Region One
Vegetation Classification, Mapping, Inventory and Analysis Report

$$\bar{x} = \frac{\sum x}{n}$$

Numbered Report 09-03 **May, 2009**

The Region 1 Existing Vegetation Map Products (VMap) Release 9.1.1

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1. Executive Summary

Existing vegetation is the primary natural resource managed by the USDA Forest Service and by most forest landowners and land management agencies. The agency is charged with managing vegetation for a variety of human uses while maintaining the integrity of ecosystem components and processes at national, regional, and local scales. One of the most fundamental information needs to support ecosystem assessment and land management planning is consistent and continuous current vegetation data of sufficient accuracy and precision to address the principal issues and resource concerns. Many of the analyses needed to address multiple resource issues are essentially analyses of vegetation pattern and process relationships. These vegetation analyses are used to support a variety of Forest Service business needs including:

- Forest planning, including revision and amendment of existing plans
- Forest-level and regional fuels assessments
- Forest-level assessments to support the Regional Integrated Restoration and Protection Strategy
- Ecosystem assessment at the watershed scale that assess all lands within a watershed (4^{th}/5^{th} HUC EAWS) independent of ownership
- Resource Planning Act reporting requirements
- Forest and rangeland mountain range/large landscape assessments
- Post-fire assessments and BAER work
- Project-level cumulative effects analyses

Responding to these business needs, the Regional Forester's Team has tasked the Northern Region, Resource Information Management (RIM) Board, to develop a plan to construct and maintain a current vegetation map database across all administrative units in the Northern Region. The Northern Region Vegetation Mapping Program, hereafter referred to as VMap, was designed to meet this information management need. The VMap program started in 2001 and at the time of this publication (May, 2009), only 2 administrative units within the Northern Region have yet to have a VMap database constructed.

The result of VMap is a multi-level geospatial database used to produce four primary map products; lifeform, tree canopy cover class, tree diameter, and tree dominance type. Additional add-ons to the database are included for Eastside forests to address non-forest map classes (e.g., grassland and shrubland vegetation communities). The VMap database can produce products to meet information needs at various levels of analysis according to National and Regional direction established by the *Existing Vegetation Classification and Mapping Technical Guide* (Brohman and Bryant, 2005) and the *Region 1 Multi-level Classification, Mapping, Inventory, and Analysis System* (Berglund and others, 2009). The details of database and map product development and accuracy assessment are included in the project report.

2. Introduction

Existing vegetation is the primary natural resource managed by the USDA Forest Service and by most forest landowners and land management agencies. The agency is charged with managing vegetation for a variety of human uses while maintaining the integrity of ecosystem components and processes at national, regional, and local scales. One of the most fundamental information needs to support ecosystem assessment and land management planning is consistent and continuous current vegetation data of sufficient accuracy and precision to address the principal issues and resource concerns. Many of the analyses needed to address multiple resource issues are essentially analyses of vegetation pattern and process relationships. These vegetation analyses are used to support a variety of Forest Service business needs including:

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Responding to this information need, the Regional Forester's Team has tasked the Northern Region, Resource Information Management (RIM) Board, to develop a plan to construct and maintain a current vegetation map database across all administrative units in the Northern Region. The Northern Region Vegetation Mapping Program, hereafter referred to as VMap, was designed to meet this information management need. The VMap program was started in 2001 and at the time of this publication (May, 2009), only 2 administrative units within the Northern Region have yet to have a VMap database constructed.

Ecosystem assessment and land management planning at national and regional scales require consistent standards for classification and mapping of existing vegetation. The agency must, therefore, describe and map fundamental units of vegetation that can be interpreted to address numerous questions. This requires hierarchical classification and multi-scale mapping so existing vegetation can be described and mapped at the appropriate level of detail for each issue. In the early stages of the program, it became increasingly obvious that VMap was not a mapping project but, in fact, a classification, mapping, and inventory project. Over the years since VMap inception, coordination with the Northern Region Vegetation Council and the Regional Forest and Rangeland Staff resulted in the modification of VMap processes and resulting product development to accomplish these longer-term objectives as described in the *Region 1 Multi-level Classification, Mapping, Inventory, and Analysis System* (Berglund and others, 2009) and the *Existing Vegetation Classification and Mapping Technical Guide* (Brohman and Bryant, 2005).

VMap produces four primary map products from its geodatabase; lifeform, tree canopy cover class, tree size class, and tree dominance type. Additional add-ons to the database are included for Eastside forests to address non-forest map classes (e.g., grassland and shrubland vegetation communities). VMap provides the Northern Region with a geospatial database of vegetation and land cover produced following consistent analytical logic and methods to support the *Region 1 Multi-level Classification, Mapping, Inventory, and Analysis System* (Berglund and others, 2009). This geospatial database, with associated inventory data (i.e., FIA), supports land management planning and sustainable forest management at regional, sub-regional, and landscape assessment scales. These data also provide the analytical basis for vegetation pattern and process analyses associated with forest management planning. It is also explicitly designed to provide for project-level analyses using the same analytical logic and scale-appropriate methods. This design element facilitates establishing the relations among individual projects and Forest-wide or Regional management direction. These data should also facilitate cumulative effects analyses for many projects.

3. Classification, Mapping, and Inventory Overview

Vegetation is the primary natural resource managed by Region 1. The agency is responsible for managing vegetation for a variety of uses while maintaining the integrity of ecosystem components and processes at the broad, mid-, and project levels. One of the fundamental informational needs is consistent and continuous existing vegetation data of sufficient accuracy and precision to address resource planning, analysis, and monitoring objectives. These analyses rely on data and associated models produced from vegetation classification, mapping, and/or inventory processes. This paper discusses the integration and utilization of these data sources in Region 1.

The **R1** Vegetation **C**lassification, **M**apping, **I**nventory and **A**nalysis system (**R1-CMIA**) provides the means to derive estimates, with known reliability, of current condition and monitor changes in vegetation attributes, temporally and spatially. There is not one set of inventory data or map that is appropriate for addressing all levels of analysis on a Forest but there is a relationship, developed and supported by the Region 1 Regional Office, which provides consistency and integration.

Classification, mapping, and inventory of existing vegetation are three separate, but related, processes. Many of the analyses needed to address resource issues are essentially analyses of vegetation pattern and process relationships. All of these analyses rely on the products produced from vegetation classification, mapping, and/or inventory. The general relationship of these three is as follows:

> **Classification** is the process of grouping similar entities into named types or classes based on shared characteristics. Vegetation classification defines and describes vegetation types and/or structural characteristics. In other words vegetation classification answers the question "What is it?" To be most useful, classifications need to be consistently applied to inventory data and map products, hierarchical, mutually exclusive, exhaustive, and mappable, if a spatial depiction is needed.
>
> **Mapping** is the process of identifying the geographic distribution, extent, and patterns of vegetation types and/or structural characteristics. Vegetation mapping entails the spatial delineation of vegetation patches and assigning attribute labels to those patches. In other words, vegetation mapping answers the question "Where is it? " To be most useful, a map needs to be consistently derived and attributed.
>
> **Inventory** is the process of applying an objective set of sampling methods to quantify the amount, composition, and condition of vegetation within specified limits of statistical precision. Vegetation inventory quantifies the amount, composition, and condition of vegetation, and the reliability of the estimates. Vegetation inventory answers the question "How much is there?" To be most useful, the inventory needs to have a statistically valid sample design, be non-biased, and provide both population estimates and an indication of their reliability.

The conceptual relationships between R1 classification, mapping, and inventory are schematically depicted in figure 1.

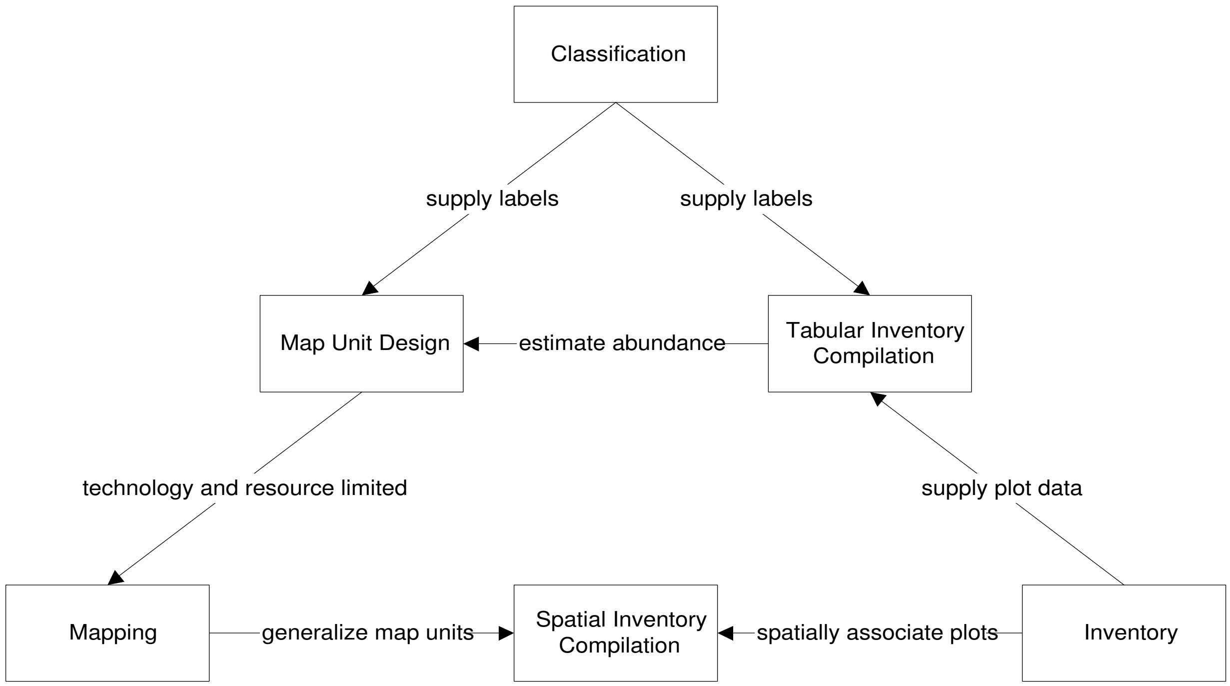


Figure 1. Relationships of vegetation classification, mapping, and inventory

This integrated approach addresses three levels of analysis: broad, mid, and base. Broad-level generally provides information for Regional, multi-Forest, or Forest analysis. Mid-level generally provides information for large landscapes such as mountain ranges and 4^{th}-code hydrologic units. Base-level generally provides information for project-level planning and decision making. See the *Region 1 Multi-level Classification, Mapping, Inventory , and Analysis System* at http://fsweb.r1.fs.fed.us/forest/inv/classify/cmia_r1_2_09.pdf for more information.

4. VMap Database and Map Products

R1-VMap uses the Region 1 Existing Vegetation Classification System (R1-ExVeg) in its map unit design. The R1-ExVeg system describes the logic for grouping entities by similarities in their floristic characteristics. The system was designed to allow consistent applications between regional inventory and map products within the Region 1 Classification, Mapping, Inventory, and Analysis framework. This has been an iterative process in Region 1 for many years as different classification schemes have been tested and evaluated for their utility by end users. This paper describes the system (i.e., methodology and algorithms) developed and accepted by the Region One Vegetation Council for classifying and mapping existing vegetation including tree canopy cover, tree diameter, and tree vertical structure. The Region 1 Vegetation Council is a consortium representing multiple resources at all levels of the Region and research foresters who use vegetation data to meet information needs.

The Region 1 existing vegetation mapping process utilizes this classification and a portion of this document describes how vegetation classification units comprise mappable features at different levels of the mapping hierarchy (mid-, and base-levels). As a result, there is a direct link between classification units and map labels. In many situations, a classification unit and an R1-VMap map label are synonymous. The Region 1 existing vegetation classification system meets, and in many cases exceeds, the requirements of an existing vegetation system as defined in the Forest Service *Existing Vegetation Classification and Mapping Technical Guide* (Brohman and Bryant, 2005) and the *National Vegetation Classification Standard* (FGDC NVC, 2008). For a more detailed description of R1-ExVeg, see the *Region 1 Existing Vegetation Classification System and its Relationship to Inventory Data and the Region 1 Existing Vegetation Map Products* at **************. The non-coniferous tree (referred to as non-forest) classification and map units are currently not included in R1-ExVeg, but will be included once complete. Please refer to appendix A for a description of the non-forest classification used to produce this version of the R1-VMap database.

The remainder of this section of the VMap documentation includes a brief description of the vegetation attributes in the MID-level feature class included in the R1-VMap database and their relationship to the Region 1 Existing Vegetation Classification System. See appendix A for the complete data dictionaries of all 2009 R1-VMap feature classes and a complete list of valid codes.

The RAW database contains the highest spatial and thematic resolution available. The datasets are very large. If there is an analysis need for the RAW, contact Region 1's Geospatial Group. The MID should provide adequate spatial resolution for most analysis needs where the polygons have been merged to a 1 acre minimum.

R1-VMap Lifeform:

Lifeform is a classification of plants based on their size, morphology, habit, life span, and woodiness (FGDC NVC, 2008). In the Region's vegetation classification system, valid lifeforms include: tree, shrub, herbaceous, sparsely vegetated, and non-vegetated. Mapped lifeform is derived from photo/image-interpretation and abundance is determined using species canopy cover. Mapped lifeforms include Tree, Shrub, Herbaceous, Sparsely Vegetated, and Water.

Tree Dominance Group 6040:

Dominance group 6040 is based on two thresholds of tree canopy cover: 60% and 40%. If the single most abundant tree species has greater than or equal to 60% of the total abundance (i.e., canopy cover, basal area, or trees per acre) for all trees, the class assigned is the species label for that most abundant tree species (e.g., ABLA, PIPO). If the abundance of the single most abundant tree species is less than 60% and greater than or equal to 40% of total tree abundance, the class assigned is the most abundant species with a suffix of the tree lifeform subclass, such as PICO-TMIX or PICO-IMIX. It is important to note that the HMIX, IMIX or TMIX suffix is based upon ALL trees within the setting, including the prefix species. It does not describe only the 'other' trees besides the dominant listed. If the abundance of the single most abundant tree species is less than 40% of total tree abundance, the class label assigned is the tree subclass (HMIX, IMIX or TMIX). Table 1 lists all tree species found in Region 1 and their assignment to shade-tolerant, shade-intolerant, or hardwood.

Table 1. Region 1 tree species assignment

Species Common Name	Plants Species Code	Assignment
aspen	POTR5	Hardwood
Cottonwood and poplar	POPUL – includes POBAT, POAN3, PODEM, POBA2)	
green ash	FRPE	
paper birch	BEPA	
alpine larch	LALY	Shade-intolerant conifer
Douglas-fir	PSME	
juniper	JUNIP – includes JUOC, JUOS, JUSC2	
limber pine	PIFL2	
lodgepole pine	PICO	
mountain mahogany	CELE3	
ponderosa pine	PIPO	
western larch	LAOC	
western white pine	PIMO3	
whitebark pine	PIAL	
Englemann spruce	PIEN	Shade-tolerant conifer
grand fir	ABGR	
mountain hemlock	TSME	
pacific yew	TABR2	
subalpine fir	ABLA	
western hemlock	TSHE	
western redcedar	THPL	

Key 3. Tree dominance group 6040. Note: XXXX = current Region 1 preferred *PLANTS Database* code for a tree species (e.g., ABLA, PIPO).

Lead	**Argument - Based on Relative Abundance (i.e., canopy cover, basal area, or trees per acre)**	**Dominance Group 6040**
From Key 2.SC1 HMIX	*Abundance of all hardwood trees $\geq$ 40% of total tree abundance.*	
DG1	HMIX: Abundance of single most abundant tree species $\geq$ 60% of total tree abundance	XXXX
DG1	HMIX: Abundance of single most abundant tree species < 60% and $\geq$ 40% of total tree abundance	XXXX-HMIX
DG1	HMIX: Abundance of single most abundant tree species < 40% of total tree abundance	HMIX
From Key 2.SC2 IMIX	*Abundance of all hardwood and shade-intolerant conifer trees $\geq$ 50% of total tree abundance.*	
DG2	IMIX: Abundance of single most abundant tree species $\geq$ 60% of total tree abundance	XXXX
DG2	IMIX: Abundance of single most abundant tree species < 60% and $\geq$ 40% of total tree abundance	XXXX-IMIX
DG2	IMIX: Abundance of single most abundant tree species < 40% of total tree abundance	IMIX
From Key 2.SC2 TMIX	*Abundance of all hardwood and shade-intolerant conifer trees < 50% of total tree abundance.*	
DG3	TMIX: Abundance of single most abundant tree species $\geq$ 60% of total tree abundance	XXXX
DG3	TMIX: Abundance of single most abundant tree species < 60% and $\geq$ 40% of total tree abundance	XXXX-TMIX
DG3	TMIX: Abundance of single most abundant tree species < 40% of total tree abundance	TMIX

No

Non-forest Dominance Group 6040:

The non-forest dominance type classification is still in draft form (see Appendix B.) Dominance type groups can be identified either by a top down approach or a bottom up approach. A bottom up approach aggregates shrub or herbaceous dominance types into dominance type groups based on the most abundant (i.e. dominant) species. Preliminary dominance types were evaluated and grouped according to the first named species. Where dominant and co-dominant species were equal in abundance (i.e. had the same absolute canopy cover values) the species priority rules for naming dominance types was followed. A species is considered to have equal abundance if the absolute canopy cover of the two most abundant species is within 10 percent canopy cover of each other. A top down approach considers only the dominant and co-dominant species observed in the field or through photo-interpretation and follows logic similar to the rule used for recording Existing Dominant Layer Species from Ecosystem Inventory and Analysis Guide (7/92), a species must have a minimum of 5 percent canopy cover or greater. The dominance type group key for shrub and herbaceous types can be found in appendix A. Composition of non-forest dominance group 6040 types is described in table 3 and differ between the MID and RAW databases because they were mapped using different processes as described in Section 6.

Table 2. Non-forest dominance type group 6040 composition

Database	Dominance group and plurality classes 6040	Dominance groups
MID	Grass-Bunch	FECA4, FEID, PASM, PSSPS, HECO26, NAV14, STIPA, AGROP2, CSMGX
	Grass-Singlestem	SCSSC, DECA18, CALO, MTNBRM, PHPR3, SMOBRO, AGCR,BOGR2,CAREXD, POEX, POA, ANNBRO, CSSGX
	Grass-Wet	CAREXW
	Shrub-Xeric	SAGE, PUTR2, RHUS, CELE3, JUNIP, CHRYS9, LOWSHRUB, ATRIP, TECA2, YUGL, SEMX
	Shrub-Mesic	POFR4, SAVE4, PRUNU, ROSA5, SYMPH,VACCI, PHMA5, SPBE2, SHEPH, SALIX, ALIN2, SDMX,
RAW	Grass-Dry	FECA4, FEID, PASM, PSSPS, HECO26, NAV14, STIPA, AGROP2, CSMGX, SCSSC, DECA18, CALO, MTNBRM, PHPR3, SMOBRO, AGCR,BOGR2,CAREXD, POEX, POA, ANNBRO, CSSGX
	Grass-Wet	CAREXW
	Shrub-Xeric	SAGE, PUTR2, RHUS, CELE3, JUNIP, CHRYS9, LOWSHRUB, ATRIP, TECA2, YUGL, SEMX
	Shrub-Mesic	POFR4, SAVE4, PRUNU, ROSA5, SYMPH,VACCI, PHMA5, SPBE2, SHEPH, SALIX, ALIN2, SDMX,

Tree Dominance 60% Plurality and 40% Plurality (MID database)

Tree dominance plurality classes are hierarchically aggregated from dominance group 6040 into two mid-level plurality classes that are supported in Region 1. Dominance plurality classes are used for most mid-level analysis needs and are attributes in the Region 1 mid-level map databases. Dominance 60% plurality classes include only single-species classes and mixed-species classes. This creates a map with classes that are based on greater than or equal to 60% canopy cover of an individual species and three heterogeneous mixed species classes. Dominance 60% plurality classes are useful when the management question of interest requires relatively pure vegetation types. Dominance 40% plurality classes consolidate all single species classes and single species-mixed species classes together based on the dominant species present. This creates a map or inventory compilation with classes that are based on greater than or equal to 40% canopy cover. Dominance 40% plurality classes are useful when the management question of interest requires the knowledge of the dominant species present in a setting. Table 4 (a complete list can be found in Appendix A) shows the conversion of dominance group 6040 types to dominance plurality classes.

Table 4. Aggregations of tree dominance group 6040 types into tree dominance 60% plurality and tree dominance 40% mid-level plurality classes. Note: XXXX = current Region 1 preferred *PLANTS Database* code for a tree species (e.g., ABLA, PIPO).

Dominance Group 6040	Dominance 60% Plurality	Dominance 40% Plurality
XXXX	XXXX	MX-XXXX
XXXX-HMIX	HMIX	MX-XXXX
XXXX-IMIX	IMIX	MX-XXXX
XXXX-TMIX	TMIX	MX-XXXX
HMIX	HMIX	HMIX
IMIX	IMIX	IMIX
TMIX	TMIX	TMIX

Tree Canopy Cover Class (MID & RAW database):

In the Region 1 existing vegetation classification system, tree canopy cover is used to describe the proportion of the ground surface covered by the vertical projection of the tree crowns. This is different from the term canopy closure which describes the proportion of the sky hemisphere obscured by vegetation when viewed from a single point on the ground. In the Region 1 existing vegetation classification system, canopy cover classes are a slight modification from national guiding documents which contain conflicting groups; the *National Vegetation Classification (NVC) System* (FGDC NVC, 2008) and the *Forest Service Existing Vegetation Classification and Mapping Technical Guide* (Brohman and Bryant, 2005). Brohman and Bryant (2005) use a system with 10-percent class breaks, while NVC has a break at 25%. We have chosen to adopt the 25% break as it best meets Region 1 business needs. Also, Brohman and Bryant's (2005) guidelines range from 0% to 100%, using 10-percent breaks. It is very uncommon to find canopy cover in excess of 70% in Region 1 and therefore the classes reflect that condition. Appendix A contains the tree canopy cover codes used in the 2009 VMap.

Shrub Canopy Cover Class (MID database):

In the Region 1 existing vegetation classification system, shrub canopy cover is used to describe the proportion of the ground surface covered by the vertical projection of the shrub crowns. Because shrub canopy cover was mapped across a large geographic area and not by model area as described in section 6, it is only included in the MID-level database. The domains of the RAW database do contain the valid shrub canopy cover codes if end users want to edit this dataset and supply appropriate labels to specific polygons. Because of lack of training data in the mesic shrub types, shrub canopy cover was only mapped for xeric shrub cover. Appendix A contains the shrub canopy cover codes used in the 2009 VMap.

Tree Size Class

Tree size is a classification of the predominant diameter class of live trees within a setting. It is calculated as basal area weighted average diameter (BAWAD) which is not greatly influenced by small trees. Since management questions typically are concerned with the larger dominant and co-dominant trees in a setting and basal area-weighted average diameter is influenced, to a greater extent, by larger trees, BAWAD was selected by the R1 Vegetation Council to be used in the Region's existing vegetation classification system. Although basal area-weighted average diameter is used when assessing tree size class on inventory data, canopy cover-weighted average diameter estimates are used when assessing tree size by photo/image-interpretation methods.

Non-Forest Litter

A litter class was mapped for the shrub and herbaceous dominance group 6040 types. Litter cover was estimated during field data collection and subsequent analysis revealed good separation of litter classes with spectral information. Three litter classes were mapped:

0-60%
60-90%
>90%

5. Accessing the Data

The 2009 VMap data is stored in each Units SDE and in the Regional Office SDE. The data can be browsed via ArcCatalog or manually loaded from SDE into an ArcMap document as long as the appropriate database connections have been established. ArcMap Layer files (i.e., symbolization and data pointer) are also stored in each Unit's SDE.

The easiest way, however, for resource specialists to access the 2009 VMap data is through the Geospatial Interface (GI). The GI is a FS-NRIS supported ArcMap extension that helps resource specialists work efficiently with ArcMap by providing tools which simplify loading data and providing various custom products to display and output data. The GI provides an easy way to:

- Find and load spatial data with or without the tabular data already attached. The GI can load one layer at a time (i.e. just roads or vegetation stands) or multiple layers at once for project or analysis work (i.e. Pick a product, click Load Data and ArcMap is populated with say water points, streams, water recreation sites all at once.).

- Display spatial data in a variety of ways using different symbology based on a layer's data attributes. For example, displaying roads based on type rather than just a single black line. This will save the user a lot of time setting data up in ArcMap.

- Run pre-defined queries of attribute data. A result table, from any of these queries, can display the attribute data only (no spatial data loaded in ArcMap), results for all the features of the selected layer, or based on features that are selected for the layer.

    - Export a map/layout to MS Word with one button click. This works for an ArcMap layout as well.

    - Export data to a variety of output formats, such as: Microsoft© Excel, Access, and Word, or text file.

    - Manipulate tabular data through a table data viewer. The viewer allows a user to easily: sort, hide, and sum columns of data. This new arrangement of the data can then be exported to any of the described in the last bullet.

    - Access data stored in various places on a local FS site as well as data at other sites.

The GI will also contain analytical tools that use the VMap data such as vegetation diversity matrices, wildlife habitat models, and FACTS activity analyses. Appendix C provides some instructions on how to get started with the GI and describes some of the GI tools currently available to work with the 2009 VMap data. For more information about the GI and to download the GI ArcMap extension, go to http://fsweb.gac.fs.fed.us/geoteam/v200/index.html

6. Methodology

Data Used — Because Landsat imagery has major limitations for non-forest mapping and non-forest cover is a significant component of eastside Forests, a different approach was used than the approach used on the westside VMap project (i.e. Landsat was the only image input on the westside VMap.)

The two cost effective data sets available for use were Landsat Thematic Mapper (TM) and National Agriculture Imagery Program (NAIP) imagery. Both of these datasets have properties that added value to the mapping work. Although the spatial resolution of Landsat TM is coarse at 30 meters, it has spectral properties that exceed what are offered in the high resolution NAIP imagery. These spectral properties are useful in discerning different types of vegetative. Landsat has a quick return cycle, repeating inventory of the same area every 16 days. This makes using multiple dates of imagery for detection of phenological changes in vegetation an important inclusion into the process. The footprint of Landsat is large (each scene covering approximately 185 sq kilometers) which makes for consistent data sets over large areas — important for larger area projects such as the eastside VMap. Because of it's high spatial resolution (1 meter), the NAIP imagery available offered properties that the Landsat could not. The polygon or map units delineated from these imagery (see secion on 'image segmentation' for a further description of this process) are very accurate as compared to what can be accomplished from Landsat and the secondary statistics derived from these imagery are useful for better mapping of various cover mapped. The downside of this imagery are that each image is small (approximately 20,000 acres) and so digital numbers can vary significantly over larger areas. Models (see section on 'Model Areas' for description of models) were kept small in the project to minimize this source of error. Given these descriptions, the following are the imagery used in the eastside VMap project.

- Two dates of Landsat Thematic Mapper imagery: A mid-summer image (July/August) and a fall image (September/October). These two dates were selected to capture "peak green" vegetation fully mature prior to it senescence, and a "fall" image to capture phenological differences in vegetation just slightly after senescence but prior to snowfall.
- 1 meter National Agriculture Imagery Program (NAIP) color infrared and natural imagery—all captured in summer 2005 except for South Dakota which was captured in 2004.

Ancillary data

In addition to the imagery, the following were also important inputs into the mapping process. All of these were produced from the Landsat or NAIP imagery or 10 meter Digital Elevation Models (DEM's).

- DEM derivatives — aspect, percent slope, curvature, solar radiation, and valley bottoms
- Second Order Image Statistics—all providing additional information for vegetation mapping. These include: texture bands (derived from the 1 meter NAIP data), Principal

Component Analysis (derived for all TM and NAIP data), Normalized Difference Vegetation Indices (NDVI), and Tassel Cap transformations.

See Appendix D for more specific information on imagery and ancillary datasets used.

Model Areas

To make the 30 meter Landsat TM and the 1 meter NAIP data useable for image processing, both sets of data were resampled to 5 meters using a cubic convolution resampling. At 5m resolution, data sets are still quite large, and given the limits of the image processing software used (eCognition), model areas were created no bigger than 350,000 acres. The larger basis for the stratification of these models coincides with the USDA Forest Service National Hierarchical Framework of Ecological Units (Bailey et al. 1994.) Beyond these units, models were further subdivided to Forest Service district or other management units and kept to a size manageable by the software used to process it. Also given consideration in these model divisions were NAIP imagery flaws. Models were created to minimize these flaws. Thirty three models were created to cover the entire project as shown below in figure (2).

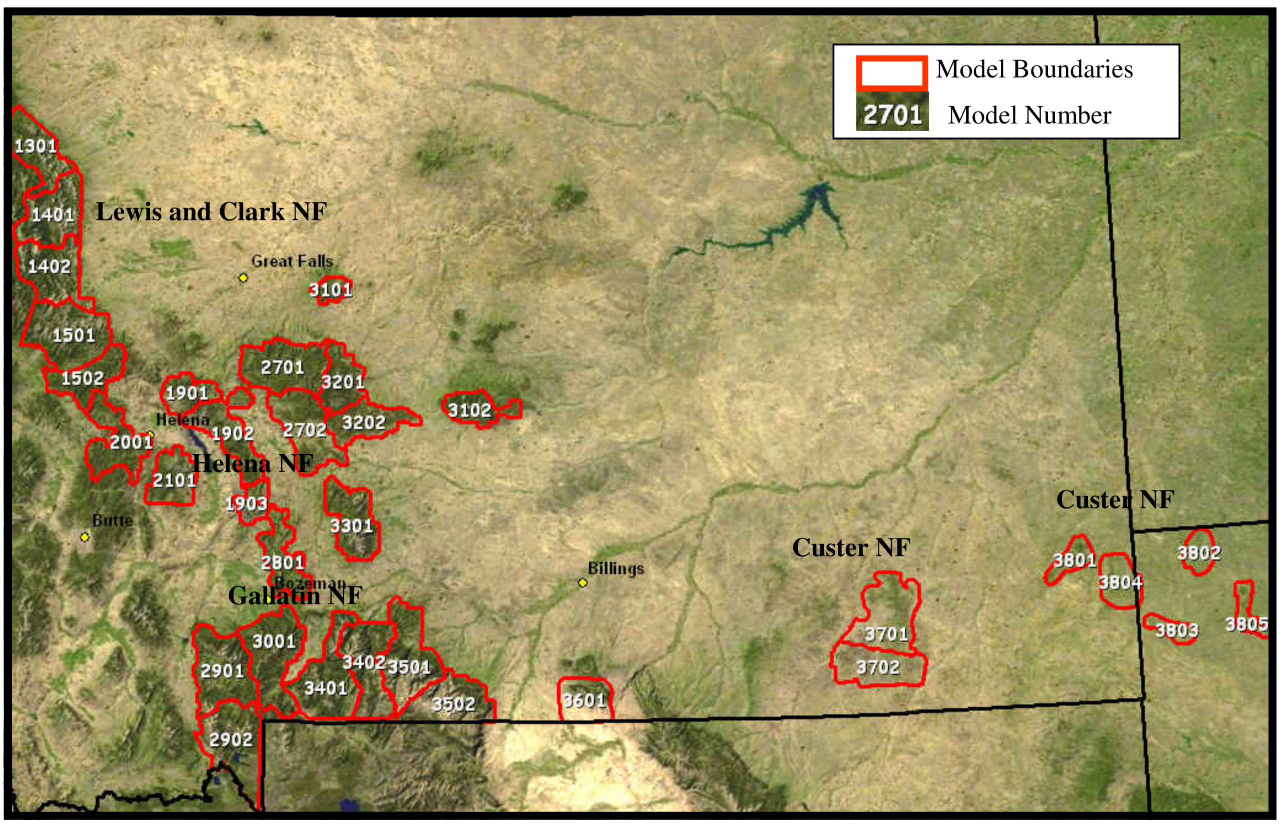


Figure 2. Thirty thee models covering the eastside VMap, covering the Helena, Gallatin, Lewis and Clark, and Custer National Forests (model boundaries over MODIS imagery.)

Image Segmentation — As stated in Ryerd and Woodcock (1996), “Image segmentation is the process of dividing digital images into spatially cohesive units, or regions. These regions represent discrete objects or areas in the image. This segmentation and merging process is influenced by the variance structure of the image data and provides the modeling units that reflect life form composition, stocking, tree crown size differences, and other vegetation and/or landcover characteristics (Haralick and Shapiro 1985, Ryerd and Woodcock 1996). Image segmentation was used in the eastside VMap to delineate vegetative features from eCognition software version 4.06. The 5m resampled NAIP being the primary input along with texture inputs derived from the 5m NAIP imagery. The segmentation process in eCognition is based on both the local variance structure within imagery and shape indices. These image objects effectively depict the elements of vegetation and landcover pattern on the landscape (McDonald et al. 2002.) Figure (3) illustrates the image segmentation-based depiction of landscape pattern displayed over 1m NAIP imagery.

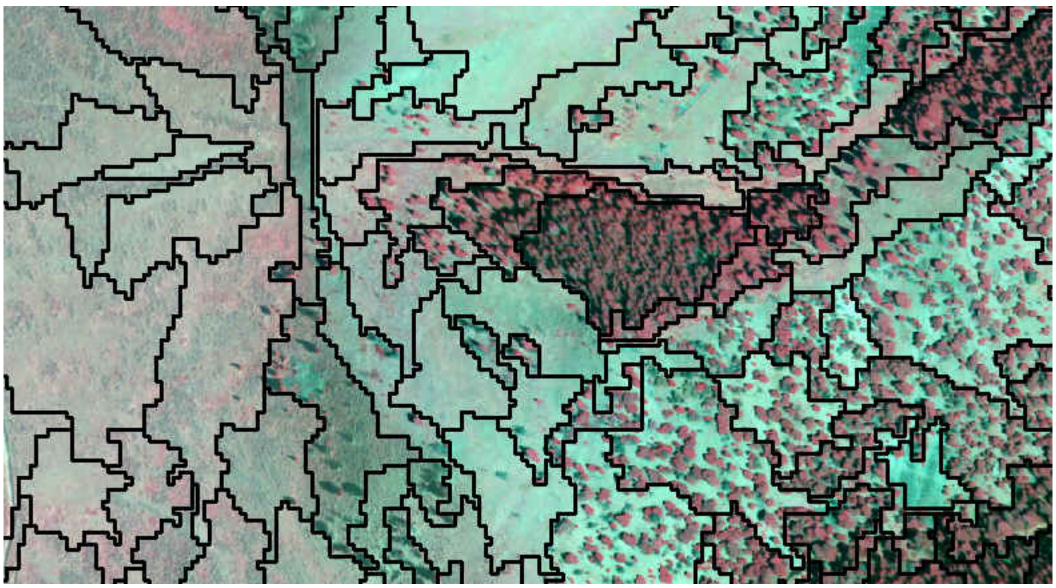


Figure 3. Example of image segmentation from eCognition Software (image segmentation draped over 1m color infrared NAIP imagery.)

Training Data—For any image processing based map product, sites of interest that represent each of the vegetation types to be mapped need to be collected. These training data are then associated with imagery and used to predict all other areas to be mapped. Since the eastside VMap had 33 models, training data was needed for each of the 33 models.

For the project, the image segmented polygons were the units used to collect each training site. Collection of the training data was completed using various methods. For tree size, tree canopy, and tree dominance type, training data was collected through photo interpretation of aerial photography by Forest resource people familiar the ground being mapped. As much as possible, selection of this photo interpreted training data was based on covering variation in the imagery, but in a lot of cases, it was also based on areas other data (i.e. stand exams and other field surveys) existed. Since non-forest data could not be interpreted from aerial photography, all of the non-forest data was collected from field sampling (contact Northern Region Geospatial Group for non-forest field sampling techniques.)

Labeling Algorithms

The Federal Geographic Data Committee (FGDC) Vegetation Classification Standards (FGDC 1997) establishes a hierarchy of existing vegetation classification with nine levels.

The top seven levels are primarily based on physiognomy. The two lowest levels, alliance and association, are based on floristic attributes. The USDA Forest Service recently released the national direction for classification and mapping of existing vegetation to implement the FGDC standards and to provide direction for classifying and mapping structural characteristics (Brohman and Bryant 2005). This direction applies to a variety of geographic extents and thematic resolutions characterized as map levels. The Northern Region Vegetation Mapping Project is specifically designed to meet this national program direction at the mid-level.

Most attribute labeling of the VMap products were accomplished using eCognition software. ECognition operates off of a hierarchy classification scheme and within that scheme, a series of functions can be used. For features easily discernable from image statistics (i.e. tree, non-tree; low tree canopy cover, high tree canopy cover), membership functions were used in the hierarchy process to separate cover types. Figure (4) shows an example of one these functions. For features less discernable (dominance type, tree size), nearest neighbor algorithms were used for classification.

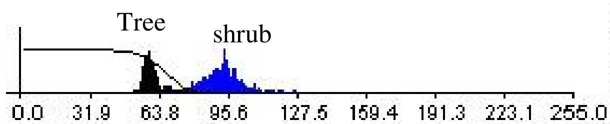
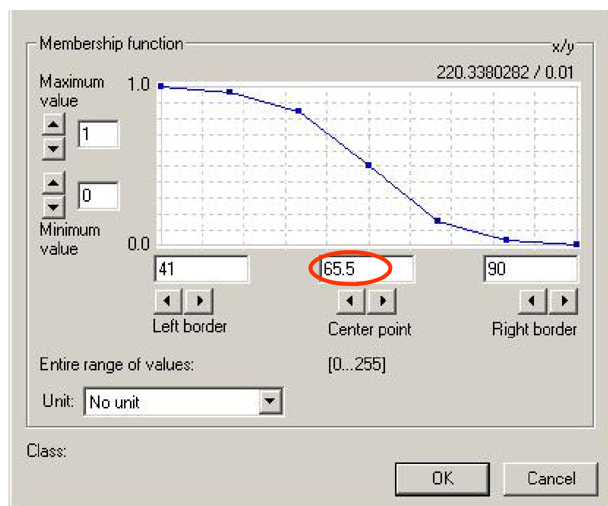


Figure 4. An example of an eCognition member ship function. The example shows 'tree' sample data (blue histogram) and ' shrub' sample data (black histogram) for one of the image inputs. Since there is such good separation between 'tree' and 'shrub' histograms in this example, a membership function is created to separate 'tree' from 'shrub'. At left, the membership excludes 'tree' at 65.5 for this input. A series of these can be created for all image inputs that show separation and combined to create outputs.



The eCognition hierarchy classification scheme sub-divides from general to specific at each level of the hierarchy with the classes at each level inheriting class descriptions from parent classes. The scheme below shows a example of this structure:

Level 1

- Forest from Non-forest is separated

↓

Level 2

- Forest (inherited from level 1)
  - ⇒ 40-100% tree crown closure (cc) separated from 10-40% tree cc
- Non-forest (inherited from level 1)
  - ⇒ Shrub cover separated from herbaceous

↓

Level 3

- 40-100% tree cc (inherited from level 2)
  - ⇒ 40-60% tree cc separated from 60-100% tree cc
- 10-40% tree cc (inherited from level 2)
  - ⇒ 10-25% tree cc separated from 25-40% tree cc
- Shrub Cover (inherited from level 2)
  - ⇒ mesic shrub separated from xeric shrub
- Herbaceous Cover (inherited from level 2)
  - ⇒ Wet grass separated from dry grass

Implementation of this classification hierarchy produces associated geospatial databases for four primary attributes. These attributes include: lifeform, dominance type, tree canopy cover, and tree size class. These original image objects were merged to a 1 acre minimum to produce mid level map products (see last part of this section for a description of merge labeling routines and section 4 for a description of map products.)

Non-forest Labeling Algorithms — All of the data that was collected for non-forest cover was done the summer of 2008. Although a lot of data was collected overall, in most cases there was not enough to use in the eCognition modeling process which was the original plan. The mean number of sites collected for each model was 85, with a few having as many as 319 and 7 of the models having less than 50. The models with a significant number of sites (over 100) will be mapped at the model level and that information will be available in fall 2009. To circumvent the problem of not having enough data, the field data was combined for 25 of the 33 models (figure 5) and classified with June 2005 Landsat TM imagery, and a series of biophysical inputs (see appendix A for a description of these inputs) and classified with 'Random Forest' a classification and regression tree model that is part of the statistical software R version 2.72 program. The algorithm for inducing a random forest was developed by Leo Breiman and Adele Cutler, and "Random Forests" is their trademark (Breiman and Cutler, 2008.) The term came from **random decision forests** that was first proposed by Tin Kam Ho of Bell Labs in 1995. The method combines Breiman's "bagging" idea (Breiman, 1996)and Ho's "random subspace method" (Ho, 1998) to construct a collection of decision trees with controlled variations.

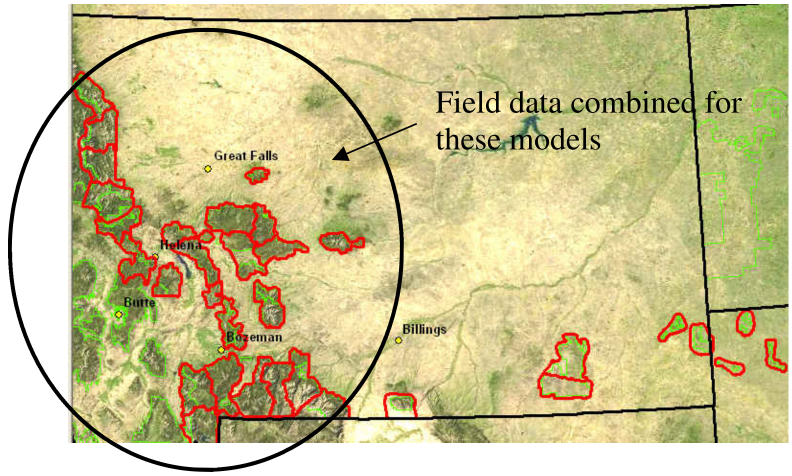


Figure 5. Picture of the models where field data was combined and classified with additional non-forest classes.

Non-forest classes were taken as far as they could in eCognition. The classes produced for all models in eCognition include: xeric shrub, mesic shrub, dry grass, wet grass, sparse vegetation, and water (see appendix A for a description of these classes.) Additional classes produced from the Random Forests classifier include: bunch grass, single stem grass, three classes of litter (0-60%, 60-90%, and > 90% litter), and two classes of xeric shrub canopy cover (10-25% and $\geq$25%).

Map Product Review — As part of the review process, all models were visited in the field the summer of 2008 and revised based on data collected from that work. This review included only tree attributes since non-forest data had not been collected yet (non-forest data was collected that same summer.) In some cases the review process revealed large enough discrepancies that major revisions were needed to some of the model attributes. Although there were errors in tree size and tree canopy cover that needed to be addressed, more of the errors were associated with dominance type.

In addition to checking draft maps for errors, a portion of the photo-interpreted training (data used to produce the final outputs) data were checked when accessible. This revealed some interesting results. With over 400 sites checked, photo-interpretation was correct for tree dominance type (large error discrepancies only — i.e., PSME dominated stand that should be ABLA dominated) 76% of the time, 63% of the time for tree canopy cover, and only 60% of the time for tree size class. In brief, the field review process was critical for correction of errors associated with the classification.

Assigning Merge Labels

The VMap mid-level polygon attributes Lifeform, Dom_Mid_40, Dom_Mid_60, Treecanopy, Treesize, Dom6040comp, and Treesizcomp were assigned based on summaries of raw-level polygon attributes. Each mid-level polygon (mid polygon) might have one or more raw-level polygons (raw polygon) within it. If a mid polygon had only one raw polygon then all mid-level attributes were based on that raw polygon. If a mid polygon had more than one raw polygon then the following process was used to assign attributes: First, conifer tree canopy was calculated based on a sum of raw polygon average area weighted tree canopy class mid-point value. If the calculated conifer tree canopy was >= 10% then a mid-level conifer Treecanopy class was assigned and mid-level Lifeform assigned "TREE", otherwise Treecanopy and Lifeform were assigned to a non-tree lifeform. Next raw polygon Dom_Mid_40, Dom_Mid_60, and Treesize majority values were assigned to the mid polygon. The mid-level Dom6040comp attribute was assigned using a descending area list of all unique raw polygon Dom_Grp_6040 values within the mid polygon. The mid-level Treesizcom attribute was assigned using a descending area list of the top two raw polygon Treesize values. The next section contains a detailed description of the process steps.

Assignment of Treecanopy and Lifeform Values
Tree Canopy was re-calculated based on an average area weighted tree canopy class mid-point value of each raw polygon within a mid polygon. First an average area weighted tree canopy mid-point value was calculated for each raw polygon and then summed for all raw polygons within a mid polygon. If the tree canopy value was greater than or equal to 10%, then a conifer Treecanopy class was assigned and Lifeform was assigned 'TREE'. If the conifer tree canopy value was less than 10% then both Treecanopy and Lifeform were assigned to the majority non-conifer life form type: 'HERB', 'SHRUB', WATER, or SPVEG. If the majority non-conifer type was a deciduous tree then Treecanopy assigned 'TREE-DECID' and Lifeform was assigned 'TREE'. The mid point values and formula used are:

Raw Tree Canopy Class	Mid-Point Value
Non-conifer 0-9.9%	1
CTR 10-24.9%	17
CTR 25-39.9%	32
CTR 40-59.9%	50
CTR 60-100%	65

Example 1 - Descending Area Table for Treecanopy and Lifeform

Acre	Treecanopy	Mid-Point Value
.40	CTR 10-24.9%	17
.32	CTR 25-39.9%	32
.20	GRASS-DRY	1
.15	SPVEG	1

Tree Canopy = 17*(0.4/1.07) + 32*(0.32/1.07) + 1*(0.2/1.07) + 1*(.15/1.07) = 16%
The mid-level tree canopy class assigned would be: CTR 10-24.9%
The mid-level lifeform assigned would be: 'TREE'

Assignment of Dom_Mid_40, Dom_Mid_60, and Treesize Values

When tree canopy class is calculated for a mid polygon it is possible for the majority of raw polygons to be a non-conifer type and still have a total conifer tree canopy cover greater than 10%. For example a mid polygon has two raw polygons with Treecanopy of 'HERB' comprising 60% of the mid polygon and one raw polygon with Treecanopy of 'CTR 25-39.9' comprising the remaining 40%. The mid polygon is assigned a 'TREE' lifeform even though the majority raw polygon Treecanopy is 'HERB'. In the next section a majority value of raw polygon attributes was used to assign Dom_Mid_40, Dom_Mid _60, and Treesize values. To account for a non-majority conifer tree type mentioned above, raw polygons with non-conifer labels were separated from raw polygons with conifer labels.

First an identity was run between the mid polygons and raw polygon feature classes. Then two tables were created from the identity feature class, one with all raw polygons assigned a conifer type Dom_Grp_60 and another with all raw polygons assigned a non-conifer type Dom_Grp_60. Frequency tables for Dom_Mid_40 and Dom_Mid_60 were run on both the conifer and non-conifer tables mentioned above. For mid polygons with conifer tree canopy greater than or equal to 10% the majority Dom_Mid_40 and Dom_Mid_60 values were selected from the respective conifer frequency table. Conversely, if conifer tree canopy was less than 10% the majority Dom_Mid_40 and Dom_Mid_60 values were selected from the respective non-conifer frequency table. A single frequency table for Treesize was run on only the conifer table. For mid polygons with conifer tree canopy greater than or equal to 10% the majority Treesize value was selected from the frequency table. For mid polygons with conifer tree canopy less than 10%, Treesize was assigned the Lifeform value generated above except for deciduous tree polygons where Treesize was assigned 'TREE-DECID' similar to Treecanopy. Below are two examples of this process.

Example 2 - Descending Area Table for Dom_Mid_40, Dom_Mid_60, and Treesize

Acre	Treecanopy	Dom_Mid_40	Dom_Mid_60	Treesize
.40	CTR 10-24.9%	MX-PICO	PICO	DBH 5-9.9"
.32	CTR 25-39.9%	MX-PSME	PSME	DBH 0-4.9"
.20	GRASS-DRY	GRASS-DRY	GRASS-DRY	HERB
.15	SPVEG	SPVEG	SPVEG	SPVEG

Conifer Majority Tables			Non-Conifer Majority Tables		
Dom40	Dom60	Treesize	Dom40	Dom60	Treesize
MX-PICO	PICO	DBH 5-9.9"	GRASS-DRY	GRASS-DRY	GRASS-DRY
MX-PSME	PSME	DBH 0-4.9"	SPVEG	SPVEG	SPVEG

In the above example tree canopy value is 16%, Treecanopy is 'CTR 10-24.9' and Lifeform is 'TREE'. Since tree canopy is greater than 10% the conifer majority tables are used to assign Dom_Mid_40 to 'MX-PICO', Dom_Mid_60 to 'PICO', and Treesize to 'DBH 5-9.9'.

Example 3 – Descending Area Table for Dom_Mid_40, Dom_Mid_60, and Treesize

Acre	Treecanopy	Dom_Mid_40	Dom_Mid_60	Treesize
.40	GRASS-DRY	GRASS-DRY	GRASS-DRY	HERB
.40	CTR 25-39.9%	MX-PSME	PSME	DBH 10-14.9”
.20	GRASS-DRY	GRASS-DRY	GRASS-DRY	HERB

Conifer Majority Tables			Non-Conifer Majority Tables		
Dom40	Dom60	Treesize	Dom40	Dom60	Treesize
MX-PSME	PSME	DBH 0-4.9”	GRASS-DRY	GRASS-DRY	HERB

In the above example tree canopy value is 12%, Treecanopy is ‘CTR 10-24.9’ and Lifeform is ‘TREE’. Since tree canopy is greater than 10% the conifer majority tables are used to assign Dom_Mid_40 to ‘MX-PSME’, Dom_Mid_60 to ‘PSME’, and Treesize to ‘DBH 10-14.9’. In this example if the initial identity table were used the majority Dom_Mid_40 and Dom_Mid_60 value would be ‘GRASS-DRY’. However, by separating the initial table into conifer and non-conifer tables the correct Dom_Mid_40 and Dom_Mid_60 values are selected.

Assignment of Dom6040comp and Treesizcomp Values

The purpose of the Dom6040comp and Treesizcomp attributes are to provide users with a summary of the raw polygon Dom_Grp_60 and Treesize values within a mid polygon. A frequency was run for all raw polygon Dom_Grp_60 values within a mid polygon. Then a descending acre list of all unique Dom_Grp_60 values was created and assigned to the Dom6040comp attribute. For the Treesizcomp attribute two methods were used: if tree canopy value was greater than or equal to 10% then only raw polygon conifer Treesize values within a mid-level polygon were used in a frequency similar to above. Only the first two descending acre unique Treesize values were assigned to the Treesizcomp attribute. If tree canopy value was less than 10% then the non-conifer Treecanopy attribute determined above was assigned.

For example two Dom6040comp value is: ‘PICO//PSME//GRASS-DRY//SPVEG.
And the Treesizcomp value is: ‘DBH 5-9.9”//DBH 0-4.9”’

For example three Dom6040comp value is: ‘GRASS-DRY//PSME’.
And the Treesizcomp value is: ‘DBH 0-4.9

7. Maintenance and Update

Maintenance and update of the VMap databases are two distinct processes. Maintenance refers to identifying areas of potential vegetation change as a result of fire, harvest, or insect and disease activities. Historically, the VMap database was flagged with these areas in subsequent releases. The identification of potential vegetation changes will be a continual process starting with the 2009 VMap release. Tools that identify VMap polygons that likely have had vegetation change will be developed and offered through the Geospatial Interface. These tools will identify potential activities from each Unit's FACTS activity layer and the Regional Aerial Detection Survey layers and produce appropriate output.

Update of VMap is a two-pronged process. The first prong is to gather comprehensive imagery for a specific area and re-run the labeling algorithms with either new or existing training data. Although the National Technical Guide for Mapping (Brohman and Bryant, 2005) suggest an update cycle of 5 years for mid-level map products, that is not feasible Region-wide under current or projected budget levels. Re-mapping with comprehensive imagery should be targeted to areas that have experienced significant vegetative change or areas with a grossly inaccurate or inadequate map that are planned for intense management activities.

The second update prong is to correct mapping errors in an existing VMap database. Depending on controls set up with your Unit's GIS Coordinator, edits can theoretically be done at any level of the VMap database (MID, BASE, or RAW), using the current attributes but giving it a new release number. For example, editing Forest Mid-level 9.1 would create a release 9.1.1 if that product is edited further before the region has a new release (e.g. 10.1 or 9.2) the edited product would be labeled 9.1.2. The NRGG will work with the Forest GIS coordinators and data stewards to establish editing rules and upward reporting business rules of those updates.

8. Accuracy Assessment

Accuracy assessment for the eastside VMap is being completed currently and will be included in the next release of this document (expected in fall 2009).

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Appendix A: Data Dictionary Release 9.1

VMap Data Dictionary v.9.1

Feature Classes

VMap : MID database

Name	Description	Type	Size	Domain
OBJECTID	Internal ESRI number	Objec-tID	4	
SHAPE	Internal ESRI number	Polygon		
VMAP_MIDID	Unique identifier for the polygon	Text	13	
ACRES	Area of the polygon in acres	Float	4	
LIFEFORM	Dominant lifeform	Text	12	lifeform
DOM_MID_40	Dominance 40% plurality	Text	16	dom_mid_40
DOM_MID_60	Dominance 60% plurality	Text	16	dom_mid_60
DOM6040COM	Dominance group 6040 types from the RAW database that comprise this mid-level polygon	Text	60	
SHRBCANOPY	Shrub canopy cover (for shrub life-form only)	Text	12	shrubcanopy
TREECANOPY	Tree canopy cover class	Text	12	treecanopy
TREESIZE	Tree size class (DBH)	Text	12	treesize
TREESIZCOM	Tree size classes from the RAW database that comprise this mid-level polygon	Text	30	
NONFORLITT	Litter class for non-forest (herb, shrub) lifeforms	Text	12	nonforlitt
ELEV	Average elevation of the polygon in meters	Short	2	
SLOPE	Average percent slope of the poly-gon	Short	2	
ASPCLASS	Dominant aspect class of the poly-gon	Text	8	aspclass
SHAPE_Length	Perimeter of the polygon in meters	Double	8	
SHAPE_Area	Area of the polygon in square me-ters	Double	8	

VMap : RAW database

Name	Description	Type	Size	Domain
OBJECTID	Internal ESRI number	ObjectID	4	
SHAPE	Internal ESRI number	Polygon		
VMAP_RAWID	Unique identifier for the polygon	Text	13	

ACRES	Area of the polygon in acres	Float	4	
LIFEFORM	Dominant lifeform	Text	12	lifeform
DOM_GRP_6040	Dominance group 6040	Text	16	dom_grp_6040
SHRBCANOPY	Shrub canopy cover (for shrub life-form only)	Text	12	shrubcanopy
TREECANOPY	Tree canopy cover class	Text	12	treecanopy
TREESIZE	Tree size class (DBH)	Text	12	treesize
ELEV	Average elevation of the polygon in meters	Short	2	
SLOPE	Average percent slope of the polygon	Short	2	
ASPCLASS	Dominant aspect class of the polygon	Text	8	aspclass
SHAPE_Length	Perimeter of the polygon in meters	Double	8	
SHAPE_Area	Area of the polygon in square meters	Double	8	

VMap : Training Data Feature Class

Name	Description	Type	Size	Domain
OBJECTID	Internal ESRI number	ObjectID	4	
SHAPE	Internal ESRI number	Polygon		
VMAP_RAWID	Unique identifier for the polygon	Text	13	
ACRES	Area of the polygon in acres	Float	4	
LIFEFORM	Dominant lifeform	Text	12	lifeform
DOM_GRP_6040	Dominance group 6040	Text	12	dom_grp_6040
SHRBCANOPY	Shrub canopy cover (for shrub lifeform only)	Text	12	shrubcanopy
TREECANOPY	Tree canopy cover class	Text	12	treecanopy
TREESIZE	Tree size class (DBH)	Text	12	treesize
TRAINTYPE	Collection method	Text	12	traintype
SHAPE_Length	Perimeter of the polygon in meters	Double	8	
SHAPE_Area	Area of the polygon in square meters	Double	8	

VMap - MID : National Data Dictionary Attributes http://fsweb.datamgt.fs.fed.us/documents/current_data_dictionary/vegetation/eveg04s.htm

Name	Type	Size	Domain
OBJECTID	ObjectID	4	
SHAPE	Polygon		
VMAP_MIDID	Text	13	
ECOREGION_DOMAIN	Text	4	ecoregion_domain

ECOREGION_DIVISION	Text	3	ecoregion_division
ECOREGION_PROVINCE	Text	4	ecoregion_province
ECOREGION_SECTION	Text	5	ecoregion_section
ECOREGION_SUBSECTION	Text	6	ecoregion_subsection
USGS_ANDERSON_1	Text	1	usgs_anderson_1
USGS_ANDERSON_2	Text	2	usgs_anderson_2
PHYSIOGNOMIC_DIVISION	Text	1	physiognomic_division
PHYSIOGNOMIC_ORDER	Text	1	physiognomic_order
PHYSIOGNOMIC_CLASS	Text	2	physiognomic_class
PHYSIOGNOMIC_SUBCLASS	Text	2	physiognomic_subclass
TOTAL_VEGETATION_CFA_CLASS	Text	2	total_vegetation_cfa
SAF_COVER_TYPE	Text	3	saf_cover_type
SRM_COVER_TYPE	Text	3	srm_cover_type
AGGREGATION_TYPE	Text	1	aggregation_type
REGIONAL_DOMINANCE_TYPE_1	Text	3	regional_dominance_type
DOMINANCE_TYPE_REFERENCE	Text	5	dominance_type_reference
NVCS_ALLIANCE_1	Text	26	nvcs_alliance
NVCS_ASSOCIATION_1	Text	47	nvcs_association
TREE_CFA_CLASS_1	Text	2	tree_cfa_class
OS_TREE_DIAMETER_CLASS_1	Text	2	os_tree_diameter_class
SHRUB_CFA_CLASS_1	Text	2	shrub_cfa_class
REGIONAL_DOMINANCE_TYPE_2	Text	3	regional_dominance_type
NVCS_ALLIANCE_2	Text	26	nvcs_alliance
NVCS_ASSOCIATION_2	Text	47	nvcs_association
TREE_CFA_CLASS_2	Text	2	tree_cfa_class
OS_TREE_DIAMETER_CLASS_2	Text	2	os_tree_diameter_class
SHRUB_CFA_CLASS_2	Text	2	shrub_cfa_class
REGIONAL_DOMINANCE_TYPE_3	Text	3	regional_dominance_type
NVCS_ALLIANCE_3	Text	26	nvcs_alliance
NVCS_ASSOCIATION_3	Text	47	nvcs_association
TREE_CFA_CLASS_3	Text	2	tree_cfa_class
OS_TREE_DIAMETER_CLASS_3	Text	2	os_tree_diameter_class
SHRUB_CFA_CLASS_3	Text	2	shrub_cfa_class
DATA_SOURCE	Text	5	data_source
SOURCE_DATE	Date		
MAP_UPDATE_CAUSE	Text	2	map_update_cause

Domains

Lifeform : Lifeform

Code	Description
HERB	Herbaceous
SHRUB	Shrubland
SPVEG	Sparsely Vegetated
TREE	Tree
WATER	Water

dom_grp_6040 : Dominance Group 6040

Code	Description
HMIX	Hardwood mix (no single species ≥40% relative cover)
IMIX	Shade-intolerant conifer mix (no single species ≥40% relative cover)
TMIX	Shade-tolerant conifer mix (no single species ≥40% relative cover)
ABGR	Grand fir dominated (≥60% relative cover)
ABGR-HMIX	Grand fir, hardwood mix
ABGR-IMIX	Grand fir, shade-intolerant conifer mix
ABGR-TMIX	Grand fir, shade-tolerant conifer mix
ABLA	Subalpine fir dominated (≥60% relative cover)
ABLA-HMIX	Subalpine fir, hardwood mix
ABLA-IMIX	Subalpine fir, shade-intolerant conifer mix
ABLA-TMIX	Subalpine fir, shade-tolerant conifer mix
BEPA	Paper birch dominated (≥60% relative cover)
BEPA-HMIX	Paper birch, hardwood mix
BEPA-IMIX	Paper birch, shade-intolerant conifer mix
BEPA-TMIX	Paper birch, shade-tolerant conifer mix
CELE3	Mountain mahogany dominated (≥60% relative cover)
CELE3-HMIX	Mountain mahogany, hardwood mix
CELE3-IMIX	Mountain mahogany, shade-intolerant conifer mix
CELE3-TMIX	Mountain mahogany, shade-tolerant conifer mix
FRPE	Green ash dominated (≥60% relative cover)
FRPE-HMIX	Green ash, hardwood mix
FRPE-IMIX	Green ash, shade-intolerant conifer mix
FRPE-TMIX	Green ash, shade-tolerant conifer mix
JUNIP	Juniper dominated (≥60% relative cover)
JUNIP-HMIX	Juniper, hardwood mix
JUNIP-IMIX	Juniper, shade-intolerant conifer mix
JUNIP-TMIX	Juniper, shade-tolerant conifer mix
LALY	Alpine larch dominated (≥60% relative cover)
LALY-HMIX	Alpine larch, hardwood mix
LALY-IMIX	Alpine larch, shade-intolerant conifer mix
LALY-TMIX	Alpine larch, shade-tolerant conifer mix
LAOC	Western larch dominated (≥60% relative cover)
LAOC-HMIX	Western larch, hardwood mix
LAOC-IMIX	Western larch, shade-intolerant conifer mix
LAOC-TMIX	Western larch, shade-tolerant conifer mix
PIAL	Whitebark pine dominated (≥60% relative cover)
PIAL-HMIX	Whitebark pine, hardwood mix
PIAL-IMIX	Whitebark pine, shade-intolerant conifer mix
PIAL-TMIX	Whitebark pine, shade-tolerant conifer mix
PICO	Lodgepole pine dominated (≥60% relative cover)
PICO-HMIX	Lodgepole pine, hardwood mix
PICO-IMIX	Lodgepole pine, shade-intolerant conifer mix
PICO-TMIX	Lodgepole pine, shade-tolerant conifer mix

PIEN	Englemann spruce dominated (≥60% relative cover)
PIEN-HMIX	Englemann spruce, hardwood mix
PIEN-IMIX	Englemann spruce, shade-intolerant conifer mix
PIEN-TMIX	Englemann spruce, shade-tolerant conifer mix
PIFL2	Limber pine dominated (≥60% relative cover)
PIFL2-HMIX	Limber pine, hardwood mix
PIFL2-IMIX	Limber pine, shade-intolerant conifer mix
PIFL2-TMIX	Limber pine, shade-tolerant conifer mix
PIMO3	Western white pine dominated (≥60% relative cover)
PIMO3-HMIX	Western white pine, hardwood mix
PIMO3-IMIX	Western white pine, shade-intolerant conifer mix
PIMO3-TMIX	Western white pine, shade-tolerant conifer mix
PIPO	Ponderosa pine dominated (≥60% relative cover)
PIPO-HMIX	Ponderosa pine, hardwood mix
PIPO-IMIX	Ponderosa pine, shade-intolerant conifer mix
PIPO-TMIX	Ponderosa pine, shade-tolerant conifer mix
POPUL	Cottonwood dominated (≥60% relative cover)
POPUL-HMIX	Cottonwood, hardwood mix
POPUL-IMIX	Cottonwood, shade-intolerant conifer mix
POPUL-TMIX	Cottonwood, shade-tolerant conifer mix
POTR5	Aspen dominated (≥60% relative cover)
POTR5-HMIX	Aspen, hardwood mix
POTR5-IMIX	Aspen, shade-intolerant conifer mix
POTR5-TMIX	Aspen, shade-tolerant conifer mix
PSME	Douglas fir dominated (≥60% relative cover)
PSME-HMIX	Douglas fir, hardwood mix
PSME-IMIX	Douglas fir, shade-intolerant conifer mix
PSME-TMIX	Douglas fir, shade-tolerant conifer mix
TABR2	Pacific yew dominated (≥60% relative cover)
TABR2-HMIX	Pacific yew, hardwood mix
TABR2-IMIX	Pacific yew, shade-intolerant conifer mix
TABR2-TMIX	Pacific yew, shade-tolerant conifer mix
THPL	Western redcedar dominated (≥60% relative cover)
THPL-HMIX	Western redcedar, hardwood mix
THPL-IMIX	Western redcedar, shade-intolerant conifer mix
THPL-TMIX	Western redcedar, shade-tolerant conifer mix
TSHE	Western hemlock dominated (≥60% relative cover)
TSHE-HMIX	Western hemlock, hardwood mix
TSHE-IMIX	Western hemlock, shade-intolerant conifer mix
TSHE-TMIX	Western hemlock, shade-tolerant conifer mix
TSME	Mountain hemlock dominated (≥60% relative cover)
TSME-HMIX	Mountain hemlock, hardwood mix
TSME-IMIX	Mountain hemlock, shade-intolerant conifer mix
TSME-TMIX	Mountain hemlock, shade-tolerant conifer mix

GRASS-DRY	Dry grass
GRASS-BUNCH	Bunchgrass
GRASS-SINGLESTEM	Single-stem grass
GRASS-WET	Wet grass
SHRUB-MESIC	Mesic shrub
SHRUB-XERIC	Xeric shrub
HERB	Herbaceous
SHRUB	Shrub
SPVEG	Sparsely vegetated
TREE	Tree
WATER	Water

dom_mid_60 : Dominance 60% Plurality

CODE	DESCRIPT
HMIX	Hardwood mix (no single species ≥60% relative cover)
IMIX	Shade-intolerant conifer mix (no single species ≥60% relative cover)
TMIX	Shade-tolerant conifer mix (no single species ≥60% relative cover)
ABGR	Grand fir dominated (≥60% relative cover)
ABLA	Subalpine fir dominated (≥60% relative cover)
BEPA	Paper birch dominated (≥60% relative cover)
CELE3	Mountain mahogany dominated (≥60% relative cover)
FRPE	Green ash dominated (≥60% relative cover)
JUNIP	Juniper dominated (≥60% relative cover)
LALY	Alpine larch dominated (≥60% relative cover)
LAOC	Western larch dominated (≥60% relative cover)
PIAL	Whitebark pine dominated (≥60% relative cover)
PICO	Lodgepole pine dominated (≥60% relative cover)
PIEN	Englemann spruce dominated (≥60% relative cover)
PIFL2	Limber pine dominated (≥60% relative cover)
PIMO3	Western white pine dominated (≥60% relative cover)
PIPO	Ponderosa pine dominated (≥60% relative cover)
POPUL	Cottonwood dominated (≥60% relative cover)
POTR5	Aspen dominated (≥60% relative cover)
PSME	Douglas fir dominated (≥60% relative cover)
TABR2	Pacific yew dominated (≥60% relative cover)
THPL	Western redcedar dominated (≥60% relative cover)
TSHE	Western hemlock dominated (≥60% relative cover)
TSME	Mountain hemlock dominated (≥60% relative cover)
GRASS-DRY	Dry grass
GRASS-BUNCH	Bunchgrass
GRASS-SINGLESTEM	Single-stem grass
GRASS-WET	Wet grass
SHRUB-MESIC	Mesic shrub
SHRUB-XERIC	Xeric shrub
HERB	Herbaceous
SHRUB	Shrub
SPVEG	Sparsely vegetated
TREE	Tree
WATER	Water

shrubcanopy : Shrub Canopy Cover Class

Code	Description
XSH 10-24.9%	Xeric shrub canopy cover 10-24.9%
XSH >=25%	Xeric shrub canopy cover ≥ 25%
SHRUB-MESIC	Mesic shrub
SHRUB-XERIC	Xeric shrub
HERB	Herbaceous
SHRUB	Shrub
SPVEG	Sparsely vegetated
TREE	Tree
WATER	Water

treecanopy : Tree Canopy Cover Class

Code	Description
CTR 10-24.9%	CTR 10-24.9%
CTR 25-39.9%	CTR 25-39.9%
CTR 40-59.9%	CTR 40-59.9%
CTR >= 60%	CTR ≥ 60%
DTR 10-39.9%	DTR 10-39.9%
DTR >= 40%	DTR ≥ 40%
TREE-DECID	Deciduous Tree
HERB	Herbaceous
SHRUB	Shrub
SPVEG	Sparsely vegetated
TREE	Tree
WATER	Water

treesize : Tree Size Class

Code	Description
DBH 0-4.9"	Basal area weighted average diameter 0-4.9"
DBH 5-9.9"	Basal area weighted average diameter 5-9.9"
DBH 10-14.9"	Basal area weighted average diameter 10-14.9"
DBH >= 15"	Basal area weighted average diameter ≥ 15"
TREE-DECID	Deciduous tree
HERB	Herbaceous
SHRUB	Shrub
SPVEG	Sparsely vegetated
TREE	Tree
WATER	Water

aspclass : Aspect Class

Code	Description
FLAT	Flat; slope < 5%
N	North; 338-360 & 0-22 degrees
NE	Northeast; 23-68 degrees
E	East; 68-112 degrees
SE	Southeast; 113-157 degrees
S	South; 158-202 degrees
SW	Southwest; 203-247 degrees
W	West; 248-292 degrees
NW	Northwest; 293-337 degrees

nonforlitt : Non-forest Litter Class

Code	Description
LIT < 60%	Litter < 60% in non-forest map units
LIT 60-89.9%	Litter 60-89.9% in non-forest map units
LIT >= 90%	Litter ≥ 90% in non-forest map units

traintype : Data Collection Method

Code	Description

Appendix B: Non-forest (Grass and Shrub) Dominance Type Key

SHRUB DOMINANCE TYPES

Lead	Argument	Code
S1	Relative canopy cover of single most abundant shrub species $\geq$ 60% of shrub canopy cover; If not, go to S2	**NRCS Plants code for shrub species**
S2	Relative canopy cover of two most abundant shrub species $\geq$ 60% of shrub canopy cover, and each individually $\geq$ 20% of relative shrub canopy cover of the shrub cover; If not, go to S3	**Spp1** / **Spp2** OR **Spp1=Spp2** two species with equal cover To assign DT label, use -non-riparian (**Table 1**) or riparian list (**Table 2**) as appropriate. For species other than those in the tables, list in alphabetical order where equal, or by abundance when $\geq$20% difference.
S3	Relative cover of deciduous shrubs is $\geq$ 60%, (deciduous shrub species mix; includes all species not in the evergreen list.) of the shrub cover; If not, go to S4	**SDMX**
S4	Relative cover of evergreen shrubs $\geq$ 60% of the shrub cover, (includes Artemisia spp., Cercocarpus ledifolius, Atriplex confertifolia, Juniperus communis, Juniperus horizontalis, Arctostaphylos uva-ursi. (evergreen shrub species mix) If not, go to S5	**SEMX**
S5	Otherwise (deciduous and evergreen shrub species mix)	**SEDX**

Table 1 Upland and Alpine Shrub List

Note: The order follows Mueggler and Stewart

Rank Order	PLANTS Code		Species Name
1	ARTR	***UPLAND SHRUBS***	*A. tridentata, A. tridentata* ssp. *vaseyana; A. tridentata* ssp. *wyomingensis; A. tridentata* ssp. *tridentata*
2	ARCA13		*Artemisia cana*
3	PUTR		*Purshia tridentata*
4	DAFR6		*Potentilla (Dasisphora) fruticosa*
5	ARAR8		*Artemisia arbuscula; A. nova*
6	ARTR4		*Artemisia tripartita*
7	Rhus		*Rhus trilobata; R. aromatica*
8	CELE3		*Cercocarpus ledifolius*
9	SAVE4		*Sarcobatus vermiculatus*
10	JUCO		*Juniperus communis; J. horizontalis*
11	Erica		*Chrysothamnus Ericameria) viscidiflorus; C. nauseosus*
12	PRVI		*Prunus virginiana*
13	Rosa		*Rosa arkansana R. woodsii*
14	Sympho		*Symphoricarpos. albus, S. occidentale*
15	Vacci		*Vaccinium* sp.*; V. caespitosum; V. myrtillus; V. scoparium; V. globulare*
16	PHMA5		*Physocarpus malvaceus*
17	ARFR4		*Artemisia frigida*
1	CAME7	***ALPINE***	*Cassiope mertensiana*
2	DROC		*Dryas octepetala*
3	PHEM		*Phyllodoce empetriformis*
4	SAAR27		*Salix artica*
5	SAGL		*Salix glauca*
6	SAPL2		*Salix planifolia*
7	SANI8		*Salix nivalis (reticulate)*

LIFE FORM KEY

Argument	Go To
Tree life form ≥ 10% absolute canopy cover	Next line
• Evergreen trees > 60% of total tree canopy cover (includes LAOC and LALY)	T2
• Deciduous trees > 60% of total tree canopy cover (deciduous tree)	T6
• Otherwise (mixed deciduous and evergreen)	T1
Tree life form < 10% and **Shrub life form ≥ 10%** absolute canopy cover	S1
Tree life form <10% and shrub life form <10% and Herbaceous (graminoid/forb) life form ≥ 10% absolute canopy cover, elevation ≥ 8000 feet *(reserved)*	A1
Herbaceous (graminoid/forb) life form ≥ 10% absolute canopy cover, elevation < 8000 feet	H1
Combined canopy cover of trees, shrubs, and herbs ≥ 1% (Sparsely vegetated)	**SVG (done)**
Combined canopy cover of trees, shrubs, and herbs < 1% (Non-vegetated)	**NVG (done)**

Please note: As you work through the shrub and herbaceous keys, you may encounter two situations:

1. **You may have a species which is clearly dominant, but there is no Dominance Type label to assign the plot in your list. Label the DT "Other".**

2. **You have a co-dominant or sub-dominant species that is not included in the Dominance Type list. For example, you would record the DT as ARTRW/Other. In this example, if ARTRW/PUTR is not in the DT list but PUTR is clearly a subdominant species on the plot, use the label "Other".**

HERBACEOUS TYPES

Lead	Argument	Code
H1	Relative graminoid cover ≥ 30% of total absolute herbaceous (forb+gram) cover	**Go to H3**
H2	Relative graminoid cover < 30% of total absolute herbaceous (forb+gram) cover and…	
H2a	Relative cover of single most abundant forb species ≥ 60% of forb cover…or	**NRCS Plants code for forb species**
H2b	Relative cover of low forbs (see list below) is ≥60% of forb cover or…	**MXLF (Table 3 Low Forb)**
H2c	Relative cover of low forbs is < 60% of forb cover	**MXF (Table 3 Low Forb)**
H3	Relative cover of single most abundant graminoid species ≥ 60% of graminoid cover; if not go to H4	**NRCS Plants code for graminoid species**
H4	Relative cover of two most abundant graminoid species ≥ 60% of graminoid cover; if not go to H5	**Spp1** / **Spp2** Two species relative cover values are > 20% apart. **Spp1=Spp2*** Two species relative cover values are ≤ 20% apart. ***Note:** use order listed in Table 4 non-riparian graminoids or Table 5 riparian graminoid list as appropriate. For species other than those in the tables, list in alphabetical order.
H5	Relative cover of two most abundant graminoid species are < 60% of graminoid cover **and ...**	(see **Table 6** graminoid functional list)
H5a	Relative cover of cool season mid graminoid species is ≥ 60% of the graminoid cover, cool season mid graminoid species mix or	**CSMG**.
H5b	Relative cover of cool season short graminoid species ≥ 60% of the graminoid cover, cool season short graminoid species mix or	**CSSG**
H5c	Relative cover of warm season short graminoid species ≥ 60% of the graminoid cover, arm season short graminoid species mix or	**WSSG**
H5d	Relative cover of warm season mid graminoid ≥ 60% of the graminoid cover, warm season mid graminoid species mix or	**WSMG**
H5e	Warm season tall graminoid ≥ 60% of the total graminoid cover, warm season tall graminoid species mix or	**WSTG**
H5f	Otherwise, mixed graminoid.	**MXG**

Table 3 Low Forbs

PLANTS Code	Genus	Species
ACMI2	Achillea	millefolium
ANTEN	Antennaria	all species
ARENA	Arenaria	all species
CERAS	Cerastium	all species
ERIOG	Eriogonum	all species
FRAGA	Fragaria	all species
GETR	Geum	triflorum
PHLOX	Phlox	all species
SEDE2	Selaginella	densa

TABLE 4 Non-Riparian Graminoid Rank Order

Rank Order	PLANTS Code		Species Name	
	Mtn.	Plains		
1	FESC	AGSM	*Festuca scabrella*	*Agropyron smithii*
2	FEID		*F. idahoensis*	
3	AGSM	STCO	*Agropyron smithii*	*Stipa comata*
4	AGSP		*A. spicatum*	
5	DECA18	ANSC10	*Deschampsia caespitosa*	*Androgon scoparium*
6	ANSC10	CALO	*Androgon scoparium*	*Calamovilfa longifolia*
7	STVI4	BOGR2	*Stipa viridula*	*Bouteloua gracilis*
8	STCO4	CAFI	*Stipa comata*	*Carex filifolia*
9	CALO	CAHE5	*Calamovilfa longifolia*	*Carex heliophila*
10	BOGR2	PHPR3	*Bouteloua gracilis*	*Phleum pratense*
11	PHPR3	BRIN2	*Phleum pratense*	*Bromus inermis; B. pumpellianus*
12	BRIN2	AGCR	*Bromus inermis; B. pumpellianus*	*Agropyron cristatum*
13	POPR		*P. compressa and P. pratensis*	
14	ELTR7		*Agropyron caninum, A. dasystachyum; A. trachycaulum*	
15	STIPA		*Stipa richardsonii; S. occidentalis*	
16	BRMA4		*Bromus anomalous; B. ciliatus; B. marginatus; B. porteri; B. vulgaris*	
17	POPR		*Poa* sp. *Except P. compressa and P. pratensis*	
18	BRTE		*Bromus briziformis; B. commutatus; B. japonicus; B. mollis; B. rigidus; B. secalinus; B. tectorum*	

Table 6 Graminoid Functional Group

Group code	Group or Genus	Species Name	Functional Group
AGCR	*Agropyron*	*cristatum*	CSMG
PASM	*Agropyron*	*smithii*	CSMG
ELTR	*Agropyron - group*	*caninum,dasystachyum, trachycaulum,* other *Agropyrons* not listed elsewhere	CSMG
AGROS2	*Agrostis -* group	*exarata, stolonifera, humilis,* other *Agrostis*	CSSG
BOCU	*Bouteloua*	*curtipendula*	WSMG
BOGR	*Bouteloua*	*gracilis*	WSSG
BRIN2	*Bromus*	*inermis*	CSMG
BRTE	*Bromus- ann grp*	*tectorum, japonicus,* other annual *bromes*	CSSG
BRMA4	*Bromus – perenn group*	*carinatus, ciliatus, anomalus, marginatus,* other perennial *Bromes*	CSMG
CACA4	*Calamagrostis*	*canadensis*	Riparian
CARU	*Calamagrostis*	*rubescens*	CSMG
CALO	*Calamovilfa*	*longifolia*	CSMG
CAFI	*Carex*	*filifolia*	CSSG
CAGE2	*Carex*	*geyeri*	CSSG
CAINH2	*Carex*	*heterophylla*	CSSG
CADU6	*Carex-dry group*	*group (C. duriuscula and others)*	CSSG
CANE2	*Carex-wet group*	*group*	CSMG
DAGL	*Dactylis*	*glomerata*	CSMG
DANTH	*Danthonia group*	*intermedia, unispicata, spicatum, californicum*	CSSG
DECA18	*Deschampsia*	*caespitosa*	CSMG
FECA4	*Festuca*	*campestris*	CSMG
FEID	*Festuca*	*idahoensis*	CSMG
JUBA	*Juncus-wet group*	*wet group*	CSMG
JUNCUS	*Juncus – dry grp*	*dry group*	CSSG
KOMA	*Koeleria*	*macrantha*	CSSG
PHPR3	*Phleum*	*pratense*	CSMG
POSE	*Poa* group	*fendleriana, secunda, cusickii, native poas,*	CSSG
POPR	*Poa* exotic	*compressa, pratensis*	CSSG
PSSPS	*Pseudoroegeneria*	*spicata*	CSMG
SCSCS	*Schizachyrium*	*scoparium var. scoparium*	WSMG
HECO26	*Stipa*	*comata*	CSMG
STIV4	*Stipa*	*viridula*	CSMG
STIPA	*Stipa* group	*columbiana, occidentalis, richardsonii, nelsonii, other Stipas*	CSMG
TRISE	*Trisetum* group	*spicatum, wolfii*	CSSG

RELATIVE COVER EXAMPLES

Ecodata Cover Class Codes: 1 (0-1); 3 (1.1-5%), 10 (5.1-15%); 20 (15.1-25), 30 (25.1-35); 40 (35.1-45%); 50 (45.1-55%); 60 (55.1-65%); 70 (65.1-75%); 80 (75.1-85%); 90 (85.1-95%); 98 (95.1-100%)

DOMINANCE TYPE GROUP KEY

(Use with 2008 Eastside Vmap fast plots)

Shrub and herbaceous dominance type groups are analogous to tree dominance type groups for the forested classification. The purpose of a dominance type group classification and key is to reduce the number of dominance types and create broad classes of shrub and herbaceous dominance types for development of existing vegetation map units for mid-level map products. Dominance type groups may serve as a bridge between shrub and herbaceous dominance types and mid-level non-forest map units.

The dominance type group key is intended to be used with Eastside R1Vmap fast plot protocol. For the intensive reference data collection protocol use the shrub and herbaceous dominance type keys. Dominance type groups can be identified either by a top down approach or a bottom up approach. A bottom up approach aggregates shrub or herbaceous dominance types into dominance type groups based on the most abundant (i.e. dominant) species. Preliminary dominance types were evaluated and grouped according to the first named species. Where dominant and co-dominant species were equal in abundance (i.e. had the same absolute canopy cover values) the species priority rules for naming dominance types was followed. A species is considered to have equal abundance if the absolute canopy cover of the two most abundant species is within 10 percent canopy cover of each other. A top down approach considers only the dominant and co-dominant species observed in the field or through photo-interpretation and follows logic similar to the rule used for recording Existing Dominant Layer Species from Ecosystem Inventory and Analysis Guide (7/92), a species must have a minimum of 5 percent canopy cover or greater.

LIFEFORM	Plant Code	Species or Group Identifier	Species or Genera	Other Descriptor
Forb	ACMI2	*Achillea*	*millefolium*	Low forb
Forb	ANTEN	*Antennaria* species	microphylla	Low forb
Forb	ARENA	*Arenaria species*	*all spp.*	Low forb
Forb	ASTRA	*Astragalus* group	*Astragalus miser and A. lentigenous*	
Forb	CERAS	*Cerastium*	*arvense*	Low forb
Forb	ERIOG	*Eriogonum* species	umbellatum	Low forb
Forb	FRAGA	*Fragaria* species	virginiana	Low forb
Forb	GERAN	*Geranium* species		
Forb	GEVI2	*Geranium viscosissimum*		
Forb	GETR	*Geum*	*triflorum*	Low forb
Forb	LUPIN	*Lupinus* species	*sericeus*	
Forb	PHLOX	*Phlox* species	hoodii	Low forb
Forb	SEDE2	*Selaginella*	*densa*	Low forb
Forb	TAOF	*Taraxacum*	*officinale*	Low forb
Forb	TRIFO	*Trifolium* species	all species - repens or pratense (red - big head)	
Graminoid	POPR	*Poa* exotic	*compressa, pratensis*	CSSG
Graminoid	AGCR	*Agropyron*	*cristatum*	CSMG
Graminoid	PASM	*Agropyron (Pascopyrum)*	*smithii*	CSMG
Graminoid	ELTR7	*Agropyron* group (represented by Elymus trachycaulus)	*caninum,dasystachyum, trachycaulum,* other *Agropyrons* not listed elsewhere	CSMG
Graminoid	BOGR	*Bouteloua*	*gracilis*	WSSG
Graminoid	BRIN2	*Bromus*	*inermis*	CSMG
Graminoid	BRTE	*Bromus* annual	*tectorum, japonicus,* other annual *bromes*	CSSG
Graminoid	CACA4	*Calamagrostis*	*canadensis*	Riparian
Graminoid	CALO	*Calamovilfa*	*longifolia*	CSMG
Graminoid	CAFI	*Carex*	*filifolia*	CSSG
Graminoid	CAGE2	*Carex*	*geyeri*	CSSG
Graminoid	CAINH2	*Carex*	*heterophylla*	CSSG
Graminoid	DECA18	*Deschampsia*	*caespitosa*	Riparian
Graminoid	FECA4	*Festuca*	*campestris*	CSMG
Graminoid	FEID	*Festuca*	*idahoensis*	CSMG
Graminoid	KOMA	*Koeleria*	*macrantha*	CSSG
Graminoid	PHPR3	*Phleum*	*pratense*	CSMG
Graminoid	POSE*	*Poa* group	*fendleriana, secunda, cusickii, native poas,*	CSSG
Graminoid	PSSPS	*Pseudoroegneria*	*spicata*	CSMG
Graminoid	SCSCS	*Schizachyrium*	*scoparium var. scoparium*	WSMG
Graminoid	HECO26	*Stipa (Hesperostipa)*	*comata*	CSMG
Graminoid	NASI4	*Stipa (Nassella)*	*viridula*	CSMG

Graminoid	STIPA	*Stipa* group	*columbiana, occidentalis, richardsonii, nelsonii, other Stipas*	CSMG
Noxious Forb	CADR	*Cardaria*	*draba*	
Noxious Forb	CANU4	*Carduus*	*nutans*	
Noxious Forb	CEDI3	*Centaurea*	*diffusa*	
Noxious Forb	CEST8	*Centaurea*	*Maculosa (stoebe ssp. Micranthos)*	
Noxious Forb	ACRE3	*Centaurea (Acroptilon)*	*repens*	
Noxious Forb	CIAR4	*Cirsium*	*arvense*	
Noxious Forb	COAR4	*Convolvulus*	*arvensis*	
Noxious Forb	CYOF	*Cynoglossum*	*officinale*	
Noxious Forb	EUES	*Euphorbia*	*esula*	
Noxious Forb	HIAU	*Hieracium*	*aurantiacum*	
Noxious Forb	HYPE	*Hypericum*	*perforatum*	
Noxious Forb	LEVU	*Leucanthemum*	*vulgare*	
Noxious Forb	LIDA	*Linaria*	*dalmatica*	
Noxious Forb	LIVU2	*Linaria*	*vulgaris*	
Noxious Forb	PORE5	*Potentilla*	*recta*	
Noxious Forb	TAVU	*Tanacetum*	*vulgare*	
Shrub	ARAR8	Artemisia (low)	*arbuscula, nova*	evergreen
Shrub	ARCA13	Artemisia	*cana*	evergreen
Shrub	ARFR4	Artemisia	*frigida*	evergreen
Shrub	ARTRT	Artemisia	*tridentata var tridentata*	evergreen
Shrub	ARTRV	Artemisia	*tridentata var vaseyana*	evergreen
Shrub	ARTRW 8	Artemisia	*tridentata var wyomin-gensis*	evergreen
Shrub	ARTR4	Artemisia	*tripartita*	evergreen
Shrub	CELE3	*Cercocarpus*	*ledifolius*	evergreen
Shrub	GUSA2	*Gutierrezia*	*sarothrae*	deciduous
Shrub	JUCO6	*Juniperus*	*communis*	evergreen
Shrub	JUHO2	*Juniperus*	*horizontalis*	evergreen
Shrub	DAFR6	*Potentilla (Dasiphora)*	*fruticosa*	deciduous
Shrub	PHMA5	*Physocarpus*	*malvaceus*	deciduous
Shrub	PRVI	*Prunus*	*virginiana*	deciduous
Shrub	PUTR2	*Purshia*	*tridentata*	deciduous
Shrub	RHTR	*Rhus*	*trilobata, aromatica*	deciduous
Shrub	SAVE4	*Sarcobatus*	*vermiculatus*	deciduous
Shrub	SYAL	*Symphoricarpos*	*albus*	deciduous
Shrub	SYOC	*Symphoricarpos*	*occidentalis*	deciduous
Shrub	VACCI*	*Vaccinium species*		evergreen
Tree	FRPE	*Fraxinus*	*pennsylvanica*	deciduous
Tree	JUSC2	*Juniperus*	*scopulorum*	evergreen
Tree	PIPO	*Pinus*	*ponderosa*	evergreen

Appendix C: Accessing the Data through the Geospatial Interface

Geospatial Interface

Current Version: 2.5.1 (ArcMap 9.2 sp3 or later and ArcGIS 9.3 sp1) March 2009

What is the Geospatial Interface (GI)?

The Geospatial Interface (GI) is a PC Client ArcMapä extension, a Registration Tool, and an Oracle® Server Database, that provides data connections and user access, and resource data output. The GI helps resource specialists work more efficiently with ArcMap by simplifying data loading and providing custom products to display and output data.

New Release of Version 2.5.1

The new version 2.5.1 of the GI Client and Registration Tool is out and provides bug fixes to version 2.5.0. The new GI will still require all users to login using an eAuthentication account.

GI Client

The GI Client provides an efficient way to:

Use data stored in various places on a local FS site as well as data at other sites.

Find and load spatial data with or without the tabular data already attached. The GI can load one layer at a time or multiple layers together for project or analysis work.

Display spatial data using different symbology based on a layer's data attributes. The map shown below displays the symbology that is shown in the ArcMap Table of Contents.

Run pre-defined queries of attribute data. A result table, from any of these queries, can display the attribute data.

GI Registration (Reg) Tool

The purpose of the GI Registration Tool is to build products and organize content accessed through the GI Client:

Develop independent and interrelated resource products which provide stand alone tabular data outputs, simple or compound maps (including symbology and labeling), and joined tabular and spatial data.

Organize the outputs into both logical connections, and a logical resource hierarchy.

A GI Manager will:

Create a new data content owner and GI Editor to create products for the owner.

A GI Editor will:

Build products for General Users to simplify access to data that is displayed on the GI Client

Set up project data for use in ArcMap,

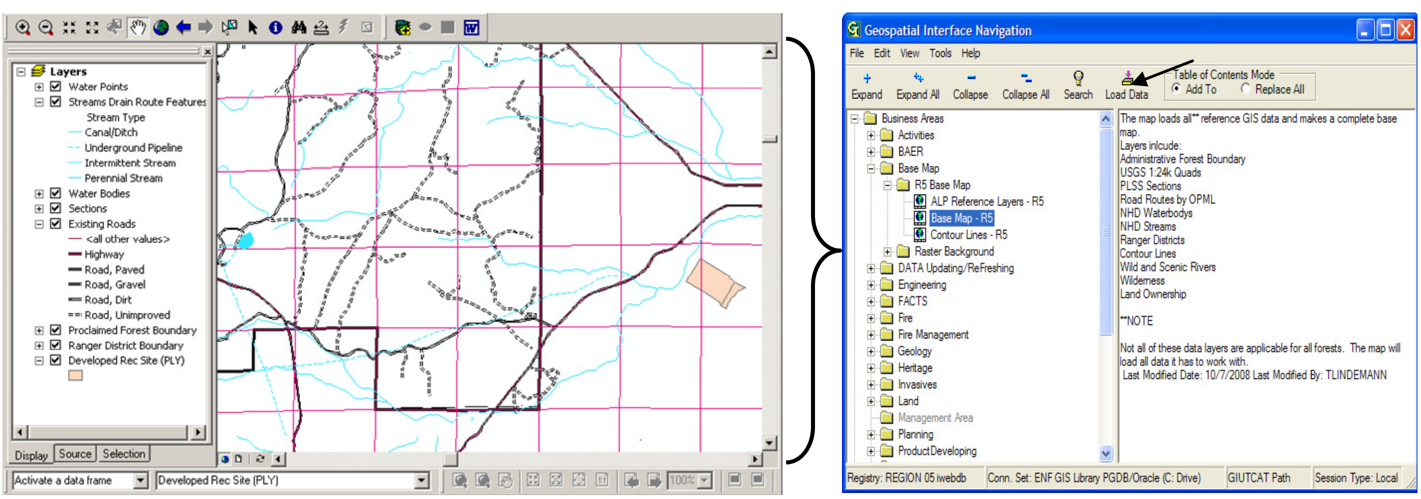
Publish the data for retrieval by others

GI Server

The GI Server is currently installed at FS-NITC. Managers and editors using the GI Registration Tool perform all work on this server. The ArcMap-GI Client user accesses products from the FS-NITCl server.

http://fsweb.gac.fs.fed.us/geoteam/index.html

GI Client ArcMap display with GI navigation window

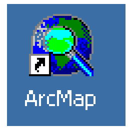


Using the Geospatial Interface

First Install the GI on your PC. Instructions for installing the GI can be found at:

http://fsweb.gac.fs.fed.us/geoteam/v200/install.htm

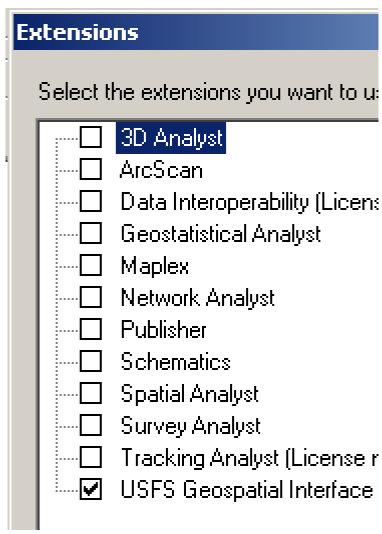
1. Start ArcMap by either double-clicking on the Icon on your desktop:



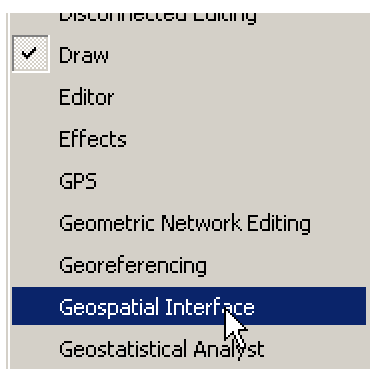
OR

Select **Start/Programs/ArcGIS/ArcMap**

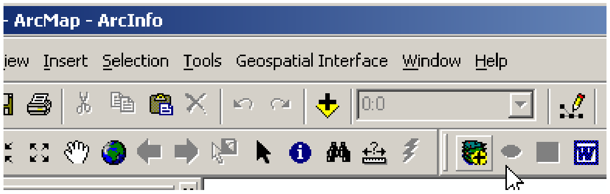
2. Turn on the GI Extension by selecting **Tools à Extensions** and clicking in the box to the left of the Geospatial Interface so a check mark appears.



3. If the Toolbar didn't turn on, turn it on manually by selecting **View à Toolbars** and clicking on **Geospatial Interface**



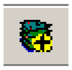
4. Drag and drop the Toolbar anywhere on the ArcMap window.



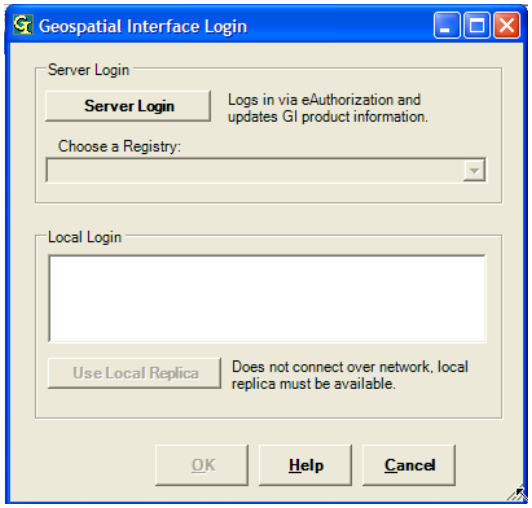
Now the GI is ready to use.

Adding Data Products

1. Click the **Add Data** button

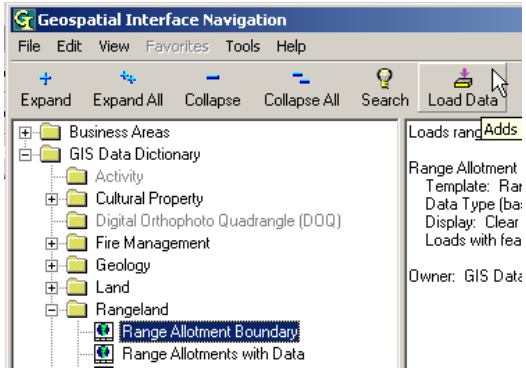


2. **Select Server Login** and choose the appropriate GI Registry for your Region.

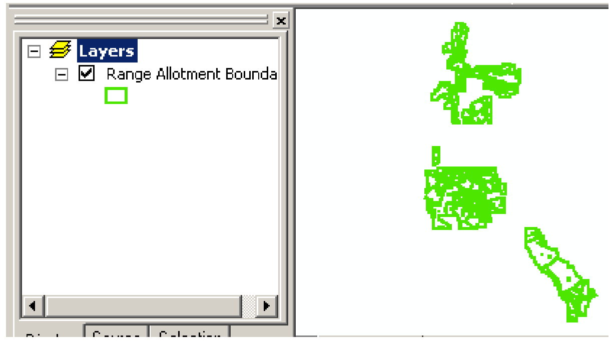


It can take a while to download the initial copy of the Registry to your PC. Once downloaded you can reuse that Registry by selecting that Registry from the list and then clicking on the **Use Local Replica** button. However, you should occasionally get updates of the Registry, so you can see and use any new products that have been added since the last time you copied it to your PC.

3. You should now see the GI Navigation Window



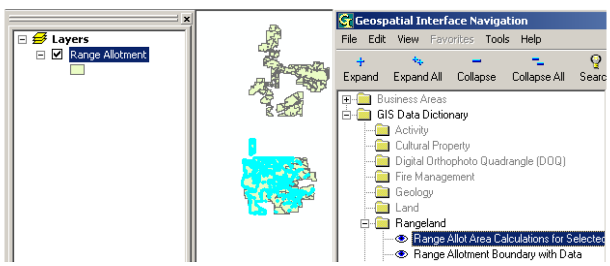
4. To add data to ArcMap, highlight any bold product and click the **Load Data** button or just double-click on the product.



Seeing Other GI Products for an Existing Layer in ArcMap

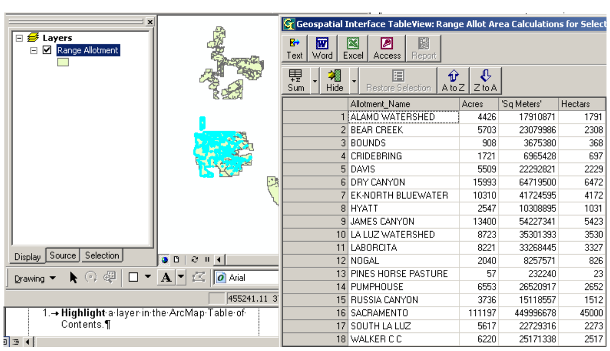
1. **Highlight** a layer in the ArcMap Table of Contents

2. **Click the Show Related Visualizations button** . This is the second button on the GI toolbar.



3. **Double click a product** you want. Below are two examples. The first is a change in how it is displayed, the second is a query on the tabular data:

1 2

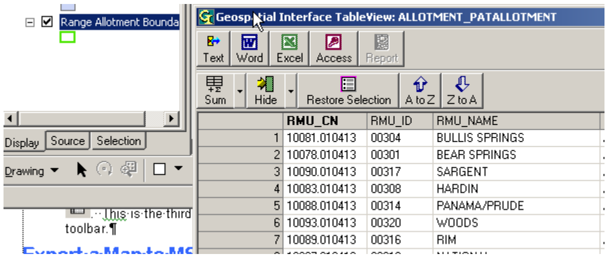


	Allotment_Name	Acres	'Sq Meters'	Hectars
1	ALAMO WATERSHED	4426	17910871	1791
2	BEAR CREEK	5703	23079986	2308
3	BOUNDS	908	3675380	368
4	CRIDEBRING	1721	6965428	697
5	DAVIS	5509	22292821	2229
6	DRY CANYON	15993	64719500	6472
7	EK-NORTH BLUEWATER	10310	41724595	4172
8	HYATT	2547	10308895	1031
9	JAMES CANYON	13400	54227341	5423
10	LA LUZ WATERSHED	8723	35301393	3530
11	LABORCITA	8221	33268445	3327
12	NOGAL	2040	8257571	826
13	PINES HORSE PASTURE	57	232240	23
14	PUMPHOUSE	6553	26520917	2652
15	RUSSIA CANYON	3736	15118557	1512
16	SACRAMENTO	111197	449996678	45000
17	SOUTH LA LUZ	5617	22729316	2273
18	WALKER C C	6220	25171338	2517

Working with Tables

1. **Highlight** a layer in the ArcMap Table of Contents.

2. Click the **GI Tabular Data Viewer** button  . This is the third button on the GI toolbar.



Export a Map to MS Word

1. **Zoom** into the area of the map you want sent to MS Word.

2. **Click the Export Map to Word** button  . This is the fourth button on the GI toolbar.

More Information

The GI Users Guide can be obtained at
http://fsweb.gac.fs.fed.us/geoteam/v200/documents.htm

BASE Helpdesk website,
http://apps.fs.fed.us/base1/tmtrack.dll?

USDA - Forest Service

Website: http://fsweb.gac.fs.fed.us/geoteam

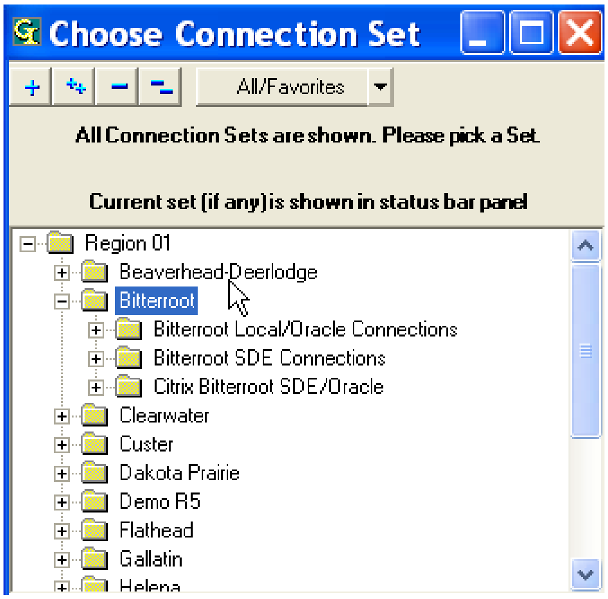
Last Revised:

April 21, 2009

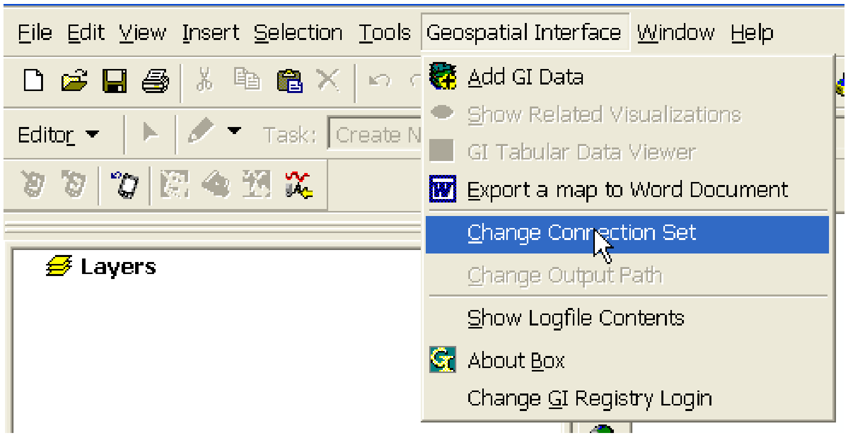
Geospatial Interface Tools for VMap data

A suite of Geospatial Interface (GI) tools have been developed and continue to be developed for the R1-VMap databases. These tools will be installed under each Region 1 Unit's GI Connection Set. Each Unit will likely have 3 Connection Sets available

1. Local PGDB/Oracle: use this connection if your spatial data is stored locally on your C: drive (following Regional or Unit file structures
2. SDE : use this connection when accessing spatial data on your Forest's SDE server
3. Citrix : this connection may be used when Region 1 Units migrate to the Kansas City Data Center but is currently not used at the time of this release.

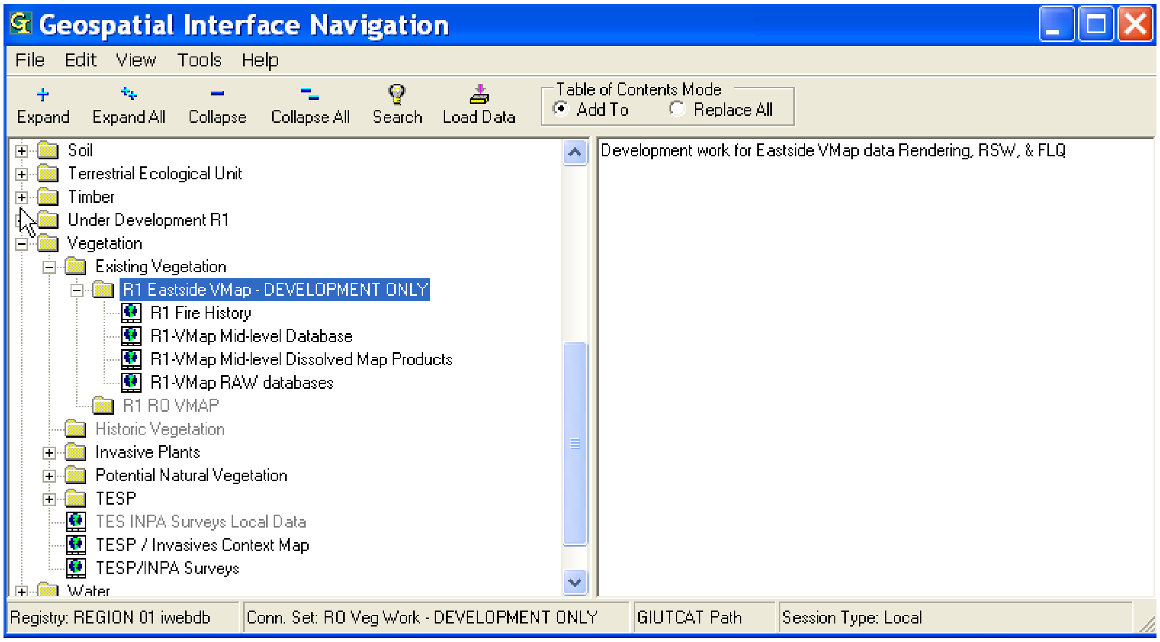


To change connection set, select that option under the Geospatial Interface menu:

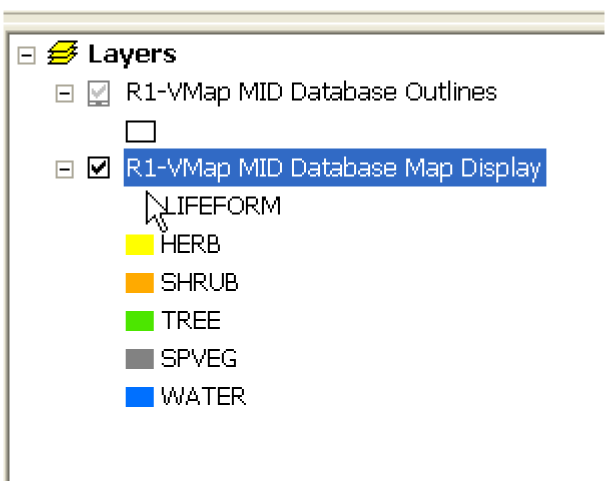


To access VMap tools, first load any of the VMap map products using the GI Get Data button on the GI toolbar:

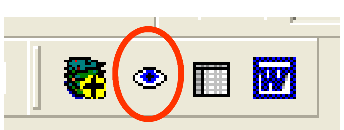
R1-VMap map products are located under the Vegetation//Existing Vegetation file structure in the GI Navigation Tree:



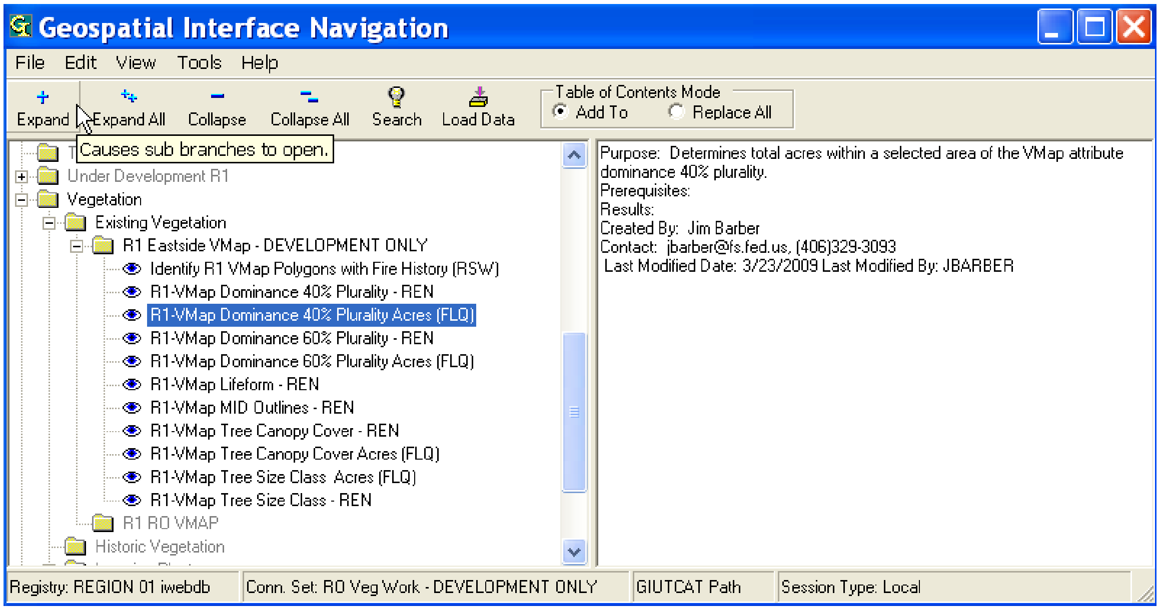
Double click on any product to load it. Once a GI map has loaded, highlight the VMap layer in the Table of Contents:



Select the ‘Show Related Visualizations’ button on the GI toolbar:



Currently available tools are displayed in the GI Navigation Tree:



Each tool should have a description that displays on the right side of the navigation tree when it is highlighted on the left side of the tree. There are generally three types of tools:

1. REN : Renderings of the data, generally these tools just display the data differently
2. FLQ : Feature Linked Queries, which create a summary table from features selected in the ArcMap display
3. RSW : Record Set Writers, which create a new feature class as a result of some spatial operation and load it into the ArcMap table of contents

Appendix D: Image and Ancillary Data Used for Modeling

1. The Landsat TM images (TM bands 1,2,3,4,5, and 7) used in the project for each model are listed in the following table:

Submodel	Landsat imagery			
	September		July	
	date	p-r	date	p-r
m1301	8/20/2005	40-26-27	7/19/2005	40-26-27
m1401	8/20/2005	40-27	7/19/2005	40-27
m1402	8/20/2005	40-27	7/19/2005	40-27
m1501	8/20/2005	40-27	7/19/2005	40-27
m1502	8/20/2005	40-27	7/19/2005	40-27
m1901	9/14/2002	39-27	7/12/2005	39-27
m1902	9/14/2002	39-27-28	7/12/2005	39-27-28
m1903	9/14/2002	39-28	7/12/2005	39-28
m2001	9/14/2002	39-28	7/12/2005	39-28
m2101	9/14/2002	39-28	7/12/2005	39-28
m2701	9/14/2002	39-27	7/12/2005	39-27
m2702	9/14/2002	39-27	7/12/2005	39-27
m2703	9/14/2002	39-27-28	7/12/2005	39-27-28
m2704	9/14/2002	39-28	7/12/2005	39-28
m2801	9/14/2002	39-28	7/12/2005	39-28
m2901		39-28-29	7/12/2005	39-28-29
m2902	9/7/2005	38-29	7/21/2005	38-29
m3001	9/7/2005	38-28-29	7/21/2005	38-28-29
m3101	9/14/2005	39-27	7/21/2005	39-27
m3102	8/6/2005	38-27-28	7/5/2005	38-27-28
m3201	8/6/2005	38-27-28	7/5/2005	38-27-28
m3202	8/6/2005	38-27-28	7/5/2005	38-27-28
m3203	8/6/2005	38-27-28	7/5/2005	38-27-28
m3301	8/6/2005	38-28	7/5/2005	38-28
m3401	9/7/2005	38-28-29	7/21/2005	38-28-29
m3402	9/7/2005	38-28-29	7/21/2005	38-28-29
m3501	9/7/2005	38-28-29	7/21/2005	38-28-29
m3502	8/12/2004	37-29	7/21/2005	38-28-29
m3602	8/12/2004	37-29	7/17/2006	37-29
m3701	9/2/2005	35-28-29	7/6/2007	35-28-29
m3702	9/2/2005	35-28-29	5/22/2005	35-28-29
m3801	8/26/2005	34-28	5/22/2005	34-28
m3802	8/26/2005	34-28	5/22/2006	34-28
m3803	8/26/2005	34-28-29	5/22/2006	34-28-29
m3804	8/26/2005	34-28	5/22/2006	34-28
m3805	8/26/2005	34-28	5/22/2006	34-28

All TM images were orthorectified to the color infrared NAIP imagery used in the project and radiance reflectance corrected.

2. NAIP imagery used in the project are color infrared (IR) digital orthorectified photos of

Montana with the majority of images acquired in summer 2005 and a small portion acquired during summer 2006. The original digital images were then processed to an IR product with a 1 meter ground sample distance (GSD) and rectified to National Mapping Standards at the 1:24,000 scale. Visit http://gisportal.mt.gov/Portal/DiscoveryServlet for complete metadata on this imagery. This imagery was sampled back to 5m using ERDAS Imagine and used for segmentation and image processing where appropriate.

Ancillary Data

1. **10 meter National Elevation Data (NED)—** (received from the Forest Service Remote Sensing Applications Center) were used in eCognition for species modeling and also used to classify portions of the non-forest cover (see 'methodology' section for classes mapped) with the Random Forest tree predictors using Rv2.7.2 (see 'methodology section for useage of Random Forest's in VMap project.

2. **Solar Radiation** — used to model non-forest cover (see methodology for the cover types mapped) and Whitebark pine (Gallatin NF only.) The function is part of ArcGIS Spatial Analyst and is a calculation of how much sun an area receives over a period of time. Since radiation can be greatly affected by topography and surface features, a key com ponent of the calculation algorithm requires generation of an upward looking hemispherical viewshed for every location in a digital elevation model. The input DEM used or this calculation was 30 meter National Elevation Data (did not use 10 meter for computation restrictions) using all default parameters. Time configuration was set to "whole year with monthly intervals" for Year 2005. See http://webhelp.esri.com/arcgisdesktop/9.2/index.cfmTopicName=Area_Solar_Radiation for a more detailed description of this function.

3. **TRASP**—- used to model non-forest cover and Whitebark pine (Gallatin NF.) The circular aspect variable is transformed to a radiation index (TRASP) in this calculation. This transformation assigns a value of zero to land oriented in a north-northeast direction, (typically the coolest and wettest orientation), and a value of one on the hotter, dryer south-southwesterly slopes.The result is a continuous variable between 0 - 1 (Roberts and Cooper 1989).

$$\text{TRASP}= \frac{1 - \cos((\text{pi} / 180)(\text{aspect} - 30))}{2}$$

4. **Slope—-** used to model non-forest cover and Whitebark pine (Gallatin NF) and in eCognition species modeling. Percent Slope calculated from the 10 meter NED data using ERDAS Imagine.

5. **CTI**—-- used to model non-forest and Whitebark pine (Gallatin NF.) CTI is a steady state wetness index. The CTI is a function of both the slope and the upstream contributing a rea per unit width orthigonal to the flow direction. CTI was desigined for hillslope catenas. Accumulation numbers in flat areas will be very large and CTI will not be a relevant variable. CTI is highly correlated with several soil attributes such as horizon

depth(r=0.55), silt percentage(r=0.61), organic matter content(r=0.57), and phosphorus(r=0.53) (Moore et al. 1993).

The implementation of CTI can be shown as:

CTI = ln (As / (tan (beta))

where As = Area Value calculated as (flow accumulation + 1) * (pixel area in m2) and beta is the slope expressed in radians.

6. **Minimum Texture—-** used in eCognition for segmentation of each model and for model ing. The texture image characterizes the spatial homogeneity or heterogeneity of each pixel based on its surrounding neighbors. Minimum texture, developed by Woodcock and Ryherd (1996), calculates a minimum variance from an adaptive window around each pixels as it's measure of the texture. The resulting texture image is a composite of the minimum variance values calculated for each pixel. As shown by Coburn and Rob erts (2004), three bands of image texture can improve classification overall by 13 percent with 4 to 8 percent improvement when compared to use of a single band of texture. The image used to create texture for each of the models was a principal component image of the 1m color infrared NAIP imagery. The texture bands were created using adaptive windows of 5x5, 15X15, and 25X25 and the resultant texture images were then resampled to 5m.

7. **Mean Texture**—- used in eCognition for segmentation and classification of the models. Mean texture was calculated from a 5m principal component of each CIR NAIP image using a mean variance using adaptive windows of 3X3, 5X5, and 9X9.

8. **Tassel Cap Transformations**—-Tassel Cap (TC) was calculated for all the Landsat imagery used in eCognition modeling process . TC is a linear transformation of the reflectance calculated TM data that rotates the data structure such that the majority of the information contained in the 6 bands will occupy 3 dimensions that are directly related to the on-the-ground physical scene characteristics (Kauth and Thomas, 1976.). These dimensions define planes of soils (brightness), vegetation (greenness), and a transitional zone that relates to canopy and soil moisture (wetness). These three dimensions capture 97%+ of the data variation in the 6 TM bands and can enable the discernment of key forest attributes (i.e., species, age, and structure.)

9. **NDVI—**The Normalized Difference Vegetation Index (NDVI) is calculated as the normalized difference between the NIR and the Red bands (NIR - R)/(NIR + R). NDVI was used in the eCognition modeling process. The NDVI is probably the most widely used vegetation index and has been shown to be related to a number of different biomass variables. Simple vegetation indices such as NDVI, however, provide an inadequate representation of complex vegetation cover as they are related only to the total amount of above-ground green leaf biomass, and give no indication of the types of vegetation present. Vegetated areas will generally yield a higher NDVI value than rock, which will have values greater than that of clouds, snow, and water. The 5meter NAIP imagery

was used to calculate NDVI and used in eCognition where applicable. In other cases, NDVI was calculated for the Landsat TM imagery was used in the modeling process.

9. **Principal Component—**used in eCognition modeling. This was calculated using ERDAS Imagine's function to create six bands of principal component. Principal component (PCA) involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal component. The first principle component accounts for as much of the variability in the data as possible. PCA has proven to be of value in analysis of multispectral data (Press et al. 1992.) The transformation of the raw remote sensor data using PCA can result in images more interpretable than the original data.

9. **LTA**—-used as an additional input for modeling some tree species in eCognition. Landtype association (LTA) mapping was done at a scale of 1:100,000 by Forest Soil Scientists using a Regionally consistent legend for dominant groups of landforms and geologic materials occurring in repeatable patterns on National Forest Land. LTA is useful for evaluating biophysical conditions over large landscapes. For more metadata information, visit http://nris.mt.gov/nrcs/soils/lta/metadata.htm#t1