………..	**52**		
	52a	Blue spruce is the second most abundant tree species; it and Douglas-fir ≥ 65% relative canopy cover......................................	**PSME-PIPU d.t.p.**	**DFmix**	**C**
	52b	Blue spruce is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover……..	**53**		
53a		Engelmann spruce is the second most abundant tree species; it and Douglas-fir ≥ 65% relative canopy cover...............................	**PSME-PIEN d.t.p.**	**DFmix**	**C**
53b		Engelmann spruce is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover……………………………………………………………… .	**54**		
	54a	Subalpine fir is the second most abundant tree species; it and Douglas-fir ≥ 65% relative canopy cover......................................	**PSME-ABLA d.t.p.**	**DFmix**	**C**
	54b	Subalpine fir is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover……..	**55**		
55a		Another forest species is the second most abundant species; it and Douglas-fir ≥ 65% relative canopy cover……………………..…..	**PSME mix d.t.p.**	**DFmix**	**C**
55b		Another forest species is not the second most abundant species.	**56**		
	56a	A woodland species is the second most abundant tree species; it and Douglas-fir total ≥ 65% relative canopy cover………………	**PSME-WD mix d.t.p.**	**DFmix**	**C**
	56b	A woodland species is not the second most abundant tree species…………………………………………………………..….....	**PSME d.t.**	**DFmix**	**C**
57a		Engelmann spruce is the most abundant tree species.................	**58**		
57b		Engelmann spruce is not the most abundant tree species...........	**66**		
	58a	Engelmann spruce ≥ 75% relative canopy cover…………….........	**PIEN-PIEN d.t.p.**	**SF**	**C**
	58b	Engelmann spruce < 75% relative cover cover............................	**59**		

			DT or DT Phase Code	Map Unit	Veg Group
59a		Quaking aspen is the second most abundant tree species; it and Engelmann spruce ≥ 65% relative canopy cover..........................	**PIEN-POTR5 d.t.p.**	**AS/C**	**D**
59b		Quaking aspen is not the second most abundant tree species and/or it and Engelmann spruce total < 65% relative canopy cover………………………………………………………………….	**60**		
	60a	Douglas-fir is the second most abundant tree species; it and Engelmann spruce ≥ 65% relative canopy cover..........................	**PIEN-PSME d.t.p.**	**SF**	**C**
	60b	Douglas-fir is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover……………..…...	**61**		
61a		White fir is the second most abundant tree species; it and Engelmann spruce ≥ 65% relative canopy cover……...................	**PIEN-ABCO d.t.p.**	**SF**	**C**
61b		White fir is not the second most abundant tree species and/or it and Engelmann spruce total < 65% relative canopy cover………	**62**		
	62a	Subalpine fir is the second most abundant tree species; it and Engelmann spruce ≥ 65% relative canopy cover..........................	**PIEN-ABLA d.t.p.**	**SF**	**C**
	62b	Subalpine fir is not the second most abundant tree species and/or it and Engelmann spruce total < 65% relative canopy cover…………………………………………………………………	**63**		
63a		Blue spruce is the second most abundant tree species; it and Engelmann spruce ≥ 65% relative canopy cover……………….....	**PIEN-PIPU d.t.p.**	**SF**	**C**
63b		Blue spruce is not the second most abundant tree species and/or it and Engelmann spruce total < 65% relative canopy cover………………………………………………………………….	**64**		
	64a	Another forest species is the second most abundant tree species; it and Engelmann spruce ≥ 65% relative canopy cover………………………………………..………..………….....	**PIEN mix d.t.p.**	**SF**	**C**
	64b	Another forest species is not the second most abundant tree species………………………………………………………....	**65**		
65a		A woodland species is the second most abundant tree species; it and Engelmann spruce total ≥ 65% relative canopy cover……….	**PIEN-WD d.t.p.**	**SF**	**C**
65b		A woodland species is not the second most abundant tree species…………………………………………………………………	**PIEN d.t.**	**SF**	**C**
	66a	White fir is the most abundant tree species.................................	**67**		
	66b	White fir is not the most abundant tree species..........................	**76**		
67a		White fir ≥ 75% relative canopy cover..	**ABCO-ABCO d.t.p.**	**WFmix**	**C**
67b		White fir < 75% relative cover cover..	**68**		
	68a	Quaking aspen is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover...	**ABCO-POTR5 d.t.p.**	**AS/C**	**D**
	68b	Quaking aspen is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover…………	**69**		
69a		Ponderosa pine is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover....................................	**ABCO-PIPO d.t.p.**	**WFmix**	**C**

			DT or DT Phase Code	Map Unit	Veg Group
69b		Ponderosa pine is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover………....	**70**		
	70a	Douglas-fir is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover...	**ABCO-PSME d.t.p.**	**WFmix**	**C**
	70b	Douglas-fir is not the second most abundant tree species and/or it and Douglas-fir total < 65% relative canopy cover……………...	**71**		
71a		Blue spruce is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover...	**ABCO-PIPU d.t.p.**	**WFmix**	**C**
71b		Blue spruce is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover………....	**72**		
	72a	Engelmann spruce is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover....................................	**ABCO-PIEN d.t.p.**	**WFmix**	**C**
	72b	Engelmann spruce is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover…………………...…………………………………….…....	**73**		
73a		Subalpine fir is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover...	**ABCO-ABLA d.t.p.**	**WFmix**	**C**
73b		Subalpine fir is not the second most abundant tree species and/or it and white fir total < 65% relative canopy cover………....	**74**		
	74a	Another forest species is the second most abundant tree species; it and white fir ≥ 65% relative canopy cover…………..….	**ABCO mix d.t.p.**	**WFmix**	**C**
	74b	Another forest species is not the second most abundant tree species…..	**75**		
75a		A woodland species is the second most abundant tree species; it and white fir total ≥ 65% relative canopy cover…………………….	**ABCO-WD d.t.p.**	**WFmix**	**C**
75b		A woodland species is not the second most abundant tree species……………………………………………………...…….....	**ABCO d.t.**	**WFmix**	**C**
	76a	Subalpine is the most abundant tree species..............................	**77**		
	76b	Subalpine fir is not the most abundant tree species……...............	**85**		
77a		Subalpine fir ≥ 75% relative canopy cover....................................	**ABLA-ABLA d.t.p.**	**SF**	**C**
77b		Subalpine fir < 75% relative cover cover......................................	**78**		
	78a	Quaking aspen is the second most abundant tree species; it and Subalpine fir ≥ 65% relative canopy cover....................................	**ABLA-POTR5 d.t.p.**	**AS/C**	**D**
	78b	Quaking aspen is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover…….	**79**		
79a		Douglas-fir is the second most abundant tree species; it and subalpine fir ≥ 65% relative canopy cover……………………..…..….	**ABLA-PSME d.t.p.**	**SF**	**C**
79b		Douglas-fir is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover……………..	**80**		
	80a	White fir is the second most abundant tree species; it and subalpine fir ≥ 65% relative canopy cover....................................	**ABLA-ABCO d.t.p.**	**SF**	**C**
	80b	White fir is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover…………..…..	**81**		

			DT or DT Phase Code	Map Unit	Veg Group
81a		Engelmann spruce is the second most abundant tree species; it and subalpine fir ≥ 65% relative canopy cover…………………....	**ABLA-PIEN d.t.p.**	**SF**	**C**
81b		Engelmann spruce is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover………………………………………………………..…...……	**82**		
	82a	Blue spruce is the second most abundant tree species; it and subalpine fir ≥ 65% relative canopy cover……………………............	**ABLA-PIPU d.t.p.**	**SF**	**C**
	82b	Blue spruce is not the second most abundant tree species and/or it and subalpine fir total < 65% relative canopy cover…….	**83**		
83a		Another forest species is the second most abundant tree species; it and subalpine fir ≥ 65% relative canopy cover……......	**ABLA mix d.t.p.**	**SF**	**C**
83b		Another forest species is not the second most abundant tree species……………………………………………………………..…..	**84**		
	84a	A woodland species is the second most abundant tree species; it and Subalpine fir total ≥ 65% relative canopy cover……..…...	**ABLA-WD d.t.p.**	**SF**	**C**
	84b	A woodland species is not the second most abundant tree species……………………………………………………………….…	**ABLA d.t.**	**SF**	**C**
85a		Curlleaf mountain mahogany is the most abundant tree species..	**CELE3 d.t.**	**MM**	**W**
85b		Curlleaf mountain mahogany is not the most abundant tree species…………………………………………………………………	**86**		
	86a	Rocky Mountain juniper is the most abundant tree species………	**87**		
	86b	Rocky Mountain juniper is not the most abundant tree species…	**92**		
87a		Rocky mountain juniper ≥ 75% relative canopy cover..................	**JUSC2-JUSC2 d.t.p.**	**RMJmix**	**W**
87b		Rocky mountain juniper < 75% relative cover cover……………...	**88**		
	88a	Ponderosa pine is the second most abundant tree species; it and Rocky Mountain juniper ≥ 65% relative canopy cover…….....	**JUSC2-PIPO d.t.p.**	**PP/WD**	**C**
	88b	Ponderosa pine is not the second most abundant tree species and/or it and Rocky Mountain juniper total < 65% relative canopy cover……………………………………………………………..………	**89**		
89a		Another forest species is the second most abundant tree species; it and Rocky Mountain juniper ≥ 65% relative canopy cover…………………………………………………………...……….	**JUSC2 mix d.t.p.**	**RMJmix**	**W**
89b		Another forest species is not the second most abundant tree species…………………………………..………………………………	**90**		
	90a	Utah Juniper, Twoneedle pinyon and/or singleleaf pinyon species is/are the second most abundant tree species………..….	**JUSC2-PJ d.t.p.**	**RMJmix**	**W**
	90b	Utah Juniper, Twoneedle pinyon and/or singleleaf pinyon species is not the second most abundant tree species…………..….	**91**		
91a		Another woodland species is the second most abundant tree species………………………………………………………………..….	**JUSC2-WD d.t.p.**	**RMJmix**	**W**
91b		A woodland species is not the second most abundant tree species……………………………………………………………..……	**JUSC2 d.t.**	**RMJmix**	**W**

			DT or DT Phase Code	Map Unit	Veg Group
	92a	Utah juniper is the most abundant tree species….........................	**JUOS d.t.**	**PJ**	**W**
	92b	Utah juniper is not the most abundant tree species…………….	**93**		
93a		Twoneedle pinyon is the most abundant tree species……….……	**PIED d.t.**	**PJ**	**W**
93b		Twoneedle pinyon is not the most abundant tree species………..	**94**		
	94a	Singleleaf pinyon is the most abundant tree species……………..	**PIMO d.t.**	**PJ**	**W**
	94b	Singleleaf pinyon is not the most abundant tree species………....	**95**		
95a		Gambel oak is the most abundant tree species ………………......	**QUGA d.t.**	**GO**	**W**
95b		Gambel oak is not the most abundant tree species………………	**96**		
	96a	Bigtooth Maple is the most abundant tree species……………..…..	**97**		
	96b	Bigtooth Maple is not the most abundant tree species…………...	**98**		
97a		Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables……………………..	**ACGR3 d.t.**	**RW**	**R**
97b		Stand not located in a riparian setting as described above………………………………………………………………..	**ACGR3 d.t.**	**GO**	**W**
	98a	Singleleaf ash is the most abundant tree species……….………	**99**		
	98b	Singleleaf ash is not the most abundant tree species……………	**Undefined**	**UND**	
99a		Singleleaf ash is associated with Utah juniper, two-needle pinyon, or singleleaf pinyon…………………………………………	**FRAN2 d.t.**	**PJ**	**W**
99b		Singleleaf ash is not associated with Utah Juniper, two-needle pinyon, or singleleaf pinyon…………………………………………	**100**		
	100a	Singleleaf ash is associated with Gambel oak…………………….	**FRAN2 d.t.**	**GO**	**W**
	100b	Singleleaf ash is not associated with Gambel oak………………..	**101**		
101a		Singleleaf ash is associated with chaparral species (p. 14) with more total cover than desert shrub species (p.14)………………..	**FRAN2 d.t.**	**CHAP**	**S**
101b		Singleleaf ash is associated with desert shrub species (p.14) with more total cover than chaparral species (p.14)………………	**FRAN2 d.t.**	**DSH**	**S**

Shrubland Key

Dominance Types

Instructions:

Plots or polygons should be keyed out based on total cover by species. This key is divided into riparian, alpine, and upland sections. **First, identify the physical setting of the plot, stand, or polygon using the key below.**

For the purposes of this key, a riparian setting is defined as an area (typically transitional between aquatic and terrestrial ecosystems) identified by soil characteristics associated with at least seasonally high water tables, distinctive vegetation that requires or tolerates free or unbound water (Manning and Padgett 1995), proximity to a stream or lake, and/or topographic position (e.g., valley bottom). The alpine setting includes the area above the upper limit of continuous forest. Above this limit, trees occur only in scattered patches and become increasingly stunted at higher elevations (Arno and Hammerly 1984). In this key, the alpine setting takes precedence over the riparian setting. The upland setting includes non-riparian areas below the continuous forest line.

It is likely that some dominance types occur in more than one of these settings. If your plot does not key out successfully in one setting, then try another setting. For example, basin big sagebrush is in the upland key but may occur in degraded riparian areas with downcut streams.

Key to Physical Habitat Setting

Key Leads:

1a	Stand is located in an alpine setting above the upper elevation limit of continuous forest………………………………………………………………………	**Go to Alpine Key (p.11)**
1b	Stand is located below the upper elevation limit of continuous forest……………	**2**
2a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables…………………………………………………………………………………	**Go to Riparian Key (p.12)**
2b	Stand not located in a riparian setting as described above……………………….	**Go to Upland Key (p.13)**

Key to Alpine Shrubland Dominance Types

Instructions:

1. Codes for dominance type and map unit can be found using Table 1. Find the name of the most abundant shrub in column 1 and move to column 2 for the dominance type code, column 3 for the map unit code, and column 4 for the map group code.
2. When two or more shrub species are equal in abundance, the species listed first in Table 1 Column 5 is used to assign the dominance type and map unit.
3. If the most abundant shrub species is not listed in Table 1, then consult with the Regional Ecologist to assign a dominance type.

Table 1: Most Abundant Alpine Shrub and Indicated Dominance Type and Veg. Type Map Unit

(1) Most Abundant Shrub (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Abies lasiocarpa krummholz	subalpine fir	ABLA-K	**ALP**	**A**	2
Picea engelmannii krummholz	Engelmann spruce	PIEN-K	**ALP**	**A**	1
Ribes montigenum	gooseberry currant	RIMO2-A	**ALP**	**A**	3
Species not listed above		See Instruction 3 above	**ALP**	**A**	
Species unidentifiable		UNKNOWN	**ALP**	**A**	

Key to Riparian Shrubland Dominance Types

Instructions:

1. Plots or polygons should be keyed out based on total cover by species.
2. Codes for dominance type and map unit can be found using Table 2. Find the name of the most abundant shrub in column 1 and move to column 2 for the dominance type code, column 3 for the map unit code, and column 4 for the map group code.
3. When two or more shrub species are equal in abundance, the species listed with the lowest ranked number in Table 2 column 5 is used to assign the dominance type and map unit.
4. If the most abundant shrub species is not listed in Table 2, then consult with the Regional Ecologist to assign a dominance type.

Table 2: Most Abundant Riparian Shrub and Indicated Dominance Type and Veg. Type Map Unit

(1) Most Abundant Shrub (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Artemisia cana ssp. viscidula	mountain silver sagebrush	ARCAV2-R	RW	**R**	17
Cornus sericea	redosier dogwood	COSE16	RW	**R**	12
Dasiphora fruticosa	shrubby cinquefoil	DAFR6-R	RW	**R**	16
Lonicera involucrata	twinberry honeysuckle	LOIN5	RW	**R**	20
Prunus virginiana	chokecherry	PRVI-R	RW	**R**	23
Rhus glabra	smooth sumac	RHGL	RW	**R**	19
Rhus trilobata	skunkbush sumac	RHTR-R	RW	**R**	14
Ribes aureum	golden currant	RIAU	RW	**R**	15
Ribes inerme	whitestem gooseberry	RIIN2	RW	**R**	11
Ribes montigenum	gooseberry currant	RIMO2-R	RW	**R**	18
Robinia neomexicana	New Mexico locust	RONE-R	RW	**R**	25
Rosa woodsii	Woods' rose	ROWO-R	RW	**R**	13
Rubus idaeus	American red raspberry	RUID-R	RW	**R**	24
Salix arizonica	Arizona willow	SAAR14	RW	**R**	9
Salix bebbiana	Bebb willow	SABE2	RW	**R**	6
Salix boothii	Booth's willow	SABO2	RW	**R**	1
Salix drummondiana	Drummond's willow	SADR	RW	**R**	2
Salix eriocephala	Missouri River willow	SAER	RW	**R**	8
Salix exigua	narrowleaf willow	SAEX	RW	**R**	4
Salix geyeriana	Geyer's willow	SAGE2	RW	**R**	3
Salix lucida ssp. lasiandra	Pacific willow	SALUL	RW	**R**	5
Salix planifolia	diamondleaf willow	SAPL2	RW	**R**	7
Salix scouleriana	Scouler's willow	SASC-R	RW	**R**	10
Sambucus nigra ssp. cerulea	blue elderberry	SANIC5-R	RW	**R**	21
Sambucus racemosa	red elderberry	SARA2-R	RW	**R**	22
Tamarix chinensis	fivestamen tamarisk	TACH2	RW	**R**	26
Tamarix parviflora	smallflower tamarisk	TAPA4	RW	**R**	27
Tamarix ramosissima	saltcedar	TARA	RW	**R**	28
Species not listed above		See Instruction 4 above	RW	**R**	
Specied unidentifiable		UNKNOWN	RW	**R**	

Key to Upland Shrubland Dominance Types

Instructions:

1. Plots or polygons should be keyed out based on total cover by species.
2. Codes for dominance type and vegetation type map unit can be found using Table 3 Find the name of the most abundant shrub in column 1 and move to column 2 for the dominance type code, column 3 for the vegetation type map unit code, and column 4 for the vegetation map group code.
3. When two or more shrub species are equal in abundance, the species listed with the lowest rank number in Table 3 column 5 is used to assign the dominance type and vegetation type map unit.
4. If the most abundant shrub species is not listed in Table 3, then consult with the Regional Ecologist to assign a dominance type.
5. If Map Unit is 'n/a' (not applicable), then a sufficient number of field sites were not available to retain the dominance type as a map unit, and it was considered too ecologically distinct to combine with another map unit. Any available field data for the dominance type were still used for coarser level mapping as appropriate (e.g., conifer vs. other vegetation) and also for describing map unit composition.

Table 3: Most Abundant Upland Shrub and Indicated Dominance Type and Veg. Type Map Unit

(1) Most Abundant Shrub (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Agave utahensis	Utah agave	AGUT	**DSH**	**S**	43
Ambrosia dumosa	burrobush	AMDU2	**DSH**	**S**	48
Amelanchier alnifolia	Saskatoon serviceberry	AMAL2	**MS**	**S**	14
Amelanchier utahensis	Utah serviceberry	AMUT	**MS**	**S**	17
Arctostaphylos patula	greenleaf manzanita	ARPA6	***TBD**	**S**	
Arctostaphylos pungens	pointleaf manzanita	ARPU5	**CHAP**	**S**	28
Artemisia cana ssp. *viscidula*	mountain silver sagebrush	ARCAV2-U	**SSB**	**S**	1
Artemisia filifolia	sand sagebrush	ARFI2	**DSH**	**S**	37
Artemisia nova	black sagebrush	ARNO4	**BLSB**	**S**	25
Artemisia pygmaea	pygmy sagebrush	ARPY2	**BLSB**	**S**	26
Artemisia tridentata ssp. tridentata	basin big sagebrush	ARTRT	**BSB**	**S**	24
Artemisia tridentata ssp. vaseyana	mountain big sagebrush	ARTRV	**MSB**	**S**	22
Artemisia tridentata ssp. wyomingensis	Wyoming big sagebrush	ARTRW8	**WSB**	**S**	23
Atriplex canescens	fourwing saltbush	ATCA2	**DSH**	**S**	34
Atriplex confertifolia	shadscale saltbush	ATCO	**DSH**	**S**	35
Ceanothus fendleri	Fendler's ceanothus	CEFE	**CHAP**	**S**	31
Ceanothus greggii	desert ceanothus	CEGR	**CHAP**	**S**	29
Ceanothus martinii	Martin's ceanothus	CEMA2	**n/a**	**S**	32
Cercocarpus intricatus	littleleaf mountain mahogany	CEIN7	***TBD**	**S**	
Cercocarpus montanus	alderleaf mountain mahogany	CEMO2	***TBD**	**S**	
Chilopsis linearis	desert willow	CHLI2	**DSH**	**S**	41
Chrysothamnus depressus	longflower rabbitbrush	CHDE2	**MS**	**S**	21
Chrysothamnus greenei	Greene's rabbitbrush	CHGR6	**BLSB**	**S**	27
Chrysothamnus vaseyi	Vasey's rabbitbrush	CHVA2	***TBD**	**S**	
Chrysothamnus viscidiflorus	yellow rabbitbrush	CHVI8	***TBD**	**S**	
Coleogyne ramosissima	blackbrush	CORA	**DSH**	**S**	45
Dasiphora fruticosa	shrubby cinquefoil	DAFR6-U	**MS**	**S**	2
Ephedra aspera	rough jointfir	EPAS	**DSH**	**S**	39
Ephedra nevadensis	Nevada jointfir	EPNE	**DSH**	**S**	51
Ephedra torreyana	Torrey's jointfir	EPTO	**DSH**	**S**	40
Ephedra viridis	mormon tea	EPVI	**DSH**	**S**	50
Ericameria nauseosa	rubber rabbitbrush	ERNA10	***TBD**	**S**	
Ericameria parryi	Parry's rabbitbrush	ERPA30	***TBD**	**S**	
Eriodictyon angustifolium	narrowleaf yerba santa	ERAN2	***TBD**	**S**	
Eriogonum fasciculatum	Eastern Mojave buckwheat	ERFA2	**DSH**	**S**	42

(1) Most Abundant Shrub (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Eriogonum microthecum	slender buckwheat	ERMI4	***TBD**	**S**	
Garrya flavescens	ashy silktassel	GAFL2	**CHAP**	**S**	30
Glossopetalon spinescens	spiny greasebush	GLSP	**DSH**	**S**	44
Gutierrezia sarothrae	broom snakeweed	GUSA2	***TBD**	**S**	
Holodiscus dumosus	rockspirea	HODU	**MS**	**S**	13
Juniperus communis	common juniper	JUCO6	**MS**	**S**	12
Krascheninnikovia lanata	winterfat	KRLA2	***TBD**	**S**	
Larrea tridentata	creosote bush	LATR2	**DSH**	**S**	46
Mahonia fremontii	Fremont's mahonia	MAFR3	***TBD**	**S**	
Mahonia repens	creeping barberry	MARE11	**MS**	**S**	16
Peraphyllum ramosissimum	wild crab apple	PERA4	***TBD**	**S**	
Prunus fasciculata	desert almond	PRFA	**DSH**	**S**	33
Prunus virginiana	chokecherry	PRVI-U	**MS**	**S**	15
Psorothamnus fremontii	Fremont's dalea	PSFR	**DSH**	**S**	47
Purshia mexicana	Mexican cliffrose	PUME	***TBD**	**S**	
Purshia tridentata	antelope bitterbrush	PUTR2	**MS**	**S**	19
Quercus turbinella	Sonoran scrub oak	QUTU2	***TBD**	**S**	
Quercus X pauciloba	few-lobe oak	QUPA4	**MS**	**S**	20
Rhus trilobata	skunkbush sumac	RHTR-U	**MS**	**S**	8
Ribes montigenum	gooseberry currant	RIMO2-U	**MS**	**S**	6
Robinia neomexicana	New Mexico locust	RONE-U	**MS**	**S**	7
Rosa woodsii	Woods' rose	ROWO-U	**MS**	**S**	9
Rubus idaeus	American red raspberry	RUID-U	**MS**	**S**	10
Salix scouleriana	Scouler's willow	SASC-U	**MS**	**S**	5
Salvia dorrii	purple sage	SADO4	**DSH**	**S**	49
Sambucus nigra ssp. cerulea	blue elderberry	SANIC5-U	**MS**	**S**	4
Sambucus racemosa	red elderberry	SARA2-U	**MS**	**S**	3
Sarcobatus vermiculatus	greasewood	SAVE4	**DSH**	**S**	36
Shepherdia rotundifolia	roundleaf buffaloberry	SHRO	**MS**	**S**	11
Symphoricarpos oreophilus	mountain snowberry	SYOR2	**MS**	**S**	18
Tetradymia canescens	spineless horsebrush	TECA2	***TBD**	**S**	
Yucca harrimaniae	Harriman's yucca	YUHA	**DSH**	**S**	38
Yucca baccata	banana yucca	YUBA	**DSH**	**S**	52
Species not listed above		See Instruction 4 above		**S**	
Species unidentifiable		UNKNOWN		**S**	

***TBD (To Be Determined)**: Assigned by field personnel on site because these species can be dominant in more than one type of map unit. Choose the Upland Shrubland Vegetation Type Map Unit assigned to the next most dominant type (not assigned as TBD) present on the site.

Grassland Key
Dominance Types

<u>Instructions:</u>

Plots or polygons should be keyed out based on total cover by species. This key is divided into riparian, alpine, and upland sections. First, identify the physical setting of the plot, stand, or polygon using the key below.

For the purposes of this key, a riparian setting is defined as an area (typically transitional between aquatic and terrestrial ecosystems) identified by soil characteristics associated with at least seasonally high water tables, distinctive vegetation that requires or tolerates free or unbound water (Manning and Padgett 1995), proximity to a stream or lake, and/or topographic position (e.g., valley bottom). The alpine setting includes the area above the upper limit of continuous forest. Above this limit trees occur only in scattered patches and become increasingly stunted at higher elevations (Arno and Hammerly 1984). In this key, the alpine setting takes precedence over the riparian setting. The upland setting includes non-riparian areas below the continuous forest line.

It is likely that some dominance types occur in more than one of these settings. If your plot does not key out successfully in one setting, then try another setting. For example, tufted hairgrass is in the riparian herbland key but also is found in the alpine and riparian herbland keys.

Key to Physical Habitat Setting

Key Leads:

1a	Stand is located in an alpine setting above the upper elevation limit of continuous forest…………………………………………………………………………………………	**Go to Alpine & Upland Key (p.17)**
1b	Stand is located below the upper elevation limit of continuous forest…………………...	**2**
2a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables………………………………………………………………………………	**Go to Riparian Key (p.16)**
2b	Stand not located in a riparian setting as described above……………………….	**Go to Alpine & Upland Key (p.17)**

Key to Riparian Grassland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 4. Find the name of the most abundant graminoid in column 1 and move to column 2 for the dominance type code, column 3 for the vegetation type map unit code, and column 4 for the vegetation map group code.
2. When two or more graminoid species are equal in abundance, the species listed with the lowest rank number in Table 4 column 5 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant graminoid species is not listed in Table 4, then consult with the Regional Ecologist to assign a dominance type.

Table 4: Most Abundant Riparian Graminoid and Indicated Dominance Type and Veg. Type Map Unit

(1) Most Abundant Graminoid (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Agrostis stolonifera	creeping bentgrass	AGST2	**RHE**	**R**	20
Agrostis variablis	mountain bentgrass	AGVA-R	**RHE**	**R**	21
Alopecurus aequalis	Shortawn foxtail	ALAE	**RHE**	**R**	6
Bromus inermis	Smooth brome	BRIN2-R	**RHE**	**R**	27
Carex aquatilis	water sedge	CAAQ	**RHE**	**R**	5
Carex douglasii	Douglas' sedge	CADO2	**RHE**	**R**	19
Carex haydeniana	cloud sedge	CAHA6-R	**RHE**	**R**	12
Carex microptera	smallwing sedge	CAMI7-R	**RHE**	**R**	10
Carex nebrascensis	Nebraska sedge	CANE2	**RHE**	**R**	8
Carex pellita	woolly sedge	CAPE42	**RHE**	**R**	14
Carex praegracilis	clustered field sedge	CAPR5-R	**RHE**	**R**	11
Carex utriculata	NW Territory sedge	CAUT	**RHE**	**R**	1
Deschampsia cespitosa	tufted hairgrass	DECE-R	**RHE**	**R**	9
Distichlis spicata	inland saltgrass	DISP	**RHE**	**R**	15
Eleocharis acicularis	needle spikerush	ELAC	**RHE**	**R**	2
Eleocharis palustris	common spikerush	ELPA3	**RHE**	**R**	3
Eleocharis parishii	Parish's spikerush	ELPA4	**RHE**	**R**	4
Glyceria striata	fowl mannagrass	GLST	**RHE**	**R**	13
Juncus arcticus ssp. litoralis	mountain rush (baltic)	JUAR2-R	**RHE**	**R**	22
Juncus drummondii	Drummond's rush	JUDR-R	**RHE**	**R**	24
Juncus longistylis	longstyle rush	JULO	**RHE**	**R**	23
Juncus nevadensis	Sierra rush	JUNE	**RHE**	**R**	25
Muhlenbergia asperifolia	scratchgrass	MUAS	**RHE**	**R**	16
Phalaris arundinacea	reed canarygrass	PHAR3	**RHE**	**R**	17
Phragmites australis	common reed	PHAU7	**RHE**	**R**	18
Poa pratensis	Kentucky bluegrass	POPR-R	**RHE**	**R**	26
Schedonorus pratensis	meadow fescue	SCPR4	**RHE**	**R**	7
Species not listed above		See Instruction 3 above	**RHE**	**R**	
Species unidentifiable		UNKNOWN	**RHE**	**R**	

Key to Alpine & Upland Grassland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 5. Find the name of the most abundant graminoid in column 1 and move to column 2 for the dominance type code, column 3 for the vegetation type map unit code, and column 4 for the vegetation map group code.
2. When two or more graminoid species are equal in abundance, the species listed with the lowest rank number in 5 Column 5 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant graminoid species is not listed in Table 5, then consult with the Regional Ecologist to assign a dominance type.
4. If Map Unit is 'n/a' (not applicable), then a sufficient number of field sites were not available to retain the dominance type as a map unit, and it was considered too ecologically distinct to combine with another map unit. Any available field data for the dominance type were still used for coarser level mapping as appropriate (e.g., conifer vs. other vegetation) and also for describing map unit composition.

Table 5: Most Abundant Upland Graminoid and Indicated Dominance Type and Veg. Type Map Unit

(1) Most Abundant Graminoid (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Achnatherum hymenoides	Indian ricegrass	**ACHY**	****TBD**	**H**	
Achnatherum lettermanii	Letterman's needlegrass	**ACLE9**	***TBD**	**A or H**	
Achnatherum nelsonii	Columbia needlegrass	**ACNE9**	**UHE**	**H**	14
Agropyron cristatum	crested wheatgrass	**AGCR**	**SHE**	**H**	24
Agrostis variablis	mountain bentgrass	**AGVA-U**	***TBD**	**A or H**	
Aristida purpurea	purple threeawn	**ARPU9**	****TBD**	**H**	
Blepharoneuron tricholepis	pine dropseed	**BLTR**	***TBD**	**A or H**	
Bouteloua gracilis	blue grama	**BOGR2**	****TBD**	**H**	
Bromus anomalus	nodding brome	**BRAN**	**UHE**	**H**	17
Bromus inermis	smooth brome	**BRIN2-U**	**SHE**	**H**	23
Bromus marginatus	mountain brome	**BRMA4**	**UHE**	**H**	10
Bromus rubens	red brome	**BRRU2**	**AHE**	**H**	29
Bromus tectorum	cheatgrass	**BRTE**	**AHE**	**H**	28
Carex duriuscula	needleleaf sedge	**CADU6**	**UHE**	**H**	15
Carex elynoides	blackroot sedge	**CAEL3**	***TBD**	**A or H**	
Carex haydeniana	cloud sedge	**CAHA6-U**	***TBD**	**A or H**	
Carex microptera	smallwing sedge	**CAMI7-U**	***TBD**	**A or H**	
Carex obtusata	obtuse sedge	**CAOB4**	***TBD**	**A or H**	
Carex occidentalis	western sedge	**CAOC2**	**UHE**	**H**	16
Carex phaeocephala	dunhead sedge	**CAPH2**	***TBD**	**A or H**	
Carex praegracilis	clustered field sedge	**CAPR5-U**	**UHE**	**H**	3
Carex rossii	Ross' sedge	**CARO5**	***TBD**	**A or H**	
Carex subnigricans	nearlyblack sedge	**CASU7**	**UHE**	**H**	12
Carex tahoensis	Tahoe sedge	**CATA**	**ALP**	**A**	1
Dactylis glomerata	orchardgrass	**DAGL**	**UHE**	**H**	20
Danthonia intermedia	timber oatgrass	**DAIN**	***TBD**	**A or H**	
Deschampsia cespitosa	tufted hairgrass	**DECE-U**	***TBD**	**A or H**	
Elymus elymoides	squirreltail	**ELEL5**	****TBD**	**H**	
Elymus glaucus	blue wildrye	**ELGL**	**UHE**	**H**	5
Elymus lanceolatus	thickspike wheatgrass	**ELLA3**	****TBD**	**H**	
Elymus scribneri	spreading wheatgrass	**ELSC4**	**n/a**	**H**	22
Elymus trachycaulus	slender wheatgrass	**ELTR7**	****TBD**	**H**	
Festuca brachyphylla (F.ovina)	alpine (sheep) fescue	**FEBR**	***TBD**	**A or H**	
Festuca idahoensis	Idaho fescue	**FEIDI2**	**UHE**	**H**	7
Festuca thurberi	Thurber's fescue	**FETH**	**UHE**	**H**	6
Hesperostipa comata	needle and thread	**HECO26**	**UHE**	**H**	11

(1) Most Abundant Graminoid (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Hordeum brachyantherum	meadow barley	**HOBR2**	**UHE**	**H**	9
Juncus arcticus ssp. litoralis	mountain rush (baltic)	**JUAR2-U**	**UHE**	**H**	2
Juncus drummondii	Drummond's rush	**JUDR-U**	***TBD**	**A or H**	
Koeleria macrantha	prairie Junegrass	**KOMA**	**UHE**	**H**	4
Leymus cinereus	basin wildrye	**LECI4**	****TBD**	**H**	
Leymus salinus ssp. salinus	saline wildrye	**LESAS**	***TBD**	**A or H**	
Muhlenbergia montana	mountain muhly	**MUMO**	**UHE**	**H**	18
Muhlenbergia pungens	sandhill muhly	**MUPU2**	**UHE**	**H**	21
Muhlenbergia richardsonis	mat muhly	**MURI**	**UHE**	**H**	13
Pascopyrum smithii	western wheatgrass	**PASM**	****TBD**	**H**	
Phleum alpinum	alpine timothy	**PHAL2**	***TBD**	**A or H**	
Phleum pratense	timothy	**PHPR3**	**UHE**	**H**	19
Piptatheropsis micrantha	littleseed ricegrass	**PIMI**	****TBD**	**H**	
Pleuraphis jamesii	James' galleta	**PLJA**	****TBD**	**H**	
Poa bulbosa	bulbous bluegrass	**POBU**	****TBD**	**H**	
Poa fendleriana	muttongrass	**POFE**	***TBD**	**A or H**	
Poa glauca var. glauca	glaucous bluegrass	**POGLG**	***TBD**	**A or H**	
Poa pratensis	Kentucky bluegrass	**POPR-U**	****TBD**	**H**	
Poa secunda	Sandberg bluegrass	**POSE**	****TBD**	**H**	
Poa secunda ssp. juncifolia	big bluegrass	**POSEJ**	****TBD**	**H**	
Poa secunda ssp. secunda	Sandberg bluegrass	**POSES6**	****TBD**	**H**	
Psathyrostachys juncea	Russian wildrye	**PSJU3**	**SHE**	**H**	27
Pseudoroegneria spicata	bluebunch wheatgrass	**PSSP6**	**UHE**	**H**	8
Secale cereale	cereal rye	**SECE**	**SHE**	**H**	26
Sporobolus cryptandrus	sand dropseed	**SPCR**	****TBD**	**H**	
Thinopyrum intermedium	intermediate wheatgrass	**THIN6**	**SHE**	**H**	25
Trisetum spicatum	spike trisetum	**TRSP2**	***TBD**	**A or H**	
Vulpia octoflora	sixweeks fescue	**VUOCO**	****TBD**	**H**	
Species not listed above		See Instruction 3 above		**H**	
Species unidentifiable		UNKNOWN		**H**	

*TBD (To Be Determined) as within the Alpine or Upland Herbaceous Vegetation Type Map Unit: Assigned by field personnel on site. These species can be dominant in the alpine setting (most often above 10,800 feet in the mapping area) or within the more broadly defined Upland Herbaceous Map Unit. Choose either Alpine or Upland depending on what best describes the site by physical habitat setting.

**TBD (To Be Determined) as within the Upland, Seeded, or Annual Herbaceous Vegetation Type Map Unit: Assigned by field personnel on site. Choose the Herbaceous Vegetation Type Map Unit assigned to the next most dominant type (not assigned as TBD) present on the site.

Forbland Key

Dominance Types

Instructions:

Plots or polygons should be keyed out based on total cover by species. This key is divided into riparian and Alpine/Upland sections. **First identify the physical setting of the plot, stand, or polygon using the key below.**

For the purposes of this key, a riparian setting is defined as an area (typically transitional between aquatic and terrestrial ecosystems) identified by soil characteristics associated with at least seasonally high water tables, distinctive vegetation that requires or tolerates free or unbound water (Manning and Padgett 1995), proximity to a stream or lake, and/or topographic position (e.g. valley bottom). The alpine setting includes the area above the upper limit of continuous forest. Above this limit trees occur only in scattered patches and become increasingly stunted at higher elevations (Arno and Hammerly 1984). In this key the alpine setting takes precedence over the riparian setting. The upland setting includes non-riparian areas below the continuous forest line.

It is likely that some dominance types occur in more than one of these settings. If your plot does not key out successfully in one setting, then try another setting. For example, slender cinquefoil is in the upland key but may occur in riparian areas.

Key to Physical Habitat Setting

Key Leads:

1a		Stand is located in an alpine setting above the upper elevation limit of continuous forest……………………………………………………………………	**Go to Alpine & Upland Key (p.21)**
1b		Stand is located below the upper elevation limit of continuous forest……………	**2**
	2a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables………………………………………………………………………………	**Go to Riparian Key (p.20)**
	2b	Stand not located in a riparian setting as described above……………………….	**Go to Alpine & Upland Key (p.21)**

Key to Riparian Forbland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 6. Find the name of the most abundant forb in column 1 and move to column 2 for the dominance type code, column 3 for the vegetation type map unit code, and column 4 for the vegetation map group code.
2. When two or more forb species are equal in abundance, the species listed with the lowest rank number in Table 6 Column 5 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant graminoid species is not listed in Table 6, then consult with the Regional Ecologist to assign a dominance type.

Table 6: Most Abundant Riparian Forb and Indicated Dominance Type and Veg. Type Map Unit

(1) Most Abundant Forb (Dominance Type)		(2) Dom. Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Astragalus agrestis	purple milkvetch	ASAG2-R	**RHE**	**R**	12
Athyrium filix-femina	common ladyfern	ATFI	**RHE**	**R**	7
Barbarea orthoceras	American yellowrocket	BAOR	**RHE**	**R**	6
Brickellia californica	California brickellbush	BRCA3-R	**RHE**	**R**	13
Caltha leptosepala	white marsh marigold	CALE4-R	**RHE**	**R**	1
Cirsium scariosum	meadow thistle	CISC2-R	**RHE**	**R**	14
Clematis ligusticifolia	western white clematis	CLLI2	**RHE**	**R**	15
Descurainia incana	mountain tansymustard	DEIN5-R	**RHE**	**R**	29
Equisetum arvense	field horsetail	EQAR-R	**RHE**	**R**	24
Erigeron ursinus	Bear River fleabane	ERUR2-R	**RHE**	**R**	30
Eurybia glauca	gray aster	EUGL19-R	**RHE**	**R**	16
Lathyrus lanszwertii	Nevada pea	LALA3-R	**RHE**	**R**	17
Ligusticum porteri	Porter's licorice-root	LIPO-R	**RHE**	**R**	18
Melilotus officinalis	sweetclover	MEOF	**RHE**	**R**	31
Mertensia arizonica	aspen bluebells	MEAR6-R	**RHE**	**R**	4
Nasturtium officinale	watercress	NAOF	**RHE**	**R**	3
Osmorhiza depauperata	bluntseed sweetroot	OSDE-R	**RHE**	**R**	19
Polygonum bistortoides	American bistort	POBI6-R	**RHE**	**R**	11
Potentilla anserina	Silverweed cinquefoil	POAN5	**RHE**	**R**	5
Potentilla gracilis	slender cinquefoil	POGR9-R	**RHE**	**R**	32
Pyrrocoma lanceolata var. lanceolata	lanceleaf goldenweed	PYLAL-R	**RHE**	**R**	20
Rudbeckia montana	montane coneflower	RUMO9-R	**RHE**	**R**	23
Solidago velutina	threenerve goldenrod	SOVE6-R	**RHE**	**R**	21
Symphyotrichum ascendens	western aster	SYAS3-R	**RHE**	**R**	25
Symphyotrichum eatonii	Eaton's aster	SYEA2-R	**RHE**	**R**	26
Taraxacum officinale	common dandelion	TAOF-R	**RHE**	**R**	33
Thermopsis montana	mountain goldenbanner	THMO6	**RHE**	**R**	8
Trifolium longipes	longstalk clover	TRLO-R	**RHE**	**R**	27
Trifolium repens	white clover	TRRE3-R	**RHE**	**R**	28
Typha domingensis	southern cattail	TYDO	**RHE**	**R**	2
Veratrum californicum	California false hellebore	VECA2	**RHE**	**R**	34
Veronica americana	American speedwell	VEAM2	**RHE**	**R**	9
Veronica anagallis-aquatica	water speedwell	VEAN2	**RHE**	**R**	10
Vicia americana	American vetch	VIAM-R	**RHE**	**R**	22
Species not listed above			See Instruction 3 above	**R**	
Species unidentifiable			UNKNOWN	**R**	

Key to Alpine & Upland Forbland Dominance Types

Instructions:

1. Codes for dominance type and vegetation type map unit can be found using Table 7. Find the name of the most abundant forb in column 2 and move to column 3 for the dominance type code, column 4 for the vegetation type map unit code, and column 5 for the vegetation map group code.
2. When two or more forb species are equal in abundance, the species listed with the lowest rank number in Table 7 is used to assign the dominance type and vegetation type map unit.
3. If the most abundant graminoid species is not listed in Table 7, then consult with the Regional Ecologist to assign a dominance type.
4. If Map Unit is 'n/a' (not applicable), then a sufficient number of field sites were not available to retain the dominance type as a map unit, and it was considered too ecologically distinct to combine with another map unit. Any available field data for the dominance type were still used for coarser level mapping as appropriate (e.g., conifer vs. other vegetation) and also for describing map unit composition.

Table 7: Most Abundant Upland Forb and Indicated Dominance Type and Veg. Type Map Unit

(1) Most Abundant Forb (Dominance Type)		(2) Dom Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Achillea millefolium	common yarrow	**ACMI2**	*****TBD**	**A or H**	
Antennaria microphylla	littleleaf pussytoes	**ANMI3-U**	***TBD**	**A or H**	
Antennaria rosulata	Kaibab pussytoes	**ANRO3**	***TBD**	**A or H**	
Artemisia campestris	field sagewort	**ARCA12**	**UHE**	**H**	59
Artemisia dracunculus	tarragon	**ARDR4**	**UHE**	**H**	25
Astragalus agrestis	purple milkvetch	**ASAG2-U**	**UHE**	**H**	4
Astragalus argophyllus	silverleaf milkvetch	**ASAR4**	**UHE**	**H**	32
Astragalus lonchocarpus	rushy milkvetch	**ASLO3**	****TBD**	**H**	
Astragalus miser	timber milkvetch	**ASMI9-U**	***TBD**	**A or H**	
Astragalus subcinereus	Silver's milkvetch	**ASSU6**	**UHE**	**H**	60
Astragalus tenellus	looseflower milkvetch	**ASTE5**	**UHE**	**H**	26
Astragalus zionis	Zion milkvetch	**ASZI**	**UHE**	**H**	52
Atriplex saccaria	sack saltbush	**ATSA**	**UHE**	**H**	33
Balsamorhiza sagittata	arrowleaf balsamroot	**BASA3**	**UHE**	**H**	21
Brickellia californica	California brickellbush	**BRCA3-U**	**UHE**	**H**	5
Caltha leptosepala	white marsh marigold	**CALE4-U**	***TBD**	**A or H**	
Cardaria draba	whitetop	**CADR**	****TBD**	**H**	
Carduus nutans	nodding plumeless thistle	**CANU4**	****TBD**	**H**	
Ceratocephala testiculata	curveseed butterwort	**CETE5**	**AHE**	**H**	85
Chenopodium atrovirens	pinyon goosefoot	**CHAT**	****TBD**	**H**	
Chorispora tenella	crossflower	**CHTE2**	**AHE**	**H**	83
Cirsium scariosum	meadow thistle	**CISC2-U**	**UHE**	**H**	6
Cirsium wheeleri	Wheeler's thistle	**CIWH**	****TBD**	**H**	
Collinsia parviflora	maiden blue eyed Mary	**COPA3**	**UHE**	**H**	30
Cryptantha fulvocanescens	tawny cryptantha	**CRFU**	**UHE**	**H**	57
Cryptantha gracilis	narrowstem cryptantha	**CRGR3**	**AHE**	**H**	86
Delphinium barbeyi	subalpine larkspur	**DEBA2**	**UHE**	**H**	20
Delphinium nuttallianum	twolobe larkspur	**DENU2**	**UHE**	**H**	34
Descurainia incana	mountain tansymustard	**DEIN5-U**	****TBD**	**H**	
Descurainia pinnata	western tansymustard	**DEPI**	**AHE**	**H**	87
Epilobium brachycarpum	tall annual willowherb	**EPBR3**	**UHE**	**H**	24
Equisetum arvense	field horsetail	**EQAR-U**	**UHE**	**H**	12
Ericameria zionis	subalpine goldenbush	**ERZI2**	**n/a**	**H**	74
Erigeron compositus	cutleaf daisy	**ERCO4**	***TBD**	**A or H**	
Erigeron divergens	spreading fleabane	**ERDI4**	**UHE**	**H**	53
Erigeron flagellaris	trailing fleabane	**ERFL**	**UHE**	**H**	27
Erigeron pumilus	shaggy fleabane	**ERPU2**	**UHE**	**H**	35
Erigeron religiosus	Clear Creek fleabane	**ERRE7**	**UHE**	**H**	61
Erigeron speciosus	aspen fleabane	**ERSP4**	**UHE**	**H**	31

(1) Most Abundant Forb (Dominance Type)		(2) Dom Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Eriogonum aretioides	Red Canyon buckwheat	**ERAR8**	**n/a**	**H**	75
Eriogonum corymbosum	crispleaf buckwheat	**ERCO14**	**UHE**	**H**	36
Erodium cicutarium	redstem stork's bill	**ERCI6**	**AHE**	**H**	88
Eurybia glauca	gray aster	**EUGL19-U**	**UHE**	**H**	7
Gentianella tortuosa	Cathedral Bluff dwarf gentian	**GETO**	**n/a**	**H**	73
Geum rossii	Ross' avens	**GERO2**	**ALP**	**A**	1
Halogeton glomeratus	saltlover	**HAGL**	**AHE**	**H**	82
Hedysarum boreale	Utah sweetvetch	**HEBO**	**UHE**	**H**	37
Heliomeris multiflora var. multiflora	showy goldeneye	**HEMUM**	**UHE**	**H**	38
Hymenopappus filifolius	fineleaf hymenopappus	**HYFI**	**UHE**	**H**	62
Hymenoxys hoopesii	owl's-claws	**HYHO**	**UHE**	**H**	8
Hymenoxys richardsonii	pingue rubberweed	**HYRI**	**UHE**	**H**	39
Ivesia kingii	King's mousetail	**IVKI**	**UHE**	**H**	40
Ivesia sabulosa	Intermountain mousetail	**IVSA**	**n/a**	**H**	76
Lactuca serriola	prickly lettuce	**LASE**	**UHE**	**H**	63
Lappula occidentalis	flatspine stickseed	**LAOC3**	**AHE**	**H**	80
Lathyrus lanszwertii	Nevada pea	**LALA3-U**	**UHE**	**H**	19
Lepidium fremontii	desert pepperweed	**LEFR2**	**UHE**	**H**	69
Leucocrinum montanum	common starlily	**LEMO4**	**UHE**	**H**	41
Lewisia rediviva	bitter root	**LERE7**	**UHE**	**H**	43
Ligusticum porteri	Porter's licorice-root	**LIPO-U**	**UHE**	**H**	11
Linum perenne	blue flax	**LIPE2**	**UHE**	**H**	54
Lomatium minimum	little desertparsley	**LOMI2**	**n/a**	**H**	77
Lotus humistratus	foothill deervetch	**LOHU2**	****TBD**	**H**	
Lupinus argenteus	silvery lupine	**LUAR3**	**UHE**	**H**	22
Lupinus sericeus	Donner Lake lupine	**LUSE2**	**UHE**	**H**	23
Machaeranthera bigelovii var. commixta	Bigelow's tansyaster	**MABIC**	**UHE**	**H**	28
Machaeranthera canescens	hoary tansyaster	**MACA2**	**UHE**	**H**	64
Medicago sativa	alfalfa	**MESA**	****TBD**	**H**	
Mertensia arizonica	aspen bluebells	**MEAR6-U**	**UHE**	**H**	3
Microsteris gracilis	slender phlox	**MIGR**	**AHE**	**H**	89
Monardella odoratissima	mountain monardella	**MOOD**	***TBD**	**A or H**	
Nicotiana attenuata	coyote tobacco	**NIAT**	**UHE**	**H**	70
Oenothera pallida	pale evening primrose	**OEPA**	**UHE**	**H**	65
Onobrychis viciifolia	sainfoin	**ONVI**	****TBD**	**H**	
Onopordum acanthium	Scotch cottonthistle	**ONAC**	**AHE**	**H**	84
Osmorhiza depauperata	bluntseed sweetroot	**OSDE-U**	**UHE**	**H**	14
Oxytropis oreophila	mountain oxytrope	**OXOR2-U**	***TBD**	**A or H**	
Packera multilobata	lobeleaf groundsel	**PAMU11**	**UHE**	**H**	55
Paronychia sessiliflora	creeping nailwort	**PASE**	**n/a**	**H**	72
Penstemon linarioides	toadflax penstemon	**PELI2**	**UHE**	**H**	44
Penstemon ophianthus	coiled anther penstemon	**PEOP**	**UHE**	**H**	66
Penstemon pachyphyllus	thickleaf beardtongue	**PEPA6**	**UHE**	**H**	45
Penstemon pinorum	Pine Valley penstemon	**PEPI4**	**UHE**	**H**	58
Penstemon procerus	littleflower penstemon	**PEPR2**	***TBD**	**A or H**	
Penstemon rydbergii	Rydberg's penstemon	**PERY**	**UHE**	**H**	29
Penstemon watsonii	Watson's penstemon	**PEWA**	**UHE**	**H**	46
Petradoria pumila	rock goldenrod	**PEPU7**	**UHE**	**H**	47
Petrophytum caespitosum	mat rockspirea	**PECA12**	**n/a**	**H**	71
Phlox austromontana	mountain phlox	**PHAU3**	**UHE**	**H**	56
Phlox pulvinata	cushion phlox	**PHPU5**	***TBD**	**A or H**	
Pleiacanthus spinosus	thorn skeletonweed	**PLSP7**	****TBD**	**H**	
Polygonum bistortoides	American bistort	**POBI6-U**	****TBD**	**A or H**	
Potentilla diversifolia	varileaf cinquefoil	**PODI2**	***TBD**	**A or H**	
Potentilla gracilis	slender cinquefoil	**POGR9-U**	***TBD**	**A or H**	

(1) Most Abundant Forb (Dominance Type)		(2) Dom Type Code	(3) Veg Type Map Unit	(4) Veg Group	(5) Rank
Potentilla hippiana	woolly cinquefoil	**POHI6**	***TBD**	**A or H**	
Pyrrocoma lanceolata var. lanceolata	lanceleaf goldenweed	**PYLAL-U**	**UHE**	**H**	10
Rudbeckia montana	montane coneflower	**RUMO9-U**	**UHE**	**H**	13
Salsola tragus	prickly Russian thistle	**SATR12**	**AHE**	**H**	79
Senecio atratus	tall blacktip ragwort	**SEAT**	**n/a**	**H**	78
Senecio flaccidus var. douglasii	Douglas' ragwort	**SEFLD**	**UHE**	**H**	67
Senecio integerrimus	lambstongue ragwort	**SEIN2**	**UHE**	**H**	48
Sibbaldia procumbens	creeping sibbaldia	**SIPR**	**ALP**	**A**	2
Sisymbrium altissimum	tall tumblemustard	**SIAL2**	**AHE**	**H**	81
Solidago multiradiata	Rocky Mountain goldenrod	**SOMU-U**	***TBD**	**A or H**	
Solidago parryi	Parry’s goldenrod	**SOPA4**	**UHE**	**H**	18
Solidago velutina	threenerve goldenrod	**SOVE6-U**	**UHE**	**H**	17
Stanleya pinnata	desert princesplume	**STPI**	**UHE**	**H**	68
Stenotus armerioides var. armerioides	thrift mock goldenweed	**STARA**	**UHE**	**H**	49
Symphyotrichum ascendens	western aster	**SYAS3-U**	***TBD**	**A or H**	
Symphyotrichum eatonii	Eaton's aster	**SYEA2-U**	**UHE**	**H**	15
Taraxacum officinale	common dandelion	**TAOF-U**	*****TBD**	**A or H**	
Tetraneuris acaulis var. acaulis	stemless four-nerve daisy	**TEACA2**	**UHE**	**H**	50
Trifolium kingii ssp. macilentum	King's clover	**TRKIM**	**UHE**	**H**	51
Trifolium longipes	longstalk clover	**TRLO-U**	***TBD**	**A or H**	
Trifolium repens	white clover	**TRRE3-U**	**UHE**	**H**	16
Vicia americana	American vetch	**VIAM-U**	**UHE**	**H**	9
Xylorhiza confertifolia	Henrieville woodyaster	**XYCO3**	**UHE**	**H**	42
Species not listed above		See Instruction 3 above			
Species unidentifiable		UNKNOWN			

*TBD (To Be Determined) as within the Alpine or Upland Herbaceous Vegetation Type Map Unit: Assigned by field personnel on site. These species can be dominant in the alpine setting (most often above 10,800 feet in the mapping area) or within the more broadly defined Upland Herbaceous Map Unit. Choose either Alpine or Upland depending on what best describes the site by physical habitat setting.

**TBD (To Be Determined) as within the Upland, Seeded or Annual Herbaceous Vegetation Type Map Unit: Assigned by field personnel on site. Choose the Herbaceous Vegetation Type Map Unit assigned to the next most dominant type (not assigned as TBD) present on the site.

***TBD (To Be Determined) following guidelines above for other TBD species. Species may be dominant in any of the Herbaceous Vegetation Types.

Non-Vegetated and Land Use Types Key*

			Map Unit	Group
1a		Area is currently used for agricultural activity (e.g. a fallow field)……..………	**AGR**	**N**
1b		Area is not currently used for agricultural activity……………………………….	**2**	
	2a	Area is currently developed for urban, residential, administrative use………..	**DEV**	**N**
	2b	Area is not currently developed for urban, residential, administrative use……	**3**	
3a		Area is dominated by open water or a confined watercourse…………………	**WA**	**N**
3b		Area is not dominated by open water or confined watercourse………………..	**4**	
	4a	Area is dominated by unburned barren land (e.g. bedrock, cliffs, scree, and talus) with all vascular plants total < 1% absolute canopy cover……………..	**BR/SV**	**N**
	4b	Area is not dominated by unburned barren land………………………………..	**5**	
5a		Area is dominated by non-vascular species (mosses, liverworts, hornworts, lichens, algae and fungus) with all vascular plants total < 1% absolute canopy cover...	**BR/SV**	**N**
5b		Area not dominated by non-vascular species ………………………………….	**Undefined**	

*Dominance Types (D.T) is not applicable (n/a) for Non-Vegetated and Land Use Types.

Appendix A:

Absolute and Relative Cover

Absolute cover of a plant species is the proportion of a plot's area included in the perpendicular downward projection of the species. These are the values recorded when sampling a vegetation plot. Relative cover of a species is the proportion it composes of the total plant cover on the plot (or the proportion of a layer's cover). Relative cover values must be calculated from absolute cover values. For example, we estimate overstory canopy cover on a plot as follows: ponderosa pine 42%, white fir 21%, and aspen 7%. These values are the absolute cover of each species. The relative cover of each species is calculated by dividing each absolute cover value by their total (70%) as follows:

	Absolute Cover	Calculation	Relative Cover
Ponderosa pine	42%	100 x 42 / 70 =	60%
White fir	21%	100 x 21 /70 =	30%
Aspen	7%	100 x 7 /70 =	10%
Total of values	70%		100%

We calculate relative cover of 60% for ponderosa pine. This means that ponderosa pine makes up 60% of the overstory tree canopy cover on the plot. Relative cover always adds up to 100%, but absolute cover does not. Because plant canopies can overlap each other, absolute cover values can add up to more than 100%. In our example, the total of the absolute cover values is 70, but this does not mean that overstory trees cover 70% of the plot. Overstory tree cover would be 70% if there were no overlap among the crowns of the three species, but only 42% with maximum overlap. The actual overstory cover must be determined when sampling the plot if the information is desired, but the sum of the species cover values is used to calculate relative cover.

If the absolute cover values in our example were all halved or all doubled, the relative cover of each species would not change even though overstory tree cover would be very different. Halving the absolute values would mean overstory cover would be between 21 and 35%, depending on the amount of overlap. Doubling the values would mean overstory cover could range from 84 to 100% (not 140%). Each of these scenarios would be very different from the original example in terms of wildlife habitat value, fuel conditions, fire behavior, and silvicultural options; but the relative cover of the tree species would be exactly the same. We should also note that they also could vary widely in spectral signature. The key point here is that relative cover values by themselves provide limited ecological information and may be of little value to resource managers. Relative cover can be derived from absolute cover, but absolute cover cannot be derived from relative cover values. This is why absolute cover is recorded in the field.

Appendix B: Map Group and Map Unit Codes

Map Group	Code
Alpine	**A**
Riparian	**R**
Herbland	**H**
Shrubland	**S**
Woodland	**W**
Deciduous Forest	**D**
Conifer Forest	**C**
Non-Vegetated/Sparse Vegetation	**N**

Vegetation Group and Vegetation Type Map Unit	Code
Alpine	**A**
Alpine Vegetation – *inclusive of alpine shrubs*	ALP
Riparian	**R**
Riparian Herbaceous (Stream & Meadow – Wet)	RHE
Riparian Woody	RW
Herbland	**H**
Annual Herbaceous	AHE
Seeded Herbaceous	SHE
Upland Herbaceous – inclusive of moist to dry meadows	UHE
Shrubland	**S**
Basin Big Sagebrush	BSB
Black Sagebrush	BLSB
Desert Shrubland (Salt, Sand and Warm Desert combined)	DSH
Interior Chaparral	CHAP
Mountain Big Sagebrush	MSB
Mountain Shrubland	MS
Silver Sagebrush	SSB
Wyoming Big Sagebrush	WSB
Woodland	**W**
Gambel Oak	GO
Mountain Mahogany	MM
Pinyon-Juniper	PJ
Rocky Mountain Juniper Mix	RMJmix
Deciduous Forest	**D**
Aspen	AS
Aspen/Conifer	AS/C
Conifer Forest	**C**
Blue Spruce	BS
Bristlecone Pine/Limber Pine	BC/LM
Douglas-fir Mix	DFmix
Ponderosa Pine	PP
Ponderosa Pine Mix	PPmix
Ponderosa Pine/Woodland	PP/WD
Spruce/Fir	SF
White Fir Mix	WFmix
Non-Vegetated/Sparse Vegetation	**N**
Agriculture	AGR
Barren/Sparse Vegetation	BR/SV
Developed	DEV
Water	WA

Appendix D: Field Reference Data Collection Guide and Protocols

Dixie National Forest
Existing Vegetation Mapping Project
Field Reference Data Collection Protocol
5/13/2013

*This protocol was updated November 2016 to reflect updates (e.g., map unit name and code changes) that occurred during the mapping process.

Introduction

This document describes the field reference data collection procedures for the Dixie National Forest Existing Vegetation Mapping Project. Topics covered in this guide include an overview of field reference site selection, a description of sites and types of plots, field materials, data collection protocols, and detailed instructions on populating the field data form. These procedures have been established following direction in the USFS Existing Vegetation Classification and Mapping Technical Guide (GTR WO-67) as well as guidelines from the Remote Sensing Applications Center and Intermountain Region.

Background

The Dixie National Forest is responsible for managing vegetation to meet a variety of uses while sustaining and restoring the integrity, biodiversity, and productivity of ecosystem components and processes. In building the knowledgebase required to accomplish this mission, existing vegetation information is collected through an integrated classification, mapping, and quantitative inventory process. This information structure is essential for conducting landscape analyses and assessments, developing conservation and restoration strategies, and revising land management plans that guide project development and implementation.

The collected data will be used to create a mid-level (1:100,000 scale) map of current (existing) vegetation communities across the Dixie National Forest. Data gathered will include information on species composition, canopy cover, and tree diameter. Dominance type and corresponding vegetation type map unit are determined using the *Dixie Vegetation Keys.* Percent canopy cover and related canopy cover map unit are identified using a combination of ocular estimation and line intercept methods. Canopy cover is estimated based on an overhead or "birds-eye" view of the plot from above. Vegetation canopy overlap is not considered. Tree diameter and associated tree size map unit are determined using diameter at breast height or diameter at root collar estimates. All collected data will be recorded in electronic format in the field reference database.

Field Reference Site Selection

A primary objective of reference data collection is to sample the vegetation communities and other landcover types occurring across the project area. A sufficient number of field samples are required for each of the proposed vegetation types to be mapped. In an effort to meet this objective, 2,040 pre-selected reference sites have been distributed across the project area.

To minimize variation in ecological and vegetation characteristics for the purposes of modeling and mapping across expansive areas, the Dixie has been divided into three geographic areas (Figure 1). The number of pre-selected sites allocated to each geographic area (GA) has been based on an analysis of existing vegetation data distributions, satellite image spectral variability, and the relative size of each GA. Six hundred sites have been identified in GA-1, 770 sites in GA2, and 670 in GA3. Within each GA, a multi-level stratification approach was used to 1) distribute a portion of pre-selected sites evenly across an unsupervised satellite image spectral classification and 2) distribute the remaining pre-selected sites based on the relative abundance of combined spectral and existing vegetation strata.

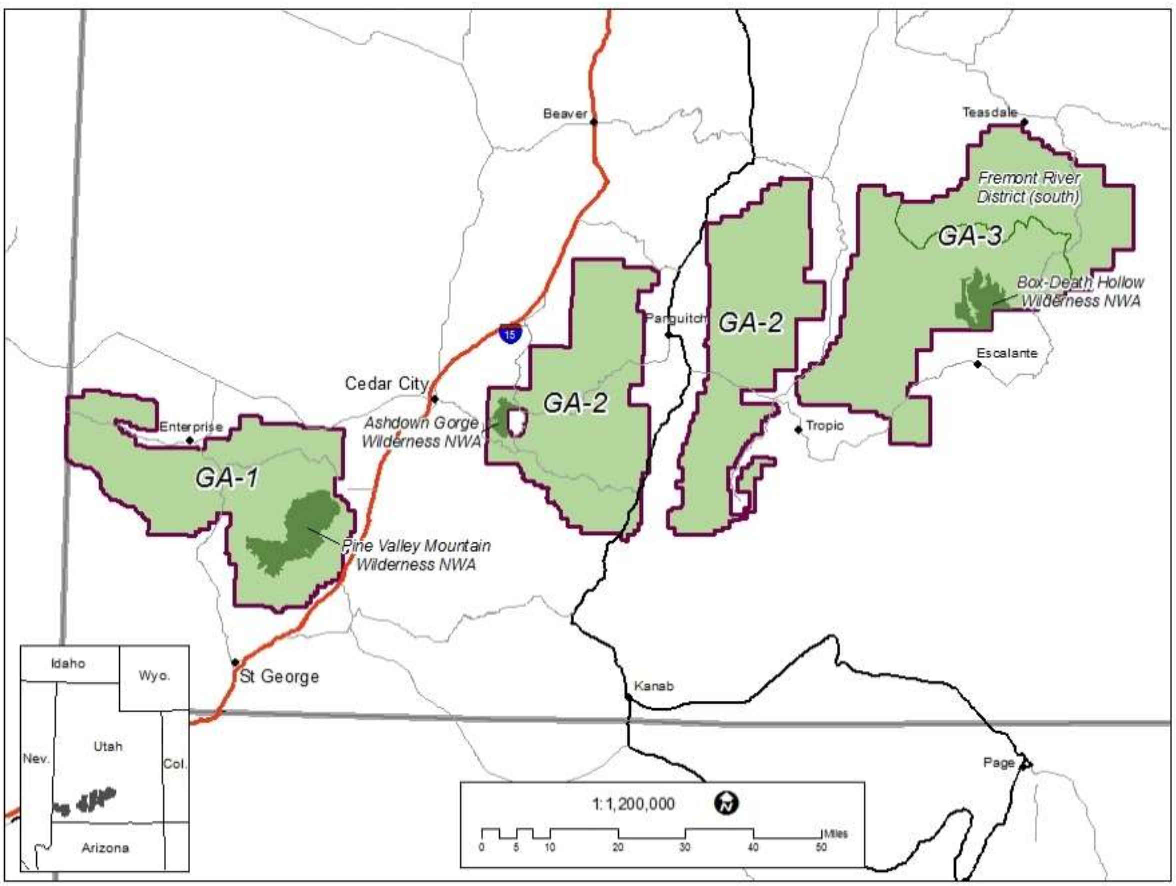


Figure 1. Geographic Areas (GA) identified for the Dixie NF mapping effort.

Due to the inherent constraints in accessing remote and extensive areas across the National Forest, sites have generally been selected within a quarter mile of a road or along trails. Consequently, sites for this project do not constitute a random sample of the mapping area, and have not been established along a systematic grid or other sampling scheme. Some sites may be located behind gates of seasonally closed roads or in roadless areas. Approximately one hundred sites have been selected in designated Wilderness Areas which require non-motorized access and possible over-night camping.

Field Reference Sites and Types of Plots

The pre-selected field reference sites consist of polygons representing relatively homogeneous vegetation patches or stands and non-vegetated elements. Each of these sites contains a predetermined number and distribution of descriptive and/or observation plots as described below. In addition to the pre-selected reference sites, field crews will also establish additional field-selected reference sites to augment the sample for under-represented vegetation types.

Field-selected sites consist of areas comprised of homogeneous vegetation characteristics that are identified in the field as crews travel to and from the pre-selected sites. Field-selected sites will be treated similar to pre-selected reference sites in that they will use the same descriptive and observation plot protocols. Each field-selected site will contain one descriptive plot, and two additional observation plots. Field crews will determine where to locate the plots within the selected area. The plots will be placed by field crews in representative locations within the reference site area.

Field information is collected using two plot protocols:

- Descriptive Plots
- Observation Plots

Descriptive Plots

Descriptive plots are established to collect vegetation composition data consisting of percent canopy cover by life form, canopy cover by species of the predominant life form, and tree species canopy cover by diameter class. For forest, woodland, and shrubland plots, canopy cover by species is estimated using ocular estimates, and optionally measured using line intercept transects. For herbaceous plots, ocular estimates are used to determine cover by graminoid and forb species. Finally, for forest and woodland plots, cover for tree species by diameter class is ocularly estimated. The resulting cover data are then applied to the vegetation keys and structure characteristic classifications to assign dominance type and map unit attributes including vegetation type, vegetation group, canopy cover and tree size.

One descriptive plot is collected for every five *pre-selected* reference sites, and one descriptive plot in every *field-selected* reference site. Descriptive plots provide detailed information on dominance type and map unit description information, and help to calibrate field crews for *observation plot* estimates below. There will never be more than one descriptive plot in a reference site.

Observation Plots

Observation plots are collected using ocular estimates to assign dominance type, and vegetation type, vegetation group, canopy cover, and tree size map unit attributes. Unlike descriptive plots, the purpose of collecting observation plots is to quickly and efficiently collect several plots across a reference site for characterizing composition and variability without collecting detailed information.

The number of observation plots collected within a *pre-selected* reference site varies between three and nine depending on the polygon size, life form, and heterogeneity as previously interpreted from high resolution imagery. For *field-selected* reference sites, two observation plots are established by field crews (in addition to the descriptive plot) to capture the representative vegetation characteristics within the site.

Provided Field Materials

Field crews have been provided the following field materials to support data collection.

- Field data collection protocol and forms: This guidance document and field data collection forms for recording reference site and plot information in the field. Procedures for collecting tree and shrub transect data are included in a separate document and form.
- Vegetation keys and map units: Dichotomous keys to vegetation formations and dominance types, and crosswalks to vegetation group and vegetation type map units. A summary of vegetation map units and codes is found in the appendices to the keys and Appendix B of this document.
- Structural characteristic map units: Tree and shrub canopy cover, and tree size map units. Map units and codes are included on the field data collection form and in Appendix B of this document.
    - Field reference site/plot list and digital plot waypoints: A list of reference site/plot ID's, and digital plot waypoints for uploading to GPS units.
    - Field overview map (~1:250,000 scale): National Forest extent, poster-size map depicting all reference site locations, site ID's, and an index grid of field navigation maps below.
    - Field navigation maps (~1:50,000 scale): Reduced extent, poster-size maps displaying reference site locations, site ID's, and detailed travel routes.
    - Reference site maps (~1:3,000 scale): Limited extent, 8.5 x 11 inch, high resolution imagery maps containing the reference site polygon, and plot locations and coordinates (waypoints) within the polygon.

Sampling Process

The sampling process involves three main steps: planning, navigation, and data collection.

Step 1 - Planning
Before leaving the office, each crew should know where they are going, understand the information to be collected, and have the appropriate gear to complete the task. Review the overview and navigation maps to determine the best travel routes. Check with your supervisor and/or crew lead

before leaving. Coordinate with designated Forest personnel to ensure access before leaving for the field.

Gear check list:

- GPS unit
- Digital camera
- Batteries (GPS and camera)
- Navigation & reference site maps
- Dominance type keys
- Field data forms
- Pencils & sharpie
- Clinometer
- Densitometer (optional)
- 100ft tape
- Diameter tape
- Compass
- Biodegradable flagging
- Whiteboard or 3 x 5" cards, etc.

Field crews are responsible for assuring that a unique reference site number is assigned to each field-selected reference site. A consecutive set of numbers >2100 should be allocated among crews prior to beginning field work, e.g. Crew 1: 2101-2200, Crew 2: 2201-2300, etc.

All field-selected reference sites must be located within the project boundary (i.e., on NF lands designated for the project). It is the responsibility of the field crew to assure that sites are within the project boundary.

Step 2 - Navigation

You have been provided with the coordinates of the reference site centers, plot locations within the reference sites, navigation maps, and individual reference site location maps (Figure 2) depicting high resolution aerial imagery to aid in navigating. Digital waypoint coordinates should be preloaded on the GPS unit. Reference sites have been located generally within ¼ mile of a motorized route or foot trail in backcountry areas to make them readily accessible. However, there is no guarantee that sites will be accessible. If you cannot get to a site due to access limitations or safety concerns, record it as not observable, note the specific reason(s), and move on to the next site.

As you navigate between pre-selected reference sites, look for vegetation types that have not been adequately sampled. A list of under-represented types will be provided by the Forest Service at regular intervals throughout the field season. Where applicable, establish and collect data for field-selected reference sites following the procedures outlined in Step 3 below.

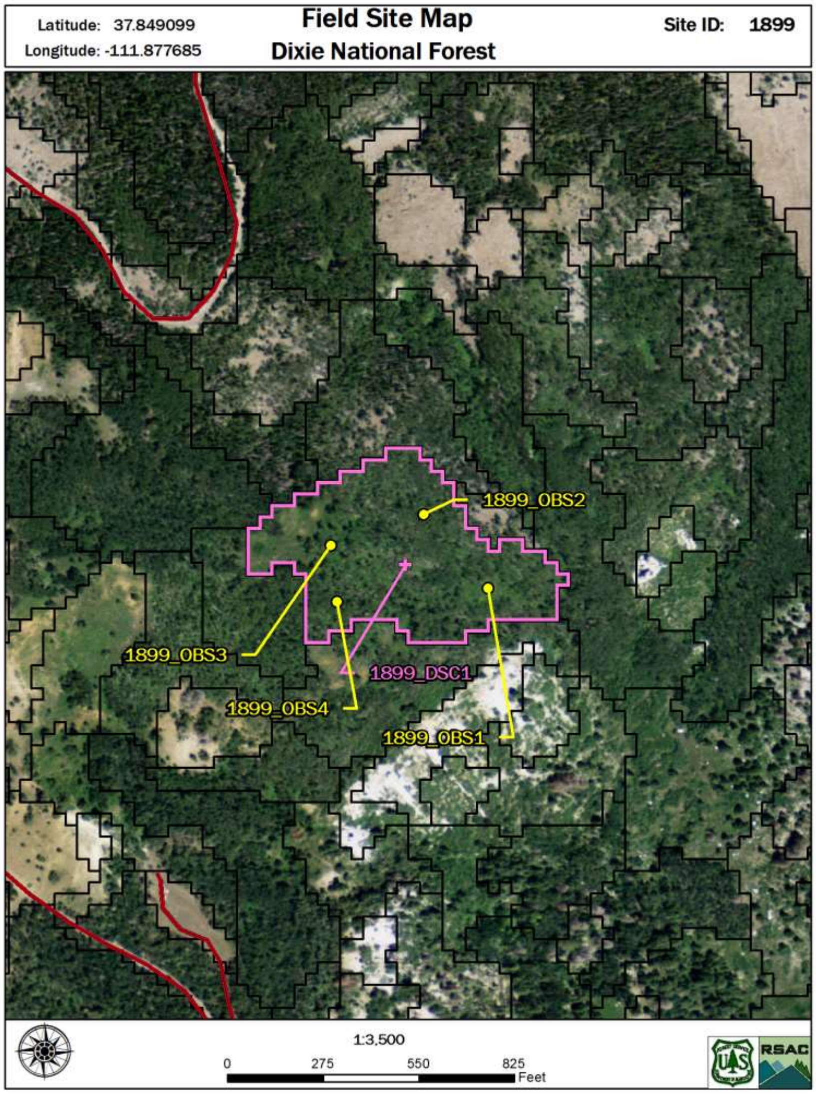


Figure 2. *Reference site map depicting a pre-selected reference site, site coordinates, descriptive and observation plot locations, and roads/trails.*

Step 3- Data Collection

<u>Pre-Selected Reference Sites</u>

Descriptive Plots

As previously noted, one descriptive plot is collected for every five reference sites. These plots are annotated on the reference site map using the identifier *DSC* followed by the plot number. Navigate to the waypoint location and place flagging at the plot center. The dimension of each plot consists of a 50 foot radius circle *corrected for slope if 10 percent or greater*. Measure and flag the plot boundaries in each cardinal direction from the center of the plot. Do not adjust for magnetic declination. In designated Wilderness Areas, use sticks or rock cairns to mark the plot instead of flagging.

Estimate all vegetation data within the plot area from an overhead or "bird's-eye" view of the plot from above. Again, vegetation canopy overlap is not considered, therefore total vegetative/non-vegetative cover for the plot area must equal 100%. It is important to walk through the entire plot before recording the most abundant species, percent canopy cover, and cover by tree diameter class. It may also be helpful to mark out a 5 foot radius subplot representing 1 percent of the plot area to assist in calibrating your estimates.

Observation Plots
Between two and nine observation plots are collected within each reference site. These plots are annotated on the reference site map using the identifier *OBS* followed by the plot number. Again, navigate to the waypoint location of the plot and place flagging at the plot center. In designated Wilderness Areas, use sticks or rock cairns to mark the plot instead of flagging. The dimension of each plot consists of a 50 foot radius circle *corrected for slope if 10 percent or greater*. It is not necessary to flag the plot boundaries. Walk through the plot and apply the same logical procedures used for the descriptive plots to ocularly estimate a dominance type, and vegetation type, vegetation group, canopy cover, and tree size map unit. These plots are meant to be quick, using your best judgment based upon experience gained while doing descriptive plots.

<u>Field-Selected Reference Sites</u>
While you are traveling from site to site and you identify areas containing vegetation types that have not been adequately sampled, establish additional reference sites using the same protocols specified for the pre-selected descriptive plots. The selection of reference sites in the field is guided by the following four principles:

1. Sites represent vegetation types that are under-represented as directed by project personnel.
2. Sites are selected in areas comprised of homogeneous vegetation type and uniform canopy cover and tree size (as applicable).
3. Sites consist of a minimum area of 1 acre for riparian and aspen types, and a minimum of 3 acres for all other types.
4. Sites represent areas of relatively uniform setting characteristics that do not contain abrupt topographic breaks, cross major streams, etc.
5. Sites must be reasonably distributed to sample vegetation communities across the landscape and not placed adjacent to other sites comprised of the same vegetation type.

One descriptive plot and two observation plots are collected within the boundary of the field-selected reference site. Plots collected must be representative of the overall site characteristics. Walk through the site to determine appropriate locations for placing the descriptive and observation plots for accurately characterizing the site. Record the actual conditions measured or observed regardless of the initial assessment of vegetation type.

Plots are collected using a new field form, assigning a new reference site number, and designating the site as a *field-selected site* (FSS). Field-selected reference sites **must** be given a completely new number; a previously assigned number cannot be used. Individual crews will be responsible for keeping track of numbers assigned to opportunistic plots.

Preliminary direction regarding under-represented types will be given at the start of the project. As field data sheets are received by project personnel, tracking and tallying of vegetation types collected will guide future selection of field-selected reference sites. It is the responsibility of field crews to coordinate with Forest Service personnel in the selection of appropriate sites.

Data Collection Forms

This section provides information on how to populate the field data forms.

Field Reference Site Information

1. Reference Site ID: Record the 4-digit site number as identified on the pre-selected reference site map, or a new 4-digit number for a field-selected site. An example field-selected site number of *2127* would represent the 27th field-selected site collected by Crew 1 (see page 5 - example field-selected site number allocation).

2. Site Type: Record the site type as "PSS" for a pre-selected site or "FSS" for a new field-selected site.

3. Names of collectors: Record the names of the personnel collecting the data by first initial and last name (e.g. J. Doe), or full names as needed to maintain unique crew member identification.

4. Month/Day/Year

5. Access Code: Record the reference site access code as "ACC" for accessible, and "NO" for not observable. (If any *plots* within the reference site are inaccessible, provide a comment in the Notes section for the individual plot.)

6. Geographic Area: Record the geographic area (GA) that the site is located in as identified on the reference site map.

Descriptive Plot Data Items

7. Plot Type: The plot type is "DSC" for a descriptive plot

8. Plot ID: The plot ID is "1" for a descriptive plot (never more than one in a reference site).

9. Latitude/Longitude Decimal Degree Coordinates: Record the coordinates for the center of the plot. It is important to collect positions **from the plot center**, so be at the center to start collection. You should try to collect 180 readings or 100% sample confidence depending on the GPS unit. Fewer than 90 readings or 50% sample confidence must be documented in the Notes section.

   GPS units must be set to the following coordinate system:

   Latitude/Longitude Decimal Degrees

   WGS84

10. <u>Field Photograph:</u> Take a single representative photo of the plot (more can be taken if necessary) and record the digital photo number and bearing. Take the photo from the plot center in a direction that captures a representative view of the vegetation characteristics contained within the plot. Use a whiteboard or other placard depicting the plot identifier and direction including the reference site ID, plot type and number, and compass bearing direction (e.g. 1024-DSC1-90). Do not adjust for magnetic declination. Upon uploading the photos to a computer, ensure the files are named/renamed to match the plot identifier.

11. <u>Ocular Plot Composition:</u> (Estimated from an overhead perspective of the plot from above). Estimate and record the total canopy cover for each life form including tree, shrub, herbaceous (graminoids and forbs), and non-vegetated. See the *Dixie Vegetation Keys* for a list of species by life form. Determine percent cover as if you were looking down on the stand from above the plot; do not double count overlapping layers that are not viewable from above. For example, smaller-sized trees being overlapped by larger ones are ignored and not counted in the canopy cover estimate. The sum of canopy cover for trees, shrubs, herbaceous and non-vegetated must total 100%. If the dominant plant species encountered on the site consists of a forb or grass (e.g. cheatgrass - *Bromus tectorum*) in a senesced condition, record the appropriate plant symbol and estimated live percent cover of the plant instead of recording the cover as non-vegetated litter. Cover estimates for nonvascular life forms (e.g. lichen, moss, etc.) are included in the non-vegetated category.

    Based on the life form cover estimates, determine the dominant life form using the *Key to Vegetation Formations*. For the dominant tree, shrub, or herbaceous life form identified, list up to the 5 most abundant species having ≥ 5% (11.2 foot radius circle) cover. For each species, record the USDA PLANTS symbol as found on the Dixie species list. If the symbol for any species is not known, its name should be written out and the symbol looked up later. If a plant can only be identified to the genus level (e.g. due to seasonal condition or disturbance), record only the plant genus and make a note of it on the form. One exception exists where a species occurring with less than 5% cover is recorded. On a plot where the most abundant tree, shrub, or herbaceous species occurs with <5% cover, record the single most abundant species in order to determine dominance type and corresponding vegetation type and group map units.

    For each of the species listed, estimate and record the percent canopy cover as viewed from above the plot. For the remaining species not individually listed (including individual species with <5% cover), estimate and record the combined percent cover for the “others combined” item on the form. Percent cover for combined grasses and combined forbs must be recorded separately. Species cover estimates must sum to the total life form cover estimate previously recorded.

12. <u>Tree Cover by Diameter Class:</u> (Only for Tree life form plots.) If tree canopy information has been collected using the optional transect protocol, list each tree species and canopy cover as recorded on the transect data form. However, if the ocular species cover estimates are considered to be more representative of the plot than the transect data, list each tree species and canopy cover as recorded in #11 and include a note in the Comments section below.

For each species, estimate the percent cover of each tree diameter class and enter it in the diameter class columns. Timber species less than 4.5 feet tall or woodland species less than 1.0" diameter at root collar are included in the smallest tree diameter class. For trees that are close to a diameter class boundary, measure diameter at breast height (DBH) or diameter at root collar (DRC) to calibrate ocular estimates. Total the estimated percent cover for each diameter class.

Determine percent cover of each diameter class as if you were looking down on the stand from above the plot; do not double count overlapping layers that are not viewable from above. For example, smaller sized trees that are being overlapped by larger ones are ignored and not counted in the diameter class estimate. Overhead crown cover extending into the circular plot area from a stem residing outside or on the border of the plot is assigned to the tree diameter class of the corresponding stem.

Tree diameter is determined by estimating DBH for all tree species except designated woodland species listed in Table 1. For woodland species, tree diameter is determined by estimating DRC. Instructions for measuring DRC for woodland species are contained in Appendix A.

Table 1. *Dixie DRC Measured Woodland Species*

JUOS	*Juniperus osteosperma*	Utah juniper
JUSC2	*Juniperus scopulorum*	Rocky Mountain juniper
ACGR3	*Acer grandidentatum*	bigtooth maple
CELE3	*Cercocarpus ledifolius*	curlleaf mountain mahogany
PIED	*Pinus edulis*	twoneedle pinyon
PIMO	*Pinus monophylla*	singleleaf pinyon
PRGL2	*Prosopis glandulosa*	honey mesquite
QUGA	*Quercus gambelii*	Gambel oak

13. Dominance Type: Determine and record the dominance type of the plot according to the vegetation keys. If the optional transect protocol is used to collect tree or shrub canopy cover, use the species transect cover measurements to determine the dominance type. However, if the ocular species cover estimates are considered to be more representative of the plot than the transect data, use the ocular estimates to determine dominance type and include a comment in the Notes section.

14. Vegetation Type Map Unit: Identify and record the vegetation type map unit for the dominance type of the plot as listed in the vegetation keys. A list of the vegetation type map units is included in Appendix B.

15. Vegetation Group Map Unit: Identify and record the vegetation group map unit for the dominance type of the plot as listed in the vegetation keys. A list of the vegetation group map units is found in Appendix B.

16. Canopy Cover Map Unit: (Only for Tree and Shrub life form plots.) Based on the life form and total life form percent canopy cover for the plot, determine and record the canopy cover map unit. For *upland tree* life form plots, record a tree cover map unit (Table B2) based on the total tree cover. Upland tree life form plots include all forest and woodland map units except Riparian Shrublands/Deciduous Tree (RSH). For *shrub* and *riparian tree* life form plots, record

a shrub cover map unit (Table B3) based on the *total shrub* or *total tree* cover respectively. For example, a narrowleaf cottonwood plot is assigned to the RSH map unit; therefore a shrub canopy cover map unit is recorded for the plot.

If the optional transect protocol was used to collect tree or shrub canopy cover, use the overall transect cover to determine the canopy cover map unit. However, the ocular estimate can be used if it is considered to be more representative of the plot than the transect data. If transect information was collected and the ocular estimate is used to determine the map unit, include a comment in the Notes section.

17. Tree Size Map Unit: (Only for Tree life form plots.) Based on the total tree canopy cover by diameter class (#12), determine the most abundant diameter class for the plot. In case of a tie, record the largest tree diameter class. For Conifer and Deciduous vegetation group plots, determine and record the *Forest* tree size map unit (Table B4). For Woodland vegetation group plots, determine and record the *Woodland* tree size map unit (Table B5).

18. Notes: Include information on the vegetation conditions, disturbances, approximate age of the disturbance, observed threatened and endangered plant species, invasive plant species, and any other pertinent information that is not included in the field form. This description is often the most valuable piece of information about a plot and provides details that can have an effect on the mapping process.

Observation Plot Data Items

As noted previously, walk through the plot and apply the same logical procedures used for the descriptive plots to ocularly estimate dominance type and map unit attributes.

19. Plot Type: The plot type is “OBS” for an observation plot.

20. Plot ID: Record the 1-digit plot ID number.

21. Latitude/Longitude Decimal Degree Coordinates: Record the coordinates for the center of the plot using the procedures described for descriptive plots.

22. Field Photograph: Take a single representative photo of the plot using the procedures described for descriptive plots.

23. Dominance Type: Walk through the plot area and ocularly estimate the composition and cover to determine the dominance type of the plot using the vegetation keys.

24. Vegetation Type Map Unit: Identify the vegetation type map unit for the dominance type of the plot as listed in the vegetation keys.

25. Vegetation Group Map Unit: Identify the vegetation group map unit for the dominance type of the plot as listed in the vegetation keys.

26. Canopy Cover Map Unit: (Only for Tree and Shrub life form plots.) Walk through the plot area and ocularly estimate the canopy cover map unit.

27. Tree Size Map Unit: (Only for Tree life form plots.) Walk through the plot area and ocularly estimate the tree size map unit.

28. Notes: Include information on the vegetation conditions, disturbances, approximate age of the disturbance, observed threatened and endangered plant species, invasive plant species, and any other pertinent information that is not included in the field form.

Field Reference Site Summary

Reference site summary calls are determined based on the majority results from the descriptive and observation plots. In cases where no dominance type or map unit is assigned to a majority of the plots, or the plots are not considered representative of the site, estimate and record a representative dominance type or map unit based on a combination of plot results and observations made while traversing the site between plots. Observations of notably different dominance types or map units while traversing the site should be included in the Notes section.

29. Dominance Type: Determine and record the majority or representative dominance type within the site based on the descriptive and observation plots, and/or notes regarding other observations made while traversing the site.

30. Vegetation Type Map Unit: Identify the vegetation type map unit for the dominance type of the site as listed in the vegetation keys.

31. Vegetation Group Map Unit: Identify the vegetation group map unit for the dominance type of the site as listed in the vegetation keys.

32. Canopy Cover Map Unit: (Only for Tree and Shrub life form reference sites.) Determine and record the majority or representative canopy cover map unit within the site based on the descriptive and observation plots, and/or notes regarding other observations made while traversing the site.

33. Tree Size Map Unit: (Only for Tree life form reference sites.) Determine and record the majority or representative tree size map unit within the site based on the descriptive and observation plots, and/or notes regarding other observations made while traversing the site.

34. Disturbance Event: If there is evidence of a recent disturbance event (fire, timber harvest, insect outbreak, wind event, etc.) within approximately the last 5 years, check the appropriate box and include any relevant information in the notes section, such as whether the plot was previously forested, contains standing dead trees, etc.

35. Notes: Include observations of other notable dominance types or map units within the site and their relative abundance. Record any additional information pertinent to the site and/or site summary calls. Include information on the vegetation conditions, disturbances, approximate age of the

disturbance, observed threatened and endangered plant species, invasive plant species, and any other pertinent information that is not included in the field form.

Appendix A.

Diameter at Root Collar (DRC)
(Adapted from Interior West Forest Inventory and Analysis P2 Field Procedures, V5.00)

For species requiring diameter at the root collar, measure the diameter at the ground line or at the stem root collar, whichever is higher. For these trees, treat clumps of stems having a unified crown and common root stock as a single tree; examples include mesquite, bigtooth maple, juniper, and mountain mahogany. Treat stems of woodland species such as Gambel oak and bigtooth maple as individual trees if they originate below the ground.

Measuring woodland stem diameters: Before measuring DRC, remove the loose material on the ground (e.g., litter) but not mineral soil. Measure just above any swells present, and in a location so that the diameter measurements are a good representation of the volume in the stems (especially when trees are extremely deformed at the base). Stems must be at least 1 foot in length and at least 1.0 inch in diameter 1 foot up from the stem diameter measurement point to qualify for measurement. Whenever DRC is impossible or extremely difficult to measure with a diameter tape (e.g., due to thorns, extreme number of limbs), stems may be estimated and recorded to the nearest 1.0-inch class. Additional instructions for DRC measurements are illustrated in Figures A1 and A2.

Computing and Recording DRC: For all trees requiring DRC, with at least one stem 1 foot in length and at least 1.0 inch in diameter 1 foot up from the stem diameter measurement point, DRC is computed as the square root of the sum of the squared stem diameters. For a single-stemmed DRC tree, the computed DRC is equal to the single diameter measured.

Use the following formula to compute DRC:

DRC = SQRT [SUM (stem diameter^2)]
Round the result to the nearest 0.1 inch. For example, a multi-stemmed woodland tree with stems of 12.2, 13.2, 3.8, and 22.1 would be calculated as:
DRC = SQRT ($12.2^2 + 13.2^2 + 3.8^2 + 22.1^2$)
= SQRT (825.93)
= 28.74
= 28.7

If a previously tallied woodland tree was completely burned and has re-sprouted at the base, treat the previously tallied tree as dead and the new sprouts (1.0-inch DRC and larger) as part of a new tree.

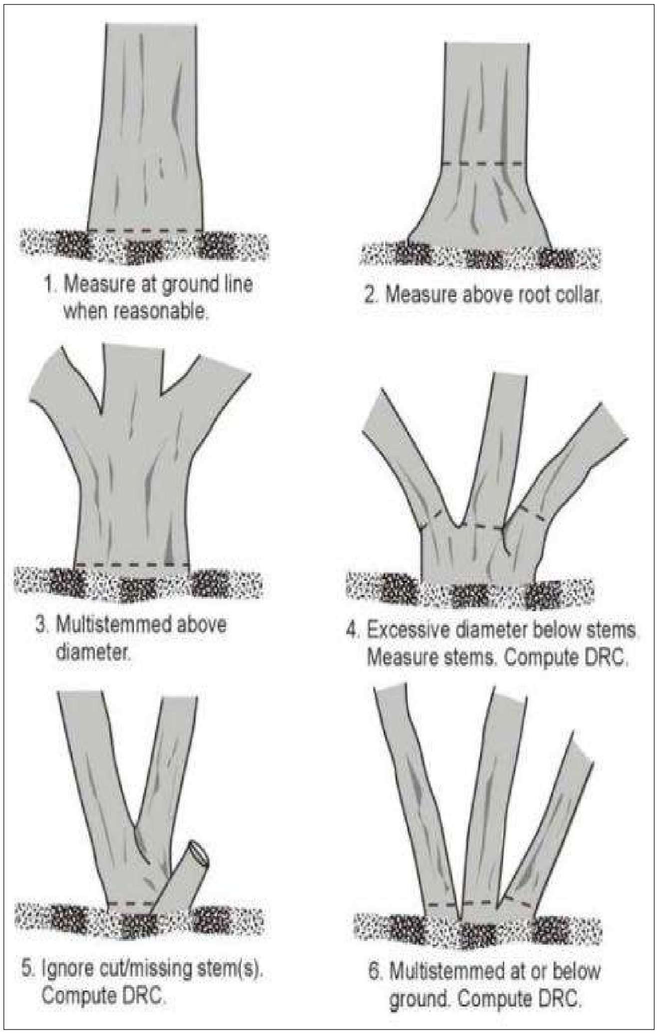


Figure A1. *How to measure DRC in a variety of situations. The cut stem in example number 5 is < 1 foot in length.*

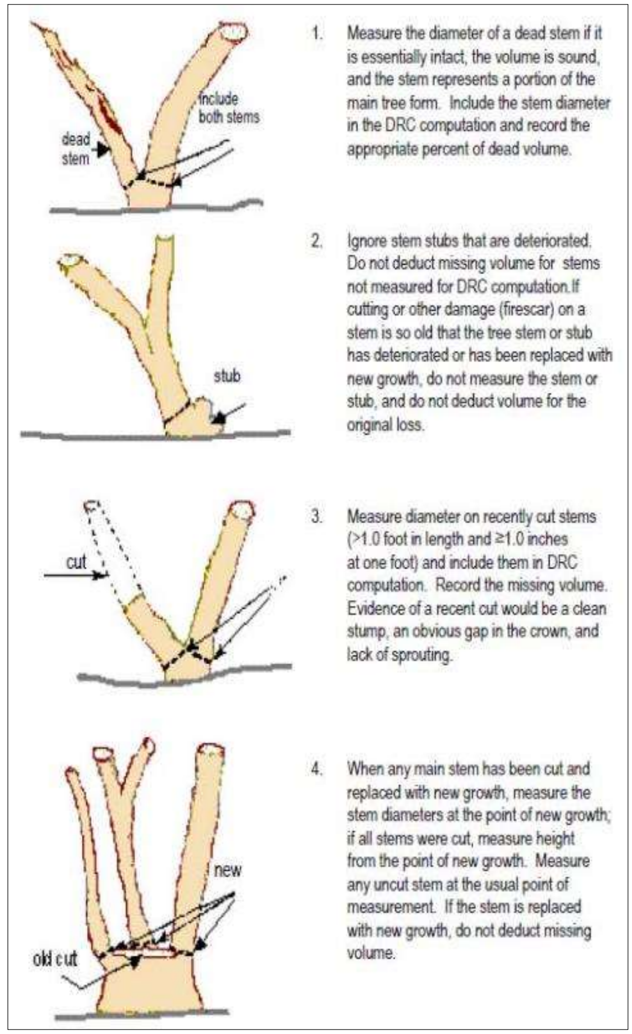


Figure A2. *Additional examples of how to measure DRC.*

Appendix B. Veg Group, Veg Type, Canopy Cover, and Tree Size Map Unit Codes

Table B1. *Vegetation Group and Type Map Units*

Vegetation Group and Vegetation Type Map Unit	Code
Alpine	**A**
Alpine Vegetation – *inclusive of alpine shrubs*	ALP
Riparian	**R**
Riparian Herbaceous (Stream & Meadow – Wet)	RHE
Riparian Woody (Stream & Meadow- Wet)	RW
Herbland	**H**
Annual Herbaceous	AHE
Seeded Herbaceous	SHE
Upland Herbaceous – inclusive of moist to dry meadows	UHE
Shrubland	**S**
Basin Big Sagebrush	BSB
Black Sagebrush	BLSB
Desert Shrubland (Salt, Sand and Warm Desert combined)	DSH
Interior Chaparral	CHAP
Mountain Big Sagebrush	MSB
Mountain Shrubland	MS
Silver Sagebrush	SSB
Wyoming Big Sagebrush	WSB
Conifer	**C**
Blue Spruce	BS
Bristlecone Pine/Limber Pine	BC/LM
Douglas-fir Mix	DFmix
Spruce/Fir	SF
Ponderosa Pine	PP
Ponderosa Pine Mix	PPmix
Ponderosa Pine/Woodland	PP/WD
White Fir Mix	WFmix
Deciduous	**D**
Aspen	AS
Aspen/Conifer	AS/C
Woodland	**W**
Gambel Oak	GO
Mountain Mahogany	MM
Pinyon-Juniper	PJ
Rocky Mountain Juniper Mix	RMJmix
Non-Vegetated/Sparse Vegetation	**N**
Agriculture	AGR
Barren/Sparse Vegetation	BR/SV
Developed	DEV
Unknown	UNK
Water	WA

Table B2. *Tree Canopy Cover Map Units*

Tree Canopy Cover Map Unit	Code
10 - 19%	TC1
20 - 39%	TC2
40 - 49%	TC3
50 - 59%	TC4
≥ 60%	TC5

Table B3. *Shrub Canopy Cover Map Units*

Shrub Canopy Cover Map Unit	Code
10 - 24%	SC1
25 - 34%	SC2
≥ 35%	SC3

Table B4. *Forest Tree Size Map Units*

Forest (DBH) Tree Size Map Unit	Code
0 - 4.9”	FS1
5 - 11.9”	FS2
12 - 17.9”	FS3
18 - 23.9”	FS4
≥ 24”	FS5

Table B5. *Woodland Tree Size Map Units*

Woodland (DRC) Tree Size Map Unit	Code
0 - 11.9”	WS1
12 - 17.9”	WS2
≥ 18”	WS3

Dixie NF – Field Reference Site Data Form

v. 5/10/2013

Field Reference Site Information

1- **Reference Site ID#:** ________________ *2-* **Site Type:** PSS FSS *3-* **Names**: ______________________________

4- **M/D/YY:** _____-_____-_____ 5- **Access Code:** ACC NO *6-* **Geographic Area:** 1 2 3

Descriptive Plot

7- **Plot Type:** ___DSC____ *8-* **Plot ID#:** __1

9- **Latitude:** _______________ **Longitude:** __________________ (DD WGS84) **GPS S/N** (last 4)**:** _______ **Waypoint:** ______

10- **Field Photograph:** _________________________ **Bearing:** ________________

11- **Ocular Plot Composition**

Tree	Cover	Shrub	Cover	Herbaceous	Cover	Non-Veg Cover	
Others Combined		Others Combined		Other Grasses Combined			
				Other Forbs Combined			
Total		Total		Total		Total	
						Lifeform & Non-Veg totals must add up to 100%:	

12- **Tree Cover by DBH or DRC Diameter Class**

Tree Code	Cover	Class 1 0 - 4.9”	Class 2 5 - 11.9”	Class 3 12 - 17.9”	Class 4 18 - 23.9”	Class 5 ≥ 24”
Others Combined						
Total						
					Tree Diameter Class totals must add up to Total % Tree Cover:	

13- **Dominance Type** _______________ *14-* **Veg Type MU** ______________ *15-* **Veg Group MU** ______________

16- **Canopy Cover MU** ______________ *17-* **Tree Size MU** ______________

18- **Notes:**

Tree Canopy Cover Map Unit	Code
10 - 19%	TC1
20 - 39%	TC2
40 - 49%	TC3
50 - 59%	TC4
≥ 60%	TC5

Shrub Canopy Cover Map Unit	Code
10 - 24%	SC1
25 - 34%	SC2
≥ 35%	SC3

Forest (DBH) Tree Size Map Unit	Code
0 - 4.9”	FS1
5 - 11.9”	FS2
12 - 17.9”	FS3
18 - 23.9”	FS4
≥ 24”	FS5

Woodland (DRC) Tree Size Map Unit	Code
0 - 11.9”	WS1
12 - 17.9”	WS2
≥ 18”	WS3

Observation Plots

19-**Plot Type:** OBS *20*- **Plot ID#** _____

21-**Latitude:** ________________ (DD WGS84)

Longitude: _______________ **GPS S/N:**_____ **Waypt:**_____

22-**Field Photo:** _____________________ **Bearing:** _________

23-**Dom Type:** ____________ *24*- **Veg Type MU:** ____________

25-**Veg Group MU:** _______ *26*- **Canopy Cover MU:** ________

27- **Tree Size MU:** ________

28-**Notes:**

19-**Plot Type:** OBS *20*- **Plot ID#** _____

21-**Latitude:** ________________ (DD WGS84)

Longitude: _______________ **GPS S/N:**_____ **Waypt:**_____

22-**Field Photo:** _____________________ **Bearing:** _________

23-**Dom Type:** ____________ *24*- **Veg Type MU:** ____________

25-**Veg Group MU:** _______ *26*- **Canopy Cover MU:** ________

27- **Tree Size MU:** ________

28-**Notes:**

19-**Plot Type:** OBS *20*- **Plot ID#** _____

21-**Latitude:** ________________ (DD WGS84)

Longitude: _______________ **GPS S/N:**_____ **Waypt:**_____

22-**Field Photo:** _____________________ **Bearing:** _________

23-**Dom Type:** ____________ *24*- **Veg Type MU:** ____________

25-**Veg Group MU:** _______ *26*- **Canopy Cover MU:** ________

27- **Tree Size MU:** ________

28-**Notes:**

19-**Plot Type:** OBS *20*- **Plot ID#** _____

21-**Latitude:** ________________ (DD WGS84)

Longitude: _______________ **GPS S/N:**_____ **Waypt:**_____

22-**Field Photo:** _____________________ **Bearing:** _________

23-**Dom Type:** ____________ *24*- **Veg Type MU:** ____________

25-**Veg Group MU:** _______ *26*- **Canopy Cover MU:** ________

27- **Tree Size MU:** ________

28-**Notes:**

19-**Plot Type:** OBS *20*- **Plot ID#** _____

21-**Latitude:** ________________ (DD WGS84)

Longitude: _______________ **GPS S/N:**_____ **Waypt:**_____

22-**Field Photo:** _____________________ **Bearing:** _________

23-**Dom Type:** ____________ *24*- **Veg Type MU:** ____________

25-**Veg Group MU:** _______ *26*- **Canopy Cover MU:** ________

27- **Tree Size MU:** ________

28-**Notes:**

19-**Plot Type:** OBS *20*- **Plot ID#** _____

21-**Latitude:** ________________ (DD WGS84)

Longitude: _______________ **GPS S/N:**_____ **Waypt:**_____

22-**Field Photo:** _____________________ **Bearing:** _________

23-**Dom Type:** ____________ *24*- **Veg Type MU:** ____________

25-**Veg Group MU:** _______ *26*- **Canopy Cover MU:** ________

27- **Tree Size MU:** ________

28-**Notes:**

19-**Plot Type:** OBS *20*- **Plot ID#** _____

21-**Latitude:** ________________ (DD WGS84)

Longitude: _______________ **GPS S/N:**_____ **Waypt:**_____

22-**Field Photo:** _____________________ **Bearing:** _________

23-**Dom Type:** ____________ *24*- **Veg Type MU:** ____________

25-**Veg Group MU:** _______ *26*- **Canopy Cover MU:** ________

27- **Tree Size MU:** ________

28-**Notes:**

Field Reference Site Summary

***29*- Dom Type** ____________

***30*- Veg Type MU** ____________

***31*- Veg Group MU** ____________

***32*- Canopy Cover MU** ____________

***33*- Tree Size MU** ____________

***34*- Disturbance Event:** □ **Burn** □ **Harvest** □ **Other**

***35*- Notes:**

Dixie NF – Field Reference Site
Descriptive and Observation Plot
Tree and Shrub Transect Data Collection Protocol
5/8/2013

Tree Cover Transects: (Only for Tree life form plots.) Tree canopy cover transects are optional, but may be used by Government inspectors for quality assurance purposes.

Lay out four 50-foot transects from the plot center in each cardinal direction (200 feet of total transect). Use the same layout configuration as was used for identifying/flagging the plot boundaries from the plot center. No adjustment is made for magnetic declination. If the slope of a transect is greater than 10 percent it should already be corrected for slope and identified/flagged accordingly. Run each transect (north, east, south, and west) from the plot center to the previously identified/flagged plot boundary using tapes. Do not allow the vegetation to deflect the alignment of the tape.

Measure and record the transect intercept length (in horizontal feet) of live tree canopy cover by tree species (for all tree sizes combined: trees, saplings, seedlings). See the *Key to Forest and Woodland Dominance Types* for a list of species to include. For determining intercept length on taller or leaning trees, it may be helpful to use a densitometer to determine vertical projection of the tree crown edge. Round and record the total measured intercept length to the nearest foot for each cardinal direction. Calculate canopy cover per species and all tree species by averaging the total intercept length from the north, south, east, and west transects. Round to nearest percent.

Shrub Cover Transects: (Only for Shrub life form plots.) Shrub canopy cover transects are optional, but may be used by Government inspectors for quality assurance purposes.

Lay out four 50-foot transects from the plot center in each cardinal direction (200 feet of total transect). Use the same layout configuration as was used for identifying/flagging the plot boundaries from the plot center. No adjustment is made for magnetic declination. If the slope of a transect is greater than 10 percent it should already be corrected for slope and identified/flagged accordingly. Run each transect (north, east, south, and west) from the plot center to the previously identified/flagged plot boundary using tapes. Do not allow the vegetation to deflect the alignment of the tape.

Measure and record the number of feet of live canopy cover intercepted for each species within each 10-foot transect increment in each cardinal direction. See the *Key to Shrubland Dominance Types* for a list of species to include. Round the estimate to the nearest 0.5 foot for each 10-foot increment. Gaps within a single plant, flowers, and flower stalks should be counted as part of the shrub. Total the estimates to determine percent cover of each species for each transect. Total all shrub species percentages to determine the shrub canopy cover for each transect. Calculate the overall shrub canopy cover by averaging the total shrub cover from the north-south and east-west transects.

Dixie NF – Field Reference Site - Descriptive and Observation Plot
Tree and Shrub Transect Data Form

1- **Reference Site & Plot ID#:** ________________ *2-* **Names**: _______________________ *3-* **M/D/YY:** _____-_____-_____

4- Tree Cover Transects – Horizontal Intercept Length

Plant Code	North (feet)	South (feet)	East (feet)	West (feet)	Total intercept length	Average cover (total/200')
Others Combined						
Total Timber	--	--	--	--		
Total Woodland	--	--	--	--		
Total (all tree spp)	--	--	--	--		
Total horiz. transect length	50	50	50	50	200	--

5– Shrub Canopy Cover – Horizontal Intercept Length

Transect North/South - Horizontal Distance

Plant Code	0-10'	10-20'	20-30'	30-40'	40-50'	50-60'	60-70'	70-80'	80-90'	90-100'	Total
Others Combined											
										Total N/S Shrub CC	

Transect East/West - Horizontal Distance

Plant Code	0-10'	10-20'	20-30'	30-40'	40-50'	50-60'	60-70'	70-80'	80-90'	90-100'	Total
Others Combined											
										Total E/W Shrub CC	
										Overall Shrub CC	

Appendix E: eCognition Layer Weights

Layer weights used to develop the modeling units (segments) in eCognition software

Layer	Weight
Landsat 5 TM – 1st Principal Component	0.5
Landsat 5 TM – Tasseled Cap (Greenness)	0.5
NAIP 2011 (10-meter) – Band 1	1.0
NAIP 2011 (10-meter) – Band 2	1.0
NAIP 2011 (10-meter) – Band 3	1.0
NAIP 2011 (10-meter) – Band 4	2.0
NAIP 2011 (10-meter) – NDVI	2.0
Trishade – Band 1	0.3
Trishade – Band 2	0.3
Trishade – Band 3	0.3

Appendix F: Tree Canopy Cover Photo-Interpretation Assessment

The Remote Sensing Applications Center completed an investigation of the Dixie NF continuous and thematic tree canopy cover maps using an independent aerial photo-interpreted (PI) dataset. A confusion matrix and an R-squared regression analysis were generated. From this analysis an evaluation of the final tree canopy cover map can be made based on photo-interpreted information.

Methods and Analysis

A random sample of 300 map features (polygons) were selected as reference sites for this assessment (Figure 1). Percent tree canopy cover was interpreted across the full spatial extent of each map feature using high resolution aerial imagery, including: 1-meter resolution color-infrared NAIP imagery from 2014 and half meter resource imagery from 2012. Each polygon was assessed independently by two analysts. In cases where the canopy cover estimate between interpreters was less than 10%, the final canopy cover label was calculated by averaging the two estimates. Polygons with label differences of 10% or more were reinterpreted. In some cases where a label could not be determined a new polygon was randomly selected and canopy cover was estimated. The PI reference values were also binned into the final thematic canopy cover classes (Table 1).

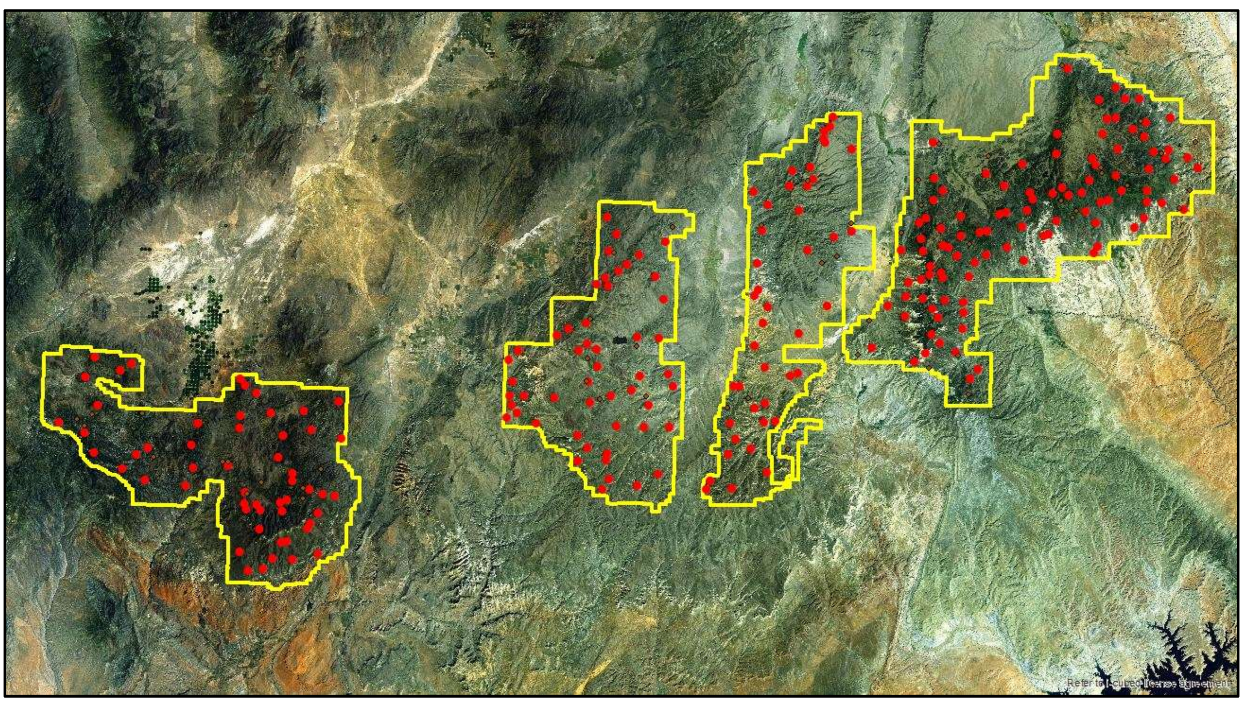


Figure 1: Locations of the 300 randomly selected reference sites (red points) that were photo-interpreted for tree canopy cover.

Table 1. Summary of photo-interpreted data classified according to the Dixie NF canopy cover map classes and the associated mapped class data.

	Canopy Cover Class (polygon count)					
Data Source	**NF (<10%)**	**TC1 (10-19%)**	**TC2 (20-39%)**	**TC3 (40-49%)**	**TC4 (50-59%)**	**TC5 (≥ 60%**
PI Reference	12	46	115	44	42	41
Dixie NF map	2	44	132	55	35	32

Results

A direct comparison of the photo-interpreted reference data set and the values from the filtered continuous canopy cover map features showed good agreement and a fairly good linear fit with an R^2 value of 0.83 (Figure 2). Accuracies of the corresponding thematic canopy cover map was estimated using a confusion matrix. The photo-interpreted sites were binned into the thematic canopy cover classes and compared against the final filtered thematic map. The overall assessment showed an accuracy of 65% (Table 2).

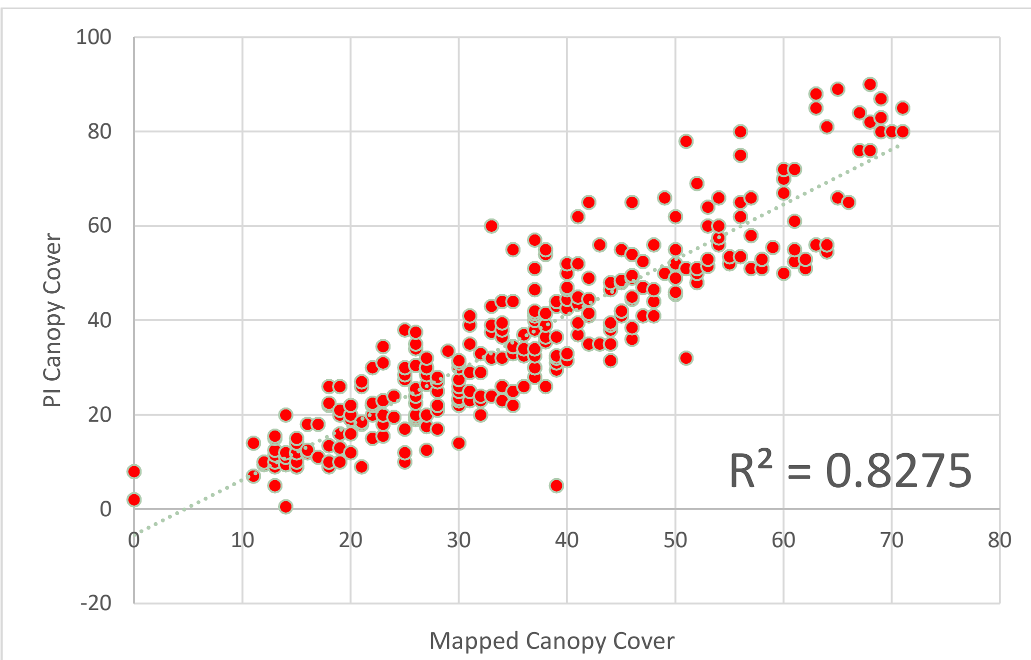


Figure 2: A scatterplot showing the linear fit (R^2 = 0.83) between the continuous canopy cover map and the photo-interpreted reference estimates.

Table 2. Confusion matrix from the filtered Dixie NF canopy cover map compared to the PI reference canopy cover.

		PI Reference Data							
	Canopy Class	NT	TC1	TC2	TC3	TC4	TC5	Total	Producer's
Dixie NF Filtered Map	NT	2	0	0	0	0	0	2	100%
	TC1	8	29	7	0	0	0	44	66%
	TC2	2	16	95	13	5	1	132	72%
	TC3	0	1	12	27	11	4	55	49%
	TC4	0	0	1	4	18	12	35	51%
	TC5	0	0	0	0	8	24	32	75%
	Total	12	46	115	44	42	41		
	User's	17%	63%	83%	61%	43%	59%		
	Overall							65%	

Appendix G: Tree Size Class Modeling Data Layers

Additional data layers used in the modeling of tree size

Data Source	# of Layers	Spatial Resolution	Description	Statistics Used	Total # of Predictors
Landsat seasonal coefficients	3	30m	Time series analysis from using imagery from 2010 – 2015. Estimates seasonal variability in speed, magnitude, and longevity of green-up and senescence.	Maximum, Mean and Standard Deviation	3
ifSAR	1	5m	Estimate of canopy height	Mean and Standard Deviation	1
Vegetation Type Map	1	10m	Mid-level existing vegetation map	Majority	1

Appendix H: Draft Map Review

DIXIE NATIONAL FOREST

EXISTING VEGETATION MAPPING PROJECT – VEGETATION TYPE DRAFT MAP REVIEW

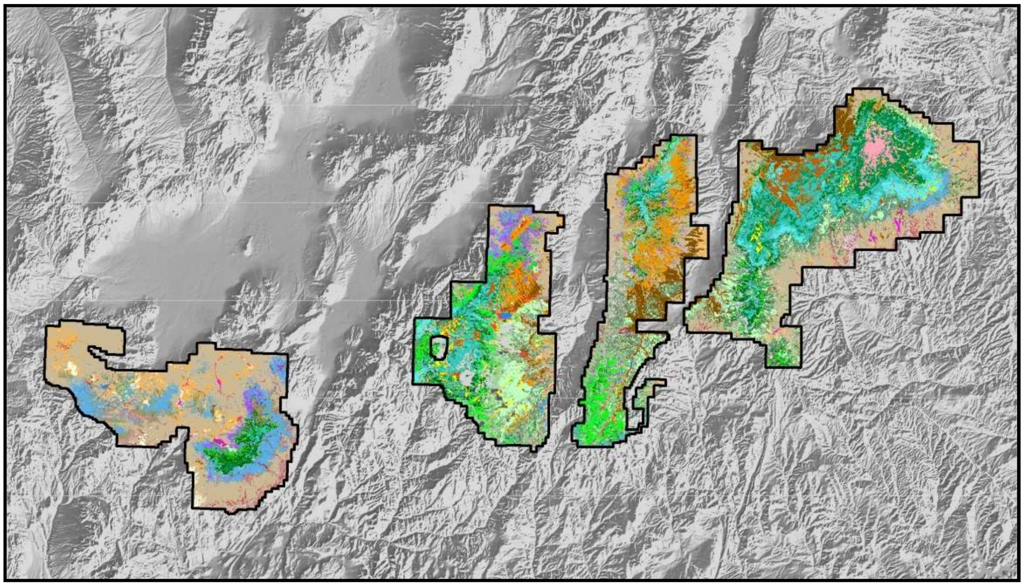
November 4 – 20, 2015

Background:

The Remote Sensing Applications Center (RSAC) was tasked by the Dixie National Forest and Intermountain Region to develop a set of mid-level existing vegetation maps. Existing vegetation is the plant cover, or floristic composition and vegetation structure, occurring at a given location at the current time (Nelson et al. 2015). This should not be confused with Potential Natural Vegetation (PNV) which describes the vegetation communities that would be established if all successional sequences were completed without interference by man under the present climatic and edaphic conditions (Tuxen 1956). The final map products for this project will include existing vegetation type, canopy cover, and tree size class.

The project has utilized remote sensing techniques and field data to map existing vegetation types. During this process, RSAC has worked with the Forests and the Regional Office to collect and develop the data layers required for implementing semi-automated remote sensing techniques. High resolution aerial imagery collected in 2011 was used to create "mapping segments" (GIS polygons) from a combination of spectral information and physical characteristics of the landscape. These segments were then assigned a vegetation type using an ensemble classifier. The vegetation type features on the draft maps have been aggregated to 2 acres for riparian types and 5 acres for upland types. The final maps will be produced at a 1:100,000 scale.

This review will focus on the draft vegetation type map only. The meeting scheduled at the Supervisor's Office in Cedar City is planned to solicit feedback from knowledgeable staff members who can evaluate the draft maps and help improve the depiction of existing vegetation on the final maps. Map revisions will be based almost entirely on the information provided from the review process. Digital maps are available via Webmap.



Vegetation type map units:

Not all vegetation types have been mapped in each district. The reference sites were reviewed at the beginning of the modeling process and the vegetation types to be depicted on the draft map were finalized. A list of the vegetation type map units and acres forest-wide and of each type in each district are on the following pages.

Map Class	Acres	%
Aspen	57,874	2.9%
Aspen/Conifer	153,060	7.8%
Douglas-fir Mix	80,938	4.1%
Ponderosa Pine	92,284	4.7%
Ponderosa Pine Mix	93,726	4.8%
Ponderosa Pine/Woodland	132,517	6.7%
White Fir Mix	73,926	3.8%
Spruce/Fir	89,771	4.6%
Blue Spruce	86	0.0%
Bristlecone Pine/Limber Pine	9,793	0.5%
Mountain Mahogany	42,810	2.2%
Pinyon-Juniper	507,890	25.9%
Rocky Mountain Juniper Mix	1,851	0.1%
Gambel Oak	105,813	5.4%
Mountain Big Sagebrush	92,193	4.7%
Wyoming Big Sagebrush	59,091	3.0%
Basin Big Sagebrush	24,686	1.3%
Silver Sagebrush	31,892	1.6%
Black Sagebrush	91,868	4.7%
Desert Shrubland	20,372	1.0%
Interior Chaparral	20,439	1.0%

Mountain Shrubland	44,674	2.3%
Alpine Vegetation	19,362	1.0%
Annual Herbaceous	10,205	0.5%
Seeded Herbaceous	3,543	0.2%
Upland Herbaceous	24,576	1.3%
Riparian Woody	8,329	0.4%
Riparian Herbaceous	12,014	0.6%
Agriculture	3,017	0.2%
Barren/Sparse Vegetation	46,600	2.4%
Developed	5,128	0.3%
Water	4,062	0.2%
Total	**1,964,389**	**100.0%**

	Pine Valley RD		Cedar City RD		Powell RD		Escalante RD		Fremont River RD	
Map Class	**Area (ac)**	**% Area**	**Area (ac)**	**% Area**	**Area (ac)**	**% Area**	**Area (ac)**	**% Area**	**Area (ac)**	**% Area**
Aspen	138	0.03%	10,892	2.69%	10,165	2.62%	24,387	5.58%	12,292	4.84%
Aspen/Conifer	4,132	0.86%	39,681	9.82%	10,090	2.60%	69,220	**15.85%**	29,937	**11.80%**
Douglas-fir Mix	13,473	2.80%	18,320	4.53%	13,938	3.59%	24,700	5.66%	10,506	4.14%
Ponderosa Pine	599	0.12%	40,742	**10.08%**	16,339	4.21%	28,432	6.51%	6,171	2.43%
Ponderosa Pine Mix	652	0.14%	40,813	**10.10%**	25,531	6.57%	21,739	4.98%	4,992	1.97%
Ponderosa Pine/Woodland	5,358	1.11%	25,384	6.28%	45,127	**11.61%**	49,761	**11.40%**	6,887	2.71%
White Fir Mix	5,403	1.12%	30,554	7.56%	30,479	7.84%	6,095	1.40%	1,395	0.55%
Spruce/Fir	3,294	0.68%	11,838	2.93%	2,377	0.61%	27,040	6.19%	45,223	17.82%
Blue Spruce	0	0.00%	51	0.01%	35	0.01%	0	0.00%	0	0.00%
Bristlecone Pine/Limber Pine	288	0.06%	3,189	0.79%	1,390	0.36%	4,642	1.06%	283	0.11%
Mountain Mahogany	9,827	2.04%	19,131	4.73%	13,333	3.43%	294	0.07%	225	0.09%
Pinyon-Juniper	228,798	**47.55%**	45,247	**11.19%**	77,730	**20.01%**	100,752	**23.07%**	55,364	**21.82%**
Rocky Mountain Juniper Mix	0	0.00%	1,069	0.26%	351	0.09%	418	0.10%	13	0.00%
Gambel Oak	78,332	**16.28%**	11,289	2.79%	6,145	1.58%	4,486	1.03%	5,563	2.19%
Mountain Big Sagebrush	1,403	0.29%	28,119	6.96%	53,880	**13.87%**	6,519	1.49%	2,272	0.90%
Wyoming Big Sagebrush	43,859	9.12%	2,380	0.59%	6,050	1.56%	3,589	0.82%	3,213	1.27%
Basin Big Sagebrush	5,853	1.22%	7,618	1.88%	6,707	1.73%	3,034	0.69%	1,474	0.58%
Silver Sagebrush	0	0.00%	7,416	1.83%	525	0.14%	10,732	2.46%	13,220	5.21%
Black Sagebrush	2,934	0.61%	13,093	3.24%	38,218	9.84%	16,616	3.81%	21,006	8.28%
Desert Shrubland	6,969	1.45%	0	0.00%	0	0.00%	9,486	2.17%	3,918	1.54%
Interior Chaparral	20,439	4.25%	0	0.00%	0	0.00%	0	0.00%	0	0.00%
Mountain Shrubland	25,180	5.23%	6,713	1.66%	10,714	2.76%	926	0.21%	1,140	0.45%
Alpine Vegetation	0	0.00%	168	0.04%	0	0.00%	191	0.04%	19,003	7.49%
Annual Herbaceous	10,188	2.12%	0	0.00%	0	0.00%	17	0.00%	0	0.00%
Seeded Herbaceous	2,681	0.56%	244	0.06%	419	0.11%	79	0.02%	120	0.05%
Upland Herbaceous	579	0.12%	12,349	3.05%	1,767	0.45%	5,644	1.29%	4,237	1.67%
Riparian Woody	4,410	0.92%	1,194	0.30%	1,246	0.32%	937	0.21%	541	0.21%
Riparian Herbaceous	1,248	0.26%	5,687	1.41%	1,899	0.49%	1,776	0.41%	1,404	0.55%
Agriculture	1,300	0.27%	10	0.00%	218	0.06%	1,411	0.32%	78	0.03%
Barren/Sparse Vegetation	2,719	0.57%	15,457	3.82%	13,416	3.45%	12,727	2.91%	2,282	0.90%
Developed	585	0.12%	4,012	0.99%	277	0.07%	205	0.05%	49	0.02%
Water	495	0.10%	1,619	0.40%	179	0.05%	814	0.19%	955	0.38%
Total	**481,136**	**100.00%**	**404,276**	**100.00%**	**388,544**	**100.00%**	**436,670**	**100.00%**	**253,762**	**100.00%**

Review Process:

For the review, provide as much information about the draft map as possible. You have been provided with digital and hardcopy draft maps. Either form of review is acceptable… Overall, it is important to focus your attention on the general vegetation patterns and distribution of vegetation types. We need information on what is correct and what is incorrect. Please remember this is a mid-level map (1:100,000 scale) and not a site map. The minimum size of an area that will be depicted on the final map is 5 acres for upland types and 2 acres for riparian types. This is not project level mapping; fine scaled vegetation patches or stands will not be represented on the final map.

For either the hard copy or digital map review you must follow the "Dixie Vegetation Keys" when determining the vegetation type map unit. This ensures that everyone is assigning types based on the same rules and descriptions.

In general, the draft map review process includes the following phases:

- Review the forest and district proportion summaries provided in this procedure.
- Review the entire district. Focus on general vegetation distribution and patterns and determine if the overall community types that you see are represented.
- Next focus on specific areas that you are most familiar with. These include areas that you have done more detailed project work on or localized studies.
- If necessary follow up with field visits to areas that are confused and correct labels cannot be easily determined.

The next sections provide a description of reviewing the digital maps.

<u>Digital draft map review procedures:</u>
Digital versions of the draft map are available through webmap. It is important to review the general distribution and extent of vegetation patterns at a scale that corresponds to the midlevel mapping scale, e.g. 1:50,000 to 1:100,000. To access the map layers using webmap use the following directions.

Webmap instructions:

Open webmap. Go to:
http://166.2.126.153/vegmaps/Dixie_Vegetation_Type_Draftmap/

1. A web browser will open, click on the OK button and the map will be displayed automatically. There are four buttons at the top of the screen, just to the right of center. These buttons from left to right are: Layer List, Edit, Identify, and Veg

Type Map Legend. The legend can be activated and deactivated by clicking on legend icon.

2. Making Edits to the map. Use the editing widget to draw polygons for areas where changes need to be made or where you see the map not following the pattern of the landscape. To begin making edits click on the editing widget. An Edit window will open. Select the map unit class you wish to place on the map. Select a drawing tool (in the lower right of the edit window) and begin digitizing on the map. After the edit is complete, an attribute box will appear. Here you will enter your name for edit tracking. Full polygon editing is available for point to point and freehand. The lower left of the editing window has tools to make selections for deleting edit features if needed.

3. Saving edits to the map. Your changes will be automatically saved to the server at RSAC when you close the webmap session.

Additional notes on using webmap:

- More…
    - Use the slider underneath each layer to adjust the transparency.
    - Static legend: Toggle the map legend on and off.
    - Editing Tools: This opens the editing interface.
    - Additional tools: Similar to tools in ArcMap, there is "identify" tool.
- Different backgrounds are available to view as reference (imagery, streets, topographic, etc.). These are available on the top right corner of the webpage under the Basemap button located in the upper right-hand corner.
- Navigation tools are on the left side of the map. Additionally you can use keyboard arrows, mouse panning with click and drag, and the scroll wheel on the mouse to zoom

District Questions & Observations:

This section provides specific questions and observations about the vegetation maps for each district.

<u>Pine Valley Ranger District:</u>

- How are the relative sagebrush distributions?
    - WSB>BSB>BLSB>MSB and no SSB
- In the current vegetation key, QUTU2 is classified as "TBD" species, not *chaparral*. In the reference data set QUTU2 made up most of the *chaparral* class. Is this ok and does it meet the Forest's and District's needs?

- Does the extent of the *desert shrub* class look reasonable?
- In areas of recent disturbance and juniper mastication, do the resultant map classes look reasonable?
- Around and above Pine Valley there are extremely mixed areas dominated by different conifer species. Does the map seem to accurately depict the patterns of these mixed forests?
- There is very little pure *aspen*, is this ok?
- Is *Douglas-fir Mix* over mapped? Should more of this be *White Fir Mix*?
- There was only 1 *Rocky Mountain Juniper* site collected in Pine Valley Ranger District, therefore it wasn't mapped. Is this alright?

<u>Cedar City Ranger District:</u>

- Lots of Mountain Mahogany is mapped at the north end of the district (Upper Bear Valley). Is this OK or is it over mapped?
- Alpine is only mapped around Brian Head. Is this OK?
- The west side of the district is dominated by Aspen/Confer and White Fir mix. Does this seem reasonable?
- The Castle Valley and Hancock Peak trailhead areas have a lot of Silver Sagebrush mapped. Is this OK?
- Most of the south-east portion of the district (Asay Bench, Markagunt Plateau, Duck Creek) is mapped as Ponderosa Pine with some Ponderosa Pine Mix. Is this OK?
- Most of the area north-north east of Panguitch Lake is mapped as Mountain Big Sagebrush and Black Sagebrush. Is this OK?
- Has Developed been over mapped – specifically in the Duck Creek, Strawberry Creek, and Mammoth Creek areas?

<u>Powell Ranger District:</u>

- Johnson Canyon – Proctor Canyon – Sunset Cliffs – Big Hollow areas (on the west side of the district) are currently mapped as mostly Pinyon-Juniper, Ponderosa Pine Mix, and Ponderosa Pine/Woodland. Does this look reasonable? This was a hard area to map because there were very few reference sites and a great deal of photo-interpretation was done.
- Much of the south end of the district is mapped as White Fir mix. Does this look reasonable?
- On the Sevier Plateau there was a large fire in 2002 (Sanford Fire). There is a lot of Aspen and Mountain Big Sage mapped. How does this area look?

- In the Mud Spring Bench – Pat Willis Draw (around Casto Canyon and the Bryce Canyon Airport) area most of the shrublands is mapped as Black Sagebrush (Ponderosa Pine/Woodland is the forested areas). Is Black Sagebrush over mapped?
- The Mt. Dutton area is mapped mostly as Aspen/Conifer and Spruce/Fir in the higher elevations and White Fir mix and Mountain Mahogany in the lower elevations. Does this look reasonable?

Escalante & Fremont River Ranger District:

- Boulder Mountain has extensive areas of alpine mapped. Is this reasonable?
- Currently no Blue Spruce is mapped, should it be and if so do you have some specific location information.
- The north -west side of the district is mapped as Black Sagebrush. Is this OK?
- How do the desert shrub areas look in the southern part of the district?
- Has Aspen/Conifer been over mapped?
- Lots of Silver Sagebrush has been mapped in the central-northern part of the district (Coyote Hollow, Hay Lakes and Big Lake). Is this OK?

References:

Nelson, M.L.; Brewer, C.K.; Solem, S.L., eds. 2015. Existing vegetation classification, mapping, and inventory technical guide, version 2.0 Gen. Tech. Rep. WO-90. Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff. 210 p.

Tuxen, R. 1956. Die heutige naturliche potentielle Vegetation als Gegenstand der vegetation-skartierung. Remagen. Berichtze zur Deutschen Landekunde. 19:200-246.

Appendix I: Merge Rules for Segments Less Than MMF Size

Vegetation Types:

• Aspen	AS	• Basin Big Sagebrush	BSB
• Aspen/Conifer	AS/C	• Silver Sagebrush	SSB
• Douglas-fir Mix	DFmix	• Black Sagebrush	BLSB
• Ponderosa Pine	PP	• Desert Shrubland	DSH
• Ponderosa Pine Mix	PPmix	• Interior Chaparral	CHAP
• Ponderosa Pine/Woodland	PP/WD	• Mountain Shrubland	MS
• White Fir Mix	WFmix	• Alpine Vegetation	ALP
• Spruce/Fir	SF	• Annual Herbaceous	AHE
• Blue Spruce	BS	• Seeded Herbaceous	SHE
• Bristlecone Pine/Limber Pine	BC/LM	• Upland Herbaceous	UHE
• Mountain Mahogany	MM	• Riparian Woody	RW
• Pinyon-Juniper	PJ	• Riparian Herbaceous	RHE
• Rocky Mtn Juniper Mix	RMJmix	• Agriculture	AGR
• Gambel Oak	GO	• Barren/Sparse Vegetation	BR/SV
• Mountain Big Sagebrush	MSB	• Developed/Urban	DEV
• Wyoming Big Sagebrush	WSB	• Water	WA

Deciduous group	DEC	= AS, AS/C
Conifer group	CON	= SF, WFmix, PP, PPmix, PP/WD, DFmix, BC/LM, BS
Woodland group	WD	= PJ, RMJmix, MM, GO
Shrub group	SH	= BLSB, WSB, MSB, BSB, SSB, MS, DSH, CHAP
Herbaceous group	HE	= UHE, AHE, SHE, ALP
Riparian group	RIP	= RW, RHE
Barren/Sparse Veg		= BR/SV
Other		= AGR, DEV (no minimum size, no filter, nothing filtering into it)
Water		= WA (no minimum size, no filter, nothing filtering into it)

Forest Types

<u>Aspen</u>

1. Aspen/Conifer
2. Ponderosa Pine Mix
3. White Fir Mix
4. Riparian Woody
5. CON
6. WD
7. SH
8. HE
9. Riparian Herbaceous
10. Barren/Sparse Veg

Aspen/Conifer

1. Aspen
2. CON
3. Riparian Woody
4. WD
5. SH
6. HE
7. Riparian Herbaceous
8. Barren/Sparse Veg

Douglas-fir Mix

1. White Fir Mix
2. Ponderosa Pine Mix
3. Spruce/Fir
4. CON
5. Aspen/Conifer
6. Aspen
7. WD
8. Riparian Woody
9. SH
10. HE
11. Riparian Herbaceous
12. Barren/Sparse veg

Ponderosa Pine

1. Ponderosa Pine Mix
2. Ponderosa Pine/Woodland
3. Douglas-fir Mix
4. White Fir Mix
5. CON
6. Aspen/Conifer
7. Aspen
8. WD
9. Riparian Woody
10. SH
11. HE
12. Riparian Herbaceous
13. Barren/Sparse veg

Ponderosa Pine Mix

1. Ponderosa Pine
2. Ponderosa Pine/Woodland
3. Douglas-fir Mix
4. White Fir Mix
5. CON
6. Aspen/Conifer
7. Aspen
8. WD
9. Riparian Woody
10. SH
11. HE
12. Riparian Herbaceous
13. Barren/Sparse veg

Ponderosa Pine/Woodland

1. Ponderosa Pine
2. Ponderosa Pine Mix
3. Douglas-fir Mix
4. White Fir Mix
5. CON
6. Aspen/Conifer
7. WD
8. Aspen
9. Riparian Woody
10. SH
11. HE
12. Riparian Herbaceous
13. Barren/Sparse veg

White Fir Mix

1. Douglas-fir Mix
2. Ponderosa Pine Mix
3. Spruce/Fir
4. Aspen/Conifer
5. CON
6. Aspen
7. WD
8. Riparian Woody
9. SH

10. HE
11. Riparian Herbaceous
12. Barren/Sparse Vegetation

<u>Spruce/Fir</u>

1. White fir Mix
2. Douglas-fir Mix
3. Aspen/Conifer
4. CON
5. Aspen
6. WD
7. Riparian Woody
8. SH
9. HE
10. Riparian Herbaceous
11. Barren/Sparse Vegetation

<u>Blue Spruce</u>

1. Spruce/Fir
2. CON
3. Aspen/Conifer
4. AS
5. WD
6. Riparian Woody
7. SH
8. HE
9. Riparian Herbaceous
10. Barren/Sparse Vegetation

<u>Bristlecone Pine/Limber Pine</u>

1. White Fir Mix
2. Spruce/Fir
3. CON
4. Aspen/Conifer
5. AS
6. ALP
7. Barren/Sparse Vegetation
8. WD
9. SH
10. HE
11. Riparian Woody
12. Riparian Herbaceous
13. Barren/Sparse Vegetation

Woodlands

Mountain Mahogany
1. Pinyon-Juniper
2. WD
3. PP/WD
4. CON
5. DEC
6. SH
7. HE
8. RIP
9. Barren/Sparse veg

Pinyon-Juniper
1. Rocky Mountain Juniper Mix
2. WD
3. Ponderosa Pine/Woodland
4. CON
5. DEC
6. SH
7. HE
8. RIP
9. Barren/Sparse veg

Rocky Mountain Juniper Mix
1. Pinyon-Juniper
2. WD
3. Ponderosa Pine/Woodland
4. CON
5. DEC
6. SH
7. HE
8. RIP
9. Barren/Sparse veg

Gambel Oak
1. WD
2. Ponderosa Pine/Woodland
3. Riparian Woody
4. SH
5. CON
6. DEC
7. HE
8. Riparian Herbaceous
9. Barren/Sparse veg

Mountain Big Sagebrush
1. Mountain Shrubland
2. Silver Sagebrush
3. Wyoming Big Sagebrush
4. Basin Big Sagebrush
5. Black Sagebrush
6. SH
7. WD
8. HE
9. CON
10. DEC
11. RIP
12. Barren/Sparse Veg

Wyoming Big Sagebrush
1. Basin Big Sagebrush
2. Black Sagebrush
3. Mountain Big Sagebrush
4. SH
5. WD
6. HE
7. CON
8. DEC
9. RIP
10. Barren/Sparse Veg

Basin Big Sagebrush
1. Wyoming Big Sagebrush
2. Mountain Big Sagebrush
3. Mountain Shrubland
4. Black Sagebrush
5. SH
6. WD
7. HE
8. CON
9. DEC
10. RIP
11. Barren/Sparse Veg

Silver Sagebrush
1. Mountain Big Sagebrush
2. Mountain Shrubland
3. Wyoming Big Sagebrush
4. Black Sagebrush
5. SH
6. WD
7. HE
8. CON
9. DEC
10. RIP
11. Barren/Sparse Veg

Black Sagebrush
1. Wyoming Big Sagebrush
2. Mountain Big Sagebrush
3. Basin Big Sagebrush
4. SH
5. WD
6. HE
7. CON
8. DEC
9. RIP
10. Barren/Sparse Veg

Desert Shrubland
1. Interior Chaparral
2. SH
3. HE
4. WD
5. CON
6. DEC
7. RIP
8. Barren/Sparse Veg

Interior Chaparral

1. DSH
2. SH
3. HE
4. WD
5. CON
6. DEC
7. RIP
8. Barren/Sparse Veg

Mountain Shrubland

1. Gambel Oak
2. Mountain Big Sagebrush
3. SH
4. WD
5. DEC
6. CON
7. HE
8. RIP
9. Barren/Sparse Veg

Herbaceous

Alpine Vegetation

1. Barren/Sparsely vegetated
2. HE
3. Riparian Herbaceous
4. SH
5. BC/LM
6. CON
7. DEC
8. WD
9. Riparian Woody

Annual Herbaceous

1. HE
2. Riparian Herbaceous
3. Barren/Sparse Veg
4. SH
5. Riparian Woody
6. WD
7. DEC
8. CON

Seeded Herbaceous

1. HE
2. Riparian Herbaceous
3. Barren/Sparse Veg
4. SH
5. Riparian Woody
6. WD
7. DEC
8. CON

Upland Herbaceous

1. HE
2. Riparian Herbaceous
3. Barren/Sparse Veg
4. SH
5. Riparian Woody
6. WD
7. DEC
8. CON

Riparian (2 acres)

Riparian Herbaceous (2 acres)

1. Riparian Woody
2. HE
3. SH
4. WD
5. DEC
6. CON
7. Barren/Sparse Veg

Riparian Woody (2 acres)

1. Riparian herbaceous
2. Gambel Oak
3. DEC
4. SH
5. WD
6. HE
7. CON
8. Barren/Sparse Veg

Non-Veg

Barren/Sparsely vegetated

1. HE
2. SH
3. WD
4. CON
5. DEC
6. RIP

Canopy Cover Classes

Filtering Rules: 5 acres (except where otherwise noted)

Tree canopy 1
- Tree canopy 2
- Tree canopy 3
- Tree canopy 4

Tree canopy 2
- Tree canopy 3
- Tree canopy 1
- Tree canopy 4

Shrub canopy 1
- Shrub canopy 2
- Shrub canopy 3
- Shrub canopy 4

Shrub canopy 2
- Shrub canopy 1
- Shrub canopy 3

Riparian Woody canopy 1 (2 acres)
- Riparian Vegetation canopy 2
- Riparian Vegetation canopy 3

Riparian Woody canopy 2 (2 acres)
- Riparian Vegetation canopy 1

Tree canopy 3
- Tree canopy 4
- Tree canopy 2
- Tree canopy 1

Tree canopy 4
- Tree canopy 3
- Tree canopy 2
- Tree canopy 1

- Shrub canopy 4

Shrub canopy 3
- Shrub canopy 2
- Shrub canopy 4
- Shrub canopy 1

- Riparian Vegetation canopy 3

Riparian Woody canopy 3 (2 acres)
- Riparian Vegetation canopy 2
- Riparian Vegetation canopy 1

Tree Size Classes

Filtering Rules: 5 acres

Forest tree size 1

- Forest tree size 2
- Forest tree size 3
- Forest tree size 4
- Forest tree size 5

Forest tree size 2

- Forest tree size 3
- Forest tree size 1
- Forest tree size 4
- Forest tree size 5

Forest tree size 3

- Forest tree size 4
- Forest tree size 2
- Forest tree size 5
- Forest tree size 1

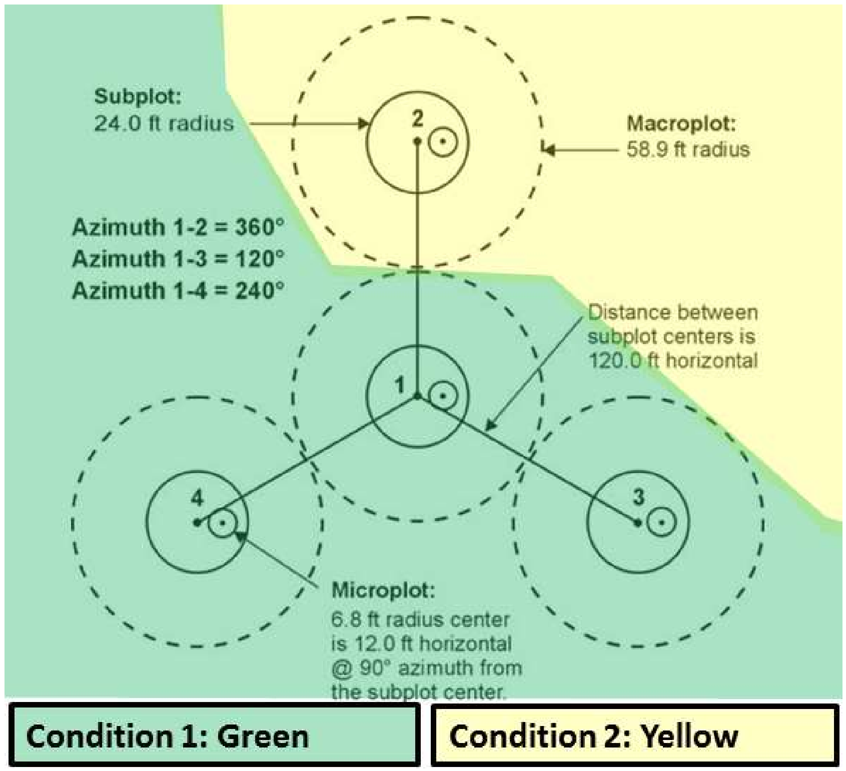
Forest tree size 4

- Forest tree size 5
- Forest tree size 3
- Forest tree size 2
- Forest tree size 1

Forest tree size 5

- Forest tree size 4
- Forest tree size 3
- Forest tree size 2
- Forest tree size 1

Appendix J: Diagram of an FIA Plot



A schematic of an FIA plot showing the four subplots. In some cases, a condition change may occur on a plot, thereby giving multiple conditions to a single plot. The schematic shows an example in which subplots 1, 3 and 4 are within condition 1, while subplot 2 is located within condition 2. Schematic source: USFS Forest Inventory and Analysis Program.