# Geographic Resource Solutions' Land Cover Mapping Capabilities and Technical Approach

For nearly 20 years Geographic Resource Solutions (GRS) has been developing and implementing processes that have been shown to result in detailed, quantitative, and accurate vegetation/land-cover map data sets. GRS has extensive experience in every phase of Land Cover/ Vegetation Mapping Projects and has successfully mapped extremely large (18-million acre) areas of an extremely remote, rugged, and inaccessible nature. GRS undertakes these projects using a team that includes staff with local expertise; these local experts will understand the area, its vegetation and ecology, and complement GRS's staff on this project. GRS's staff have already accomplished many projects, understand this type of work, and can plan, implement, and manage land cover mapping projects, in combination with the acquired local expertise, to fulfill our clients' mapping needs.

The easiest way to demonstrate GRS's mapping capabilities is to show examples of recent GRS mapping efforts of a similar nature. Having seen these results, it is far easier to conceptualize the results we provide and the processes and methodologies that we implement to generate these information products. *Simply stated, GRS does not map vegetation or land cover like any other mapping companies map vegetation*. *GRS maps vegetation cover components and develop data sets, not just maps*. Cover components are discrete estimates of cover, based on field data information collected throughout the project area. The mapping of these discrete estimates is why GRS's image processing methodology is referred to as "Discrete Classification Mapping Methodology" (DCMM). The discrete estimates we develop enable the user of the information to generate names of types simply by processing the vegetation cover components with the appropriate set of rules (a dichotomous key) to assign class or type names to the different combinations of components that have been mapped into different polygons. One tremendous advantage of this approach is that the database contains both the type designation(s) as well as the discrete estimates of cover (type) components, so the map user can process and map cover components as well as type information.

Figures 1 and 2 illustrate the difference between mapping vegetation types and mapping components. Figure 1 shows a map of all Shrub Type Alliances for a portion of Lassen Volcanic National Park (LAVO), based on our nearly completed efforts mapping this park. These Shrub Types are different shades of red, based on the estimated density of the shrub cover in the Shrub Types. From this map it looks, in general, as though the Shrubs Types are fragmented and shrub cover is not very abundant. However, for every polygon in the map GRS has estimated the amount of shrub cover present (the shrub cover component). Cover estimates are generated in total and for each major shrub species. Figure 2 represents a map of shrub cover regardless of whether the polygon is classed or categorized as a Shrub Alliance. Figure 2 illustrates that there is far more shrub cover present in non-shrub types like Tree Types than there is in Shrub Types. By mapping components, GRS can assign categorical values, like the National Vegetation Classification System (NVCS) types used in the LAVO Mapping Project, based on an evaluation of the relative magnitude of the cover components that are present in any given polygon in the map data base. This process is the same as when a Field Botanist visits an Accuracy Assessment site, estimates the cover by species, and assigns an NVCS type call to the site based on the NVCS type key that has been developed for the project. In addition, GRS estimates discrete cover values, not classes. In other words, total shrub cover might be estimated at 45.9% or 13.5% or some other discrete estimate. Assignment of density classes is simply a matter of applying an SQL update statement based on the discrete estimates, or as simple as defining a new legend in ArcGIS.

Figure 1: Lassen Volcanic National Park Classification Map Results - Shrub Type Cover

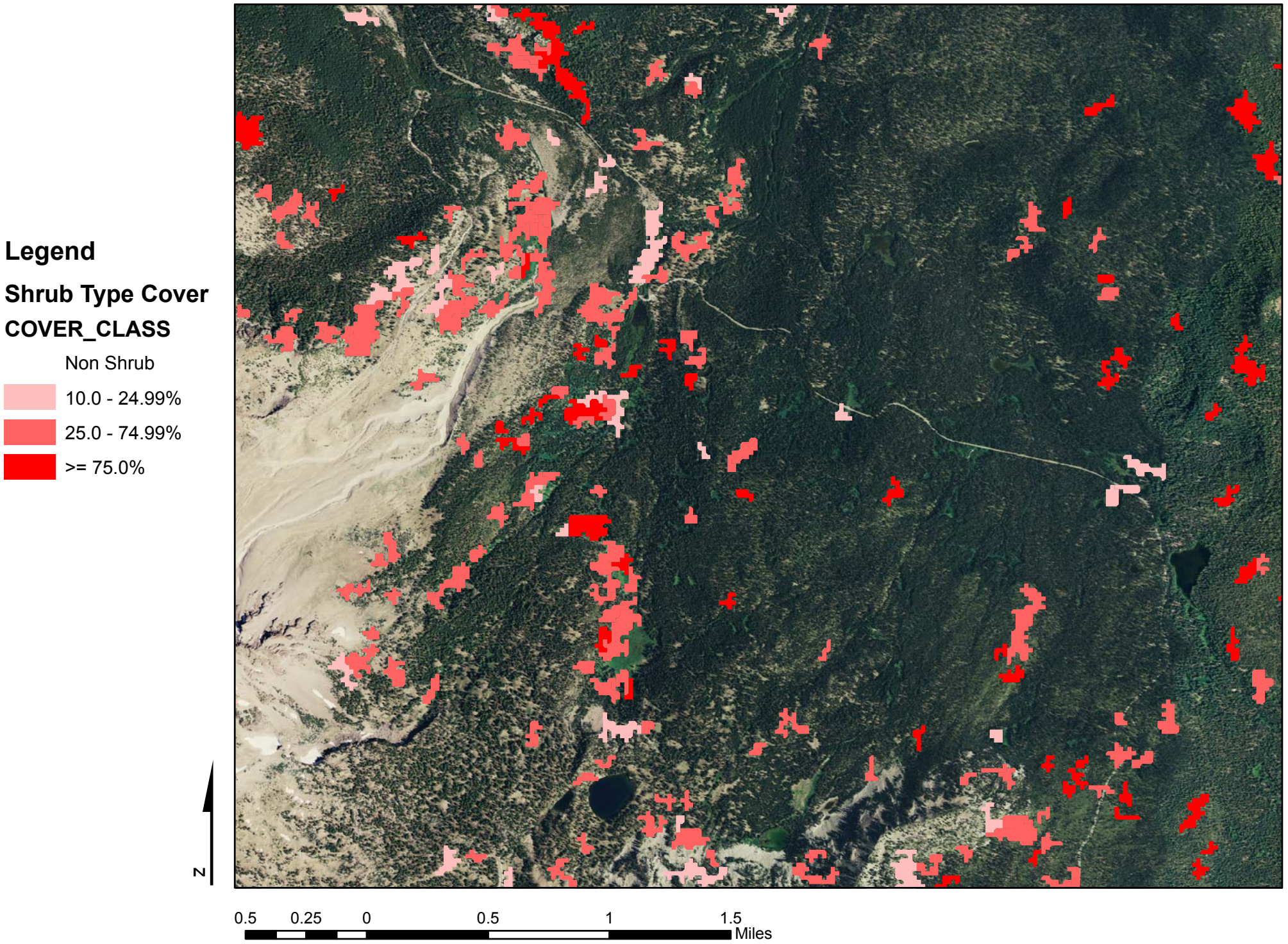
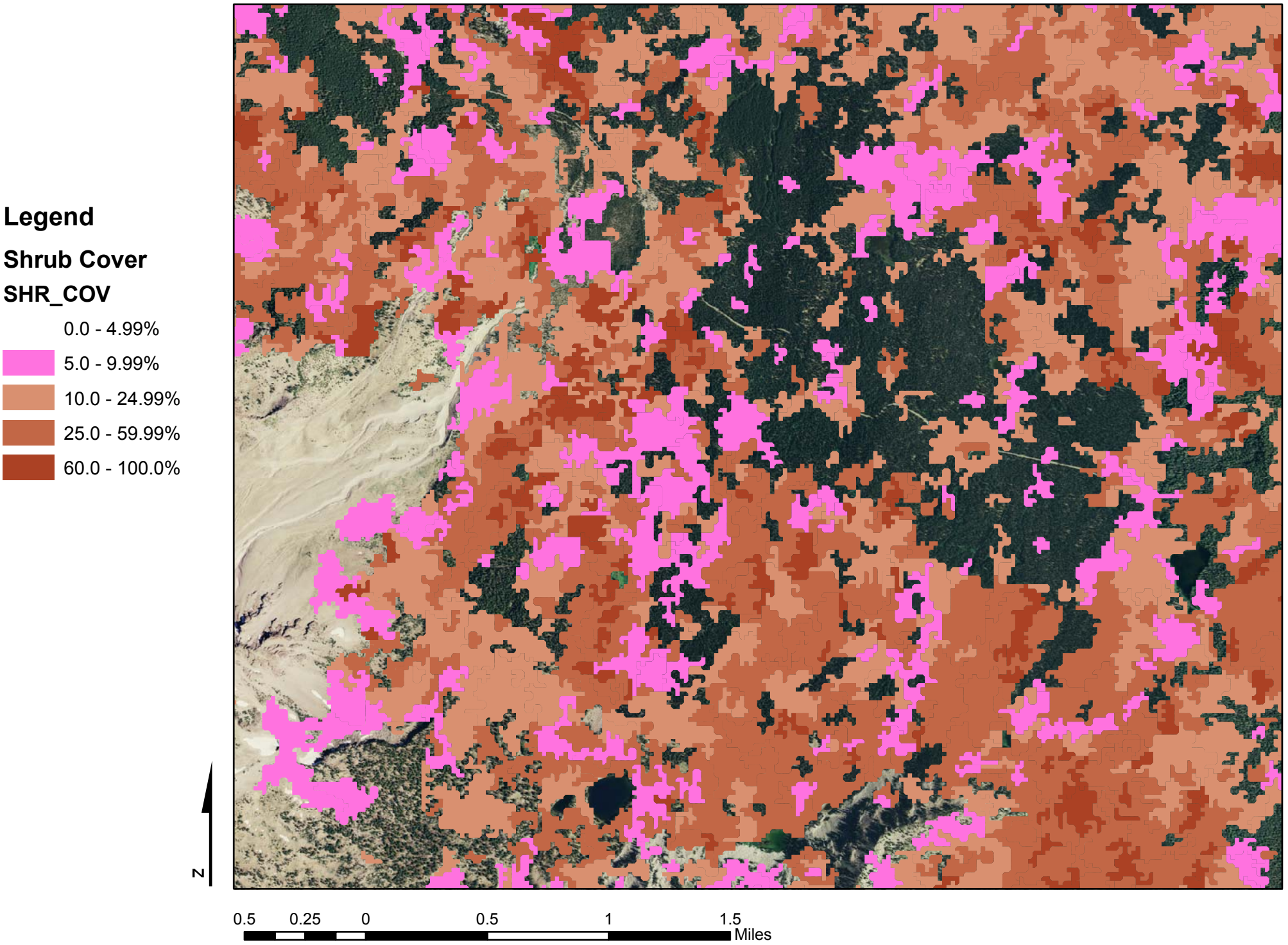


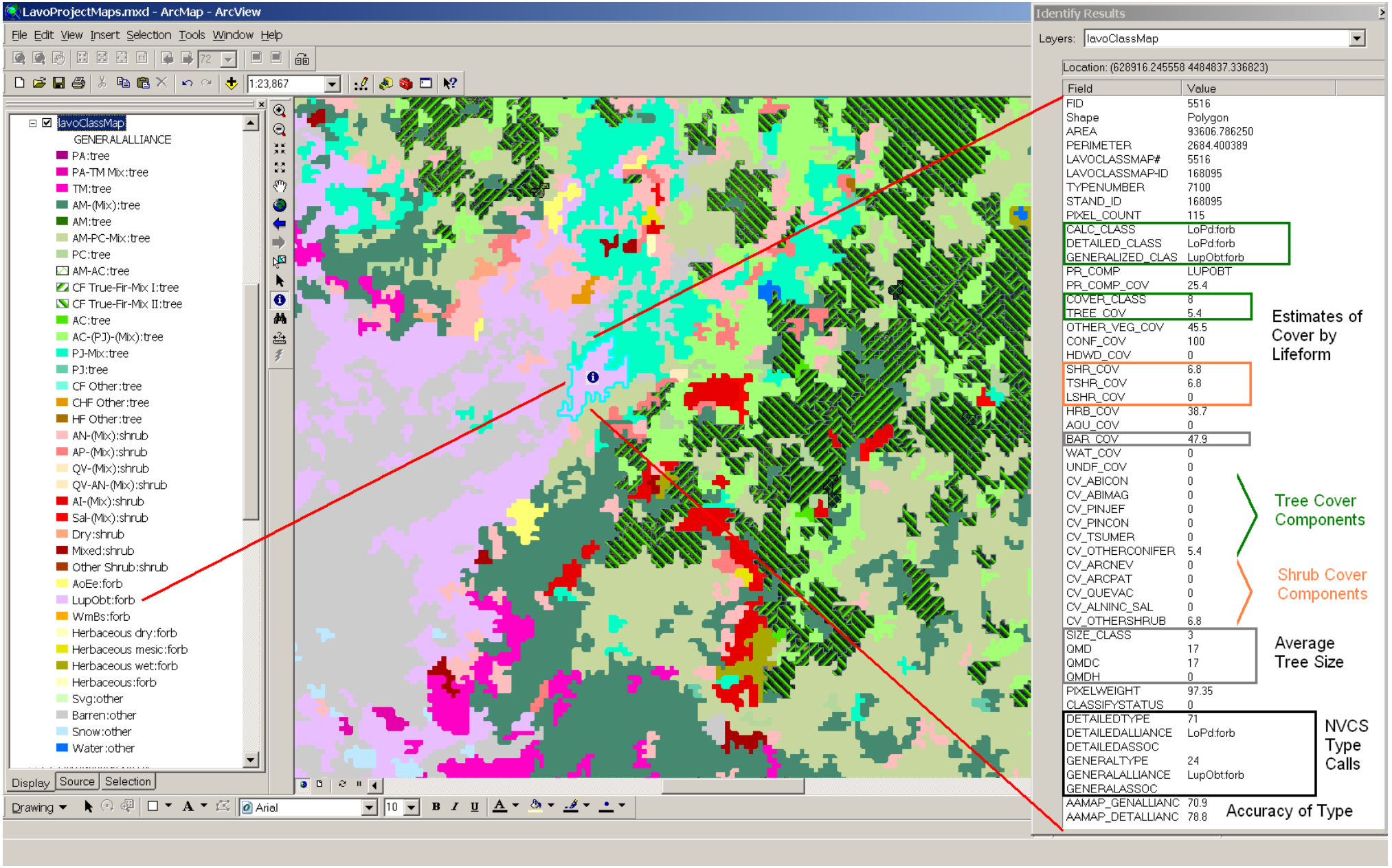
Figure 2: Lassen Volcanic National Park Classification Map Results - Shrub Cover



Figures 3 and 4 further illustrate major differences between vegetation mapping data sets developed by GRS and the more generalized categorical mapping database asked for in many solicitations we review. Resource managers often request a data set where each polygon has NVCS Alliance (Level 7) or Association (Level 8) type designations, as well as upper level information for Formation (Level 3) through Group (Level 6). In each of these figures the ArcGIS legend contains the NVCS Alliances used during the project to produce maps of LAVO. In Figure 3 the highlighted type is a LupObt:forb Alliance, whereas in Figure 4 the highlighted type is a Coniferous Forest True-Fir Mixed I:tree Alliance. These map legends represent a simplified or somewhat "Generalized" approach to the National Vegetation Classification System (NVCS) alliances that were used to map LAVO, as well as to group somewhat similar more "Detailed" Alliances that were tested as a class during the Accuracy Assessment (the 95 "Detailed" Alliances develop in the map were far too many classes for the Accuracy Assessment and consequently some of them were grouped together for the Accuracy Assessment). However, while the names of the types have been generalized, a review of the database information listed for each of these highlighted polygons reflects that an abundance of information has been estimated for each polygon. These additional items of information are based on GRS's analysis of the pixel data mapped using GRS's image classification methodology. Not only are there "Detailed" NVCS Alliance and Association calls, but there are also the calculated type calls based on GRS's software. Estimation of the predominant cover component and its corresponding cover in each polygon is also included. In addition, there are cover estimates for the different major lifeforms (tree, conifer, hardwood, shrub, tall shrub, low shrub, herbaceous plant, non-plant, and so forth) present in each polygon, as well as cover estimates for significant species (*Abies concolor, Abies magnifica, Pinus Jeffreyii, Pinus contorta, Tsuga mertensiana, Arctostaphylos nevadensis, Quercus vaccinifolia*, and so forth) as identified by the user (LAVO). The additional data items also include estimates of average tree size (conifer and hardwood), fine and coarse woody debris counts by decay class, and the accuracy of each individual mapped class. There are also data items that estimate the predominant component of each type and its corresponding cover. There is a wealth of data contained in each polygon's record.

Figure 5 shows one of the preliminary LAVO Project maps that displays map accuracy by type. This is easily accomplished using the accuracy data stored in the attributes of each polygon. Many additional maps may be created simply by creating new legends on the different data items. For example, cover of an individual species like *Abies concolor* or *Abies magnifica* can be mapped as shown in Figures 6 and 7. Figure 8 is a map of Tree Cover Density estimates, while Figure 9 is a map of Tree Size Class estimates. As already mentioned, class values are assigned based on the values of the discrete estimates. What should be readily apparent is that GRS's ability to estimate species cover components and tree sizes as discrete estimates enables the map user to assign or change class definitions and values at any time simply by applying those new definitions as either SQL update statements or as ArcGIS legend class definitions.

Such discrete data estimates are extremely useful in inventory and monitoring applications, modeling applications, and even fire fuel class mapping, as the individual polygon information may be used to crosswalk polygons to fire fuel classes. Even better, when fire fuels data have been collected at field sites, fire fuels data can be summarized and included as additional attributes in the map table, so that the vegetation and fire fuels data may be used to generate fuel class maps. This type of mapping by GRS, at no additional cost, is illustrated in Figure 10. In addition, data may be processed as raster or vector data sets. The strength of GRS's approach is that it is driven by data collected on the ground (ground truth); it uses and preserves that data through the remote sensing/image processing applications, thereby enabling the development and estimation of the discrete estimates you see in the resulting map data sets.


LavoProjectMaps.mxd - ArcMap - ArcView
File Edit View Insert Selection Tools Window Help
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lavoClassMap
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PA:tree
PA-TM Mix:tree
TM:tree
AM-(Mix):tree
AM:tree
AM-PC-Mix:tree
PC:tree
AM-AC:tree
CF True-Fir-Mix I:tree
CF True-Fir-Mix II:tree
AC:tree
AC-(PJ)-(Mix):tree
PJ-Mix:tree
PJ:tree
CF Other:tree
CHF Other:tree
HF Other:tree
AN-(Mix):shrub
AP-(Mix):shrub
QV-(Mix):shrub
QV-AN-(Mix):shrub
AI-(Mix):shrub
Sal-(Mix):shrub
Dry:shrub
Mixed:shrub
Other Shrub:shrub
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LupObt:forb
WmBs:forb
Herbaceous dry:forb
Herbaceous mesic:forb
Herbaceous wet:forb
Herbaceous:forb
Svg:other
Barren:other
Snow:other
Water:other
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Arial
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Shape Polygon
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PERIMETER 2684.400389
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LAVOCLASSMAP-ID 168095
TYPENUMBER 7100
STAND_ID 168095
PIXEL_COUNT 115
CALC_CLASS LoPd:forb
DETAILED_CLASS LoPd:forb
GENERALIZED_CLAS LupObt:forb
PR_COMP LUPOBT
PR_COMP_COV 25.4
COVER_CLASS 8
TREE_COV 5.4
OTHER_VEG_COV 45.5
CONF_COV 100
HDWD_COV 0
SHR_COV 6.8
TSHR_COV 6.8
LSHR_COV 0
HRB_COV 38.7
AQU_COV 0
BAR_COV 47.9
WAT_COV 0
UNDF_COV 0
CV_ABICON 0
CV_ABIMAG 0
CV_PINJEF 0
CV_PINCON 0
CV_TSUMER 0
CV_OTHERCONIFER 5.4
CV_ARCNEV 0
CV_ARCPAT 0
CV_QUEVAC 0
CV_ALNINC_SAL 0
CV_OTHERSHRUB 6.8
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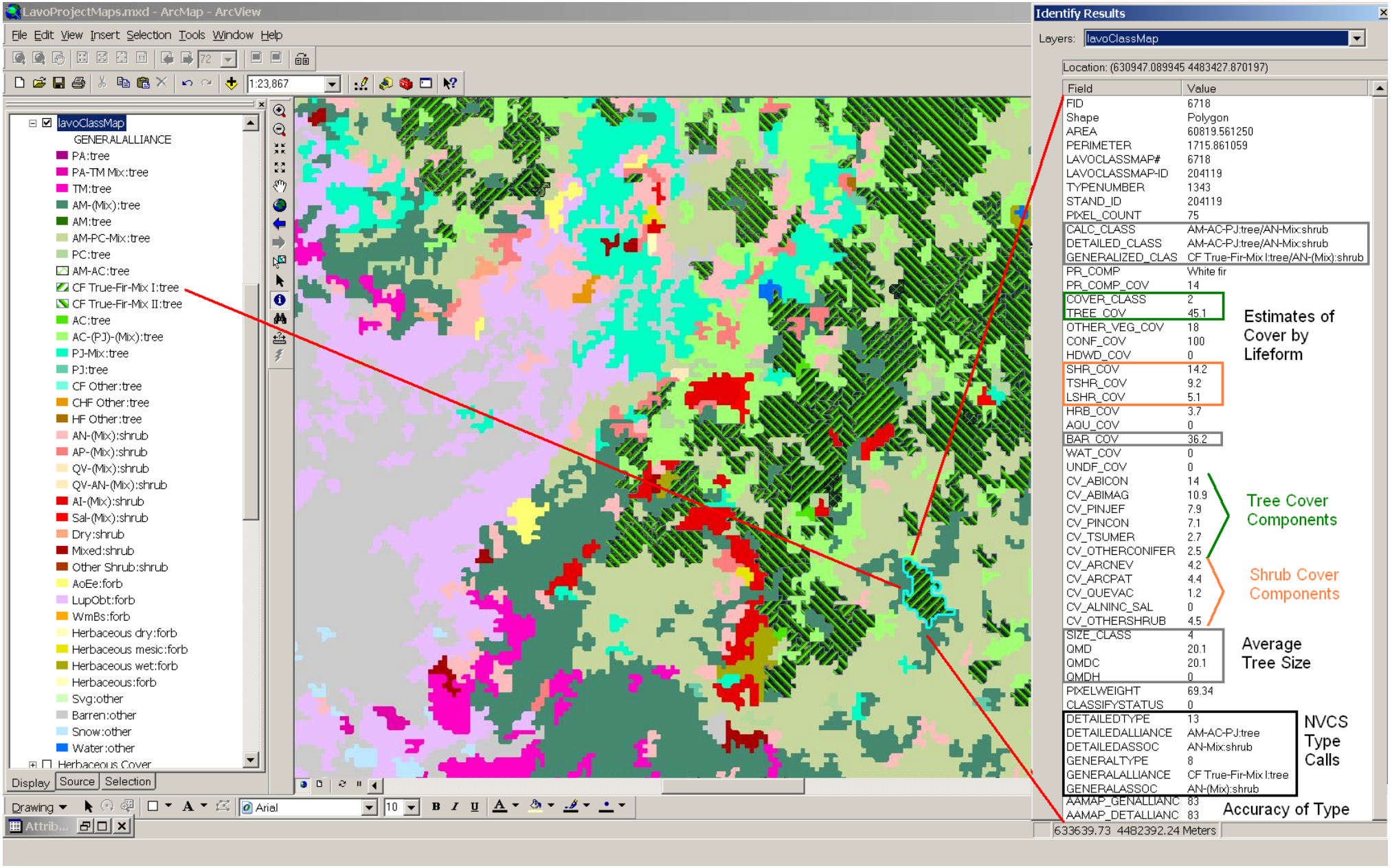
QMD 17
QMDC 17
QMDH 0
PIXELWEIGHT 97.35
CLASSIFYSTATUS 0
DETAILEDTYPE 71
DETAILEDALLIANCE LoPd:forb
DETAILEDASSOC
GENERALTYPE 24
GENERALALLIANCE LupObt:forb
GENERALASSOC
AAMAP_GENALLIANC 70.9
AAMAP_DETALLIANC 78.8
Estimates of Cover by Lifeform
Tree Cover Components
Shrub Cover Components
Average Tree Size
NVCS Type Calls
Accuracy of Type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GENERALALLIANCE
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AM-(Mix):tree
AM:tree
AM-PC-Mix:tree
PC:tree
AM-AC:tree
CF True-Fir-Mix I:tree
CF True-Fir-Mix II:tree
AC:tree
AC-(PJ)-(Mix):tree
PJ-Mix:tree
PJ:tree
CF Other:tree
CHF Other:tree
HF Other:tree
AN-(Mix):shrub
AP-(Mix):shrub
QV-(Mix):shrub
QV-AN-(Mix):shrub
AI-(Mix):shrub
Sal-(Mix):shrub
Dry:shrub
Mixed:shrub
Other Shrub:shrub
AoEe:forb
LupObt:forb
WmBs:forb
Herbaceous dry:forb
Herbaceous mesic:forb
Herbaceous wet:forb
Herbaceous:forb
Svg:other
Barren:other
Snow:other
Water:other
Herbaceous Cover
Display Source Selection
Drawing
Arial
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Attrib...
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Shape Polygon
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PERIMETER 1715.861059
LAVOCLASSMAP# 6718
LAVOCLASSMAP-ID 204119
TYPENUMBER 1343
STAND_ID 204119
PIXEL_COUNT 75
CALC_CLASS AM-AC-PJ:tree/AN-Mix:shrub
DETAILED_CLASS AM-AC-PJ:tree/AN-Mix:shrub
GENERALIZED_CLAS CF True-Fir-Mix I:tree/AN-(Mix):shrub
PR_COMP White fir
PR_COMP_COV 14
COVER_CLASS 2
TREE_COV 45.1
Estimates of Cover by Lifeform
OTHER_VEG_COV 18
CONF_COV 100
HDWD_COV 0
SHR_COV 14.2
TSHR_COV 9.2
LSHR_COV 5.1
HRB_COV 3.7
AQU_COV 0
BAR_COV 36.2
WAT_COV 0
UNDF_COV 0
CV_ABICON 14
CV_ABIMAG 10.9
CV_PINJEF 7.9
CV_PINCON 7.1
CV_TSUMER 2.7
CV_OTHERCONIFER 2.5
Tree Cover Components
CV_ARCNEV 4.2
CV_ARCPAT 4.4
CV_QUEVAC 1.2
CV_ALNINC_SAL 0
CV_OTHERSHRUB 4.5
Shrub Cover Components
SIZE_CLASS 4
QMD 20.1
QMDC 20.1
QMDH 0
Average Tree Size
PIXELWEIGHT 69.34
CLASSIFYSTATUS 0
DETAILEDTYPE 13
DETAILEDALLIANCE AM-AC-PJ:tree
DETAILEDASSOC AN-Mix:shrub
GENERALTYPE 8
GENERALALLIANCE CF True-Fir-Mix I:tree
GENERALASSOC AN-(Mix):shrub
NVCS Type Calls
AAMAP_GENALLIANC 83
AAMAP_DETALLIANC 83
Accuracy of Type
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# Figure 5: Lassen Volcanic National Park Classification Map Results

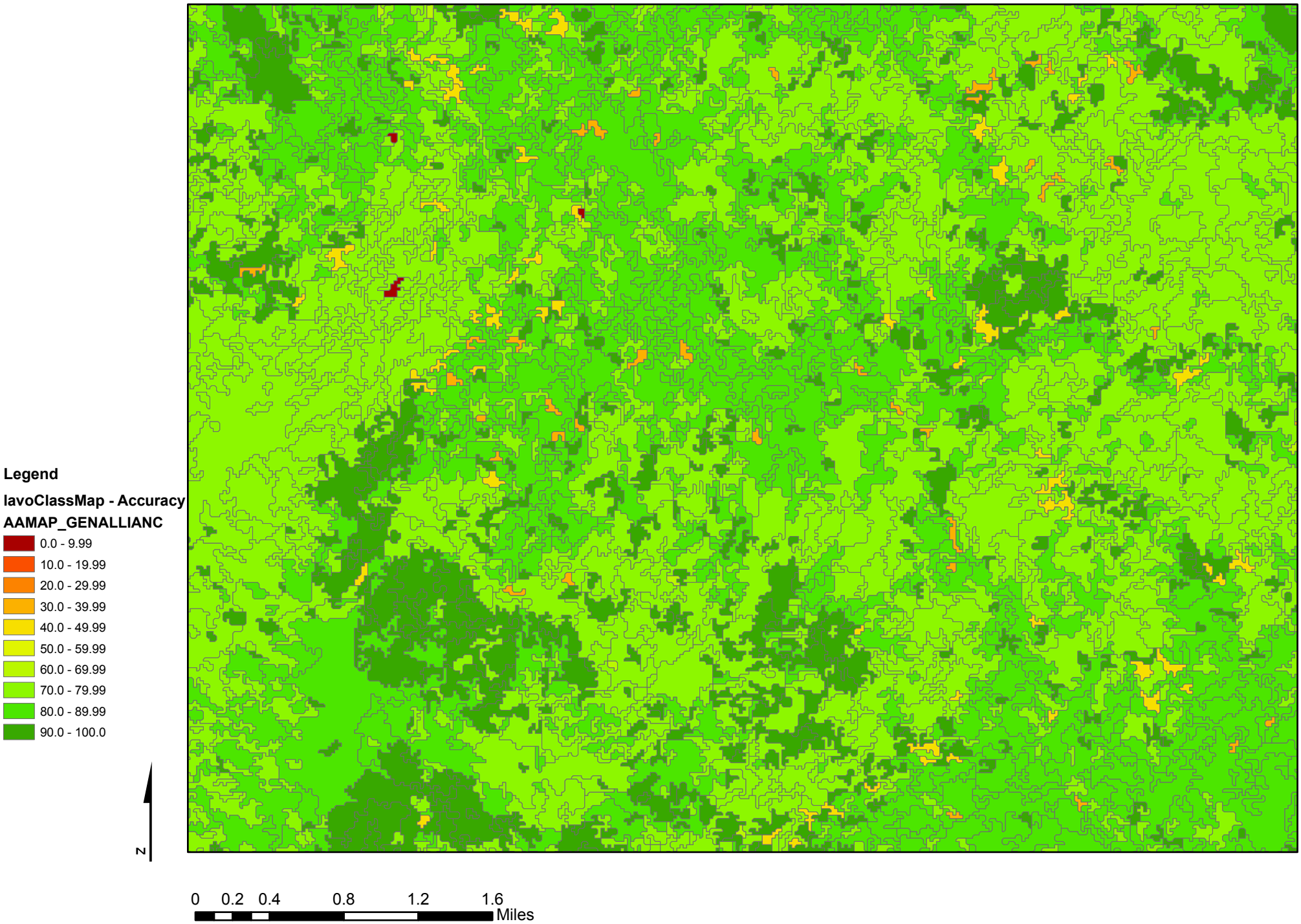


Figure 6: Lassen Volcanic National Park Classification Map Results - Abies Concolor Cover

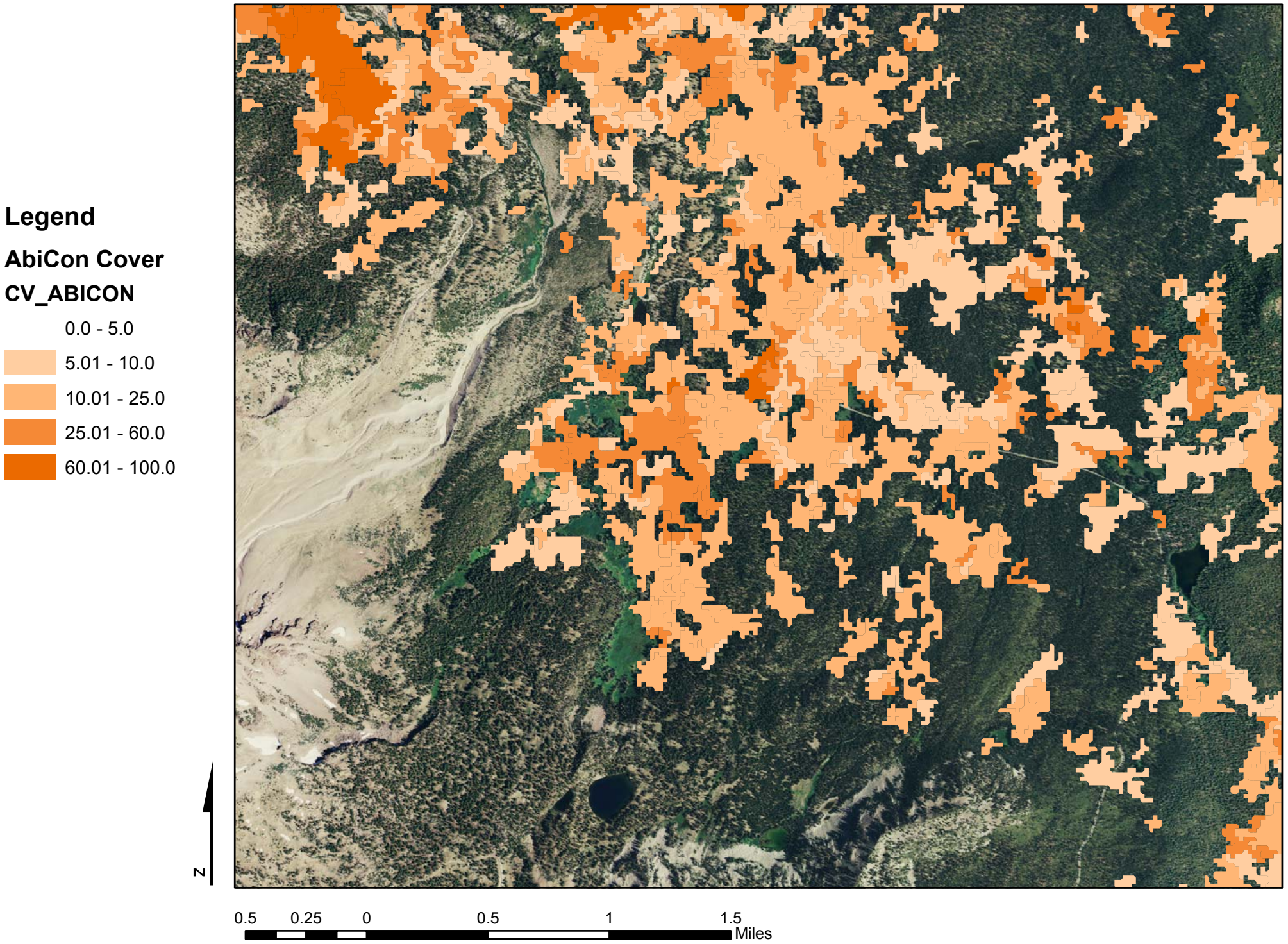


Figure 7: Lassen Volcanic National Park Classification Map Results - Abies Magnifica Cover

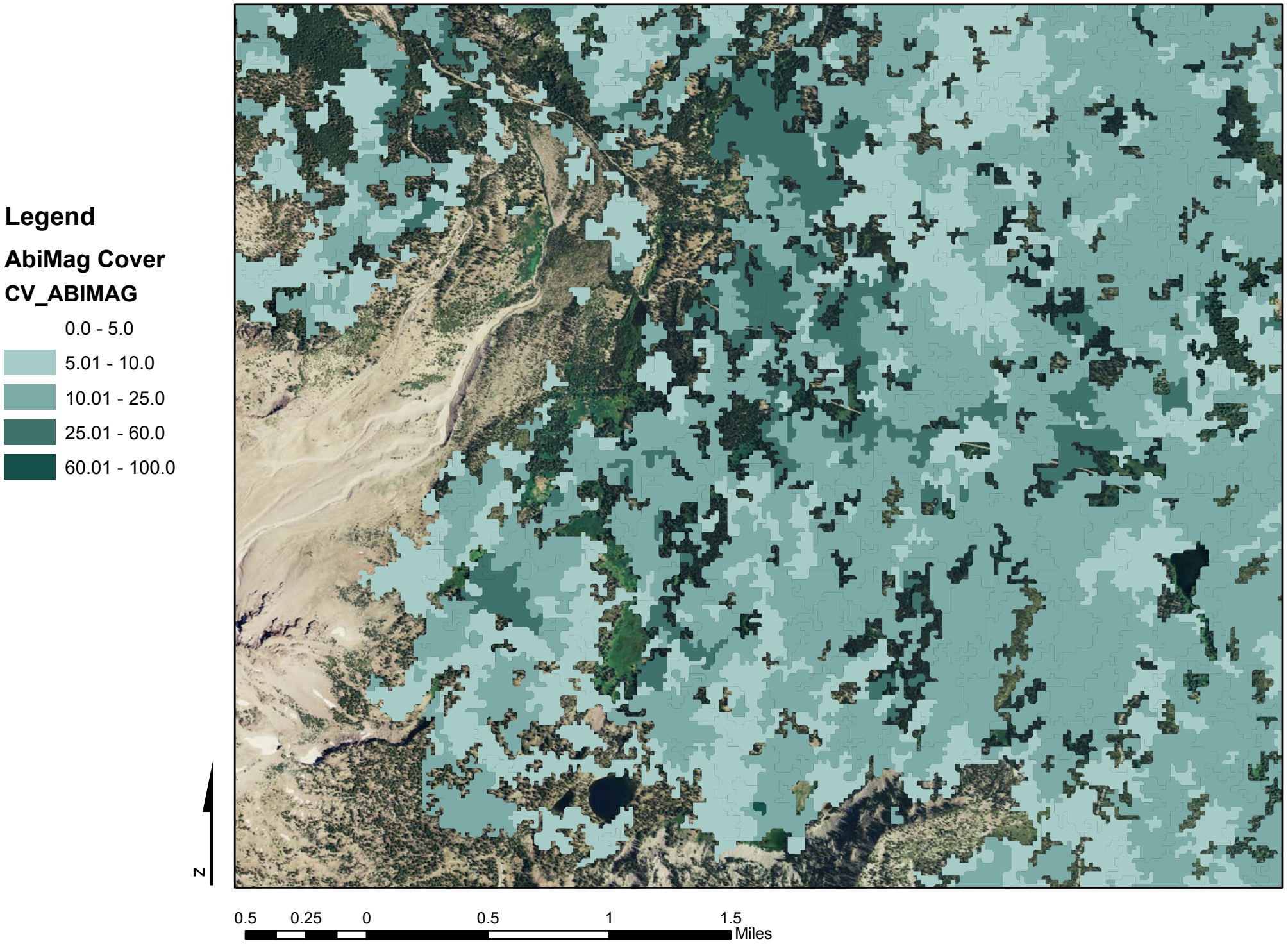


Figure 8: Lassen Volcanic National Park Classification Map Results - Tree Cover

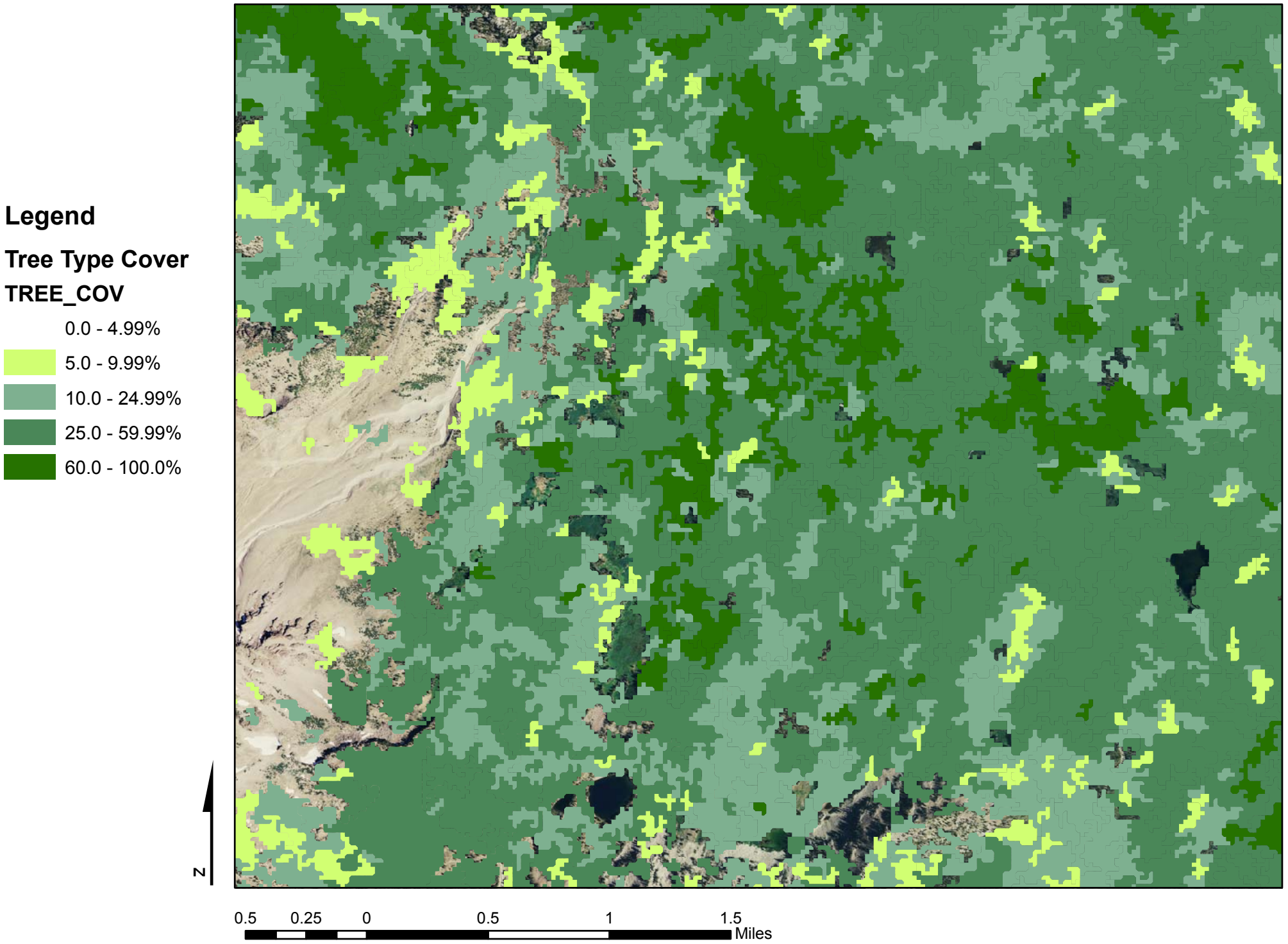
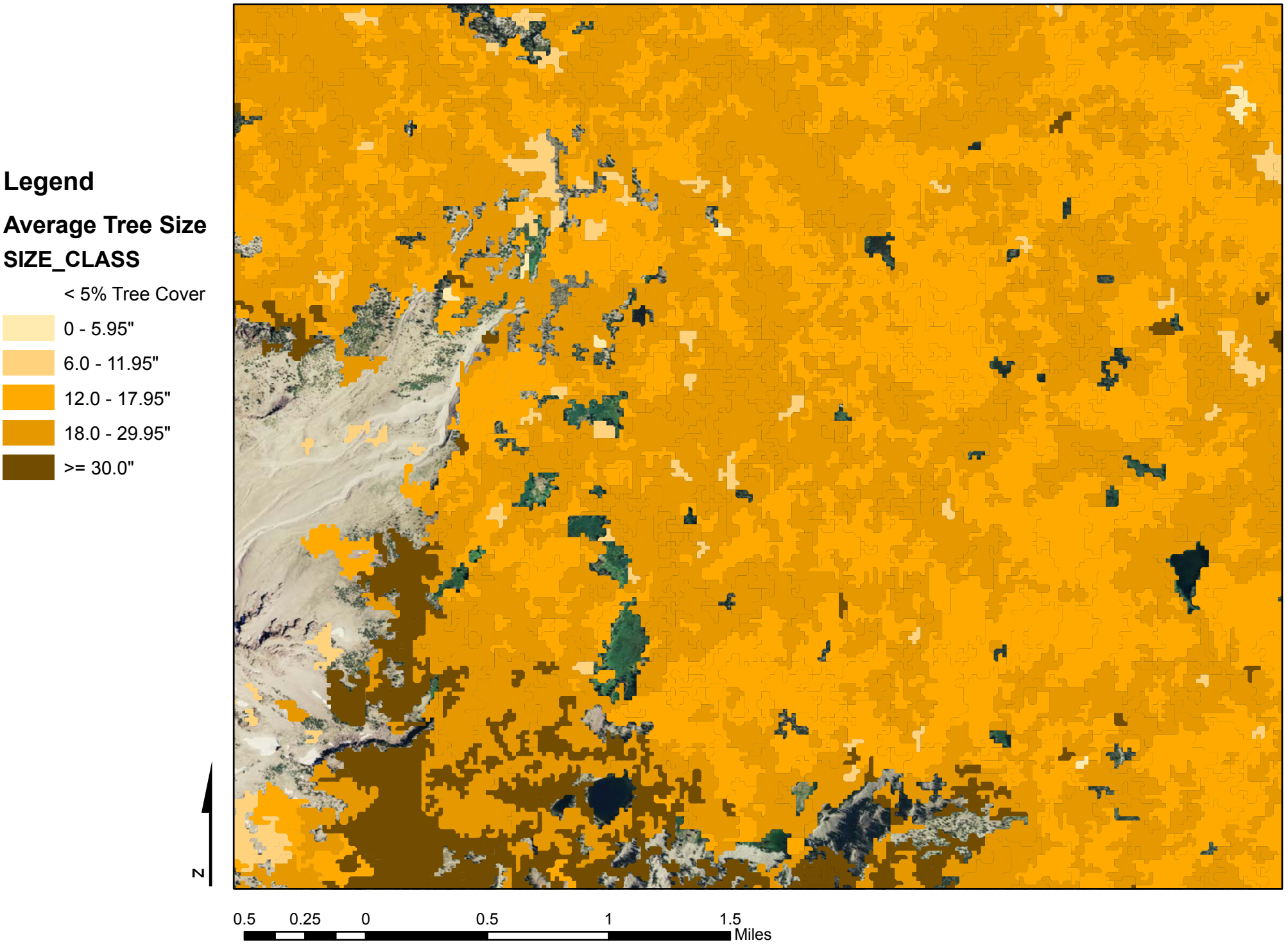
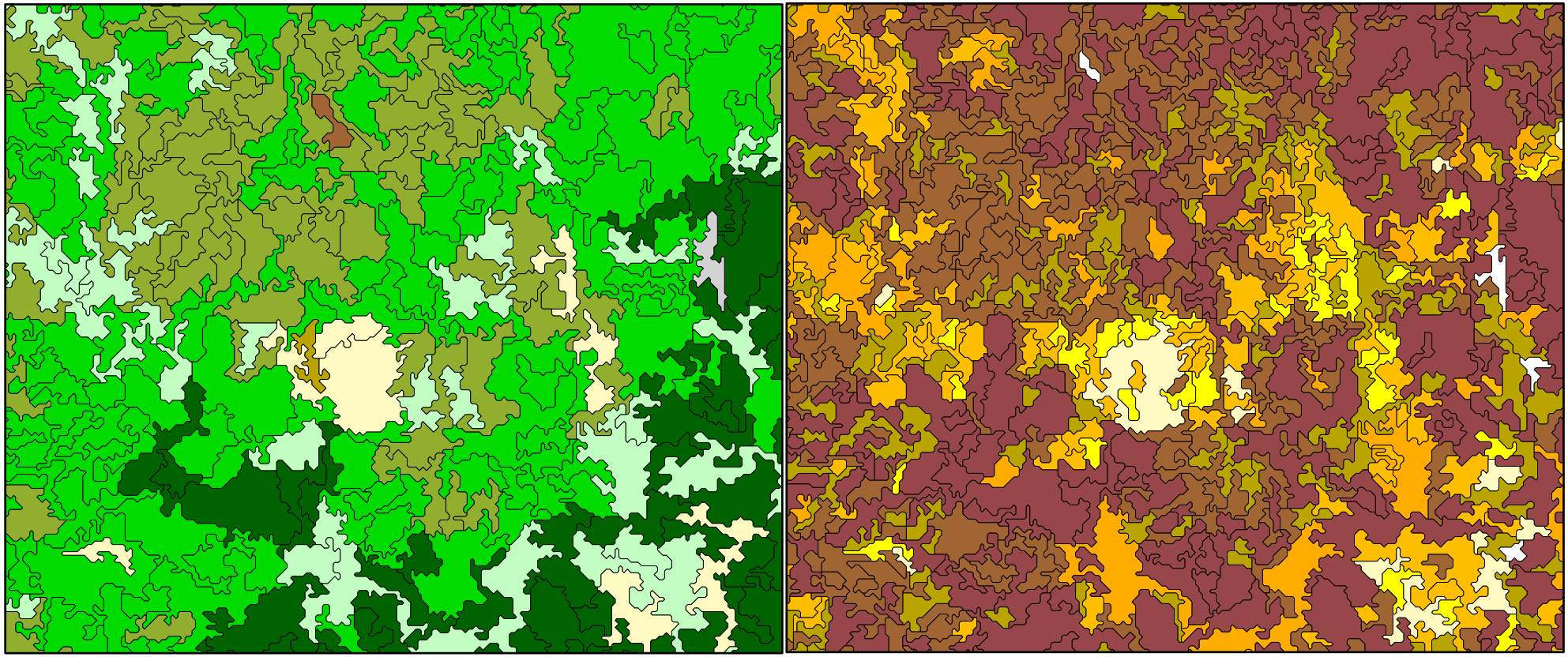


Figure 9: Lassen Volcanic National Park Classification Map Results - Tree Size



# Figure 10: Applegate Watershed Classification Map Results



## Major Type Legend

- Barren
- Grass/Forb
- Shrub/Brush
- Deciduous Hwd
- Evergreen Hwd
- Conifer/Hardwood Mix
- Mixed Conifer
- True Fir
- Unclassified

0 0.25 0.5 1 Miles

N

## Fuel Class Legend

- No Veg Component
- Forb Dominant
- Forb with Timber Overstory
- Shrub Dominant
- Shrub Dominant with Forb and Timber Component
- Mature Shrub Dominant
- Timber Dominant with Compact Litter
- Timber Dominant with Shrub/Forb Component
- Mature Timber Dominant with Woody Debris Component
- Open/Timber Dominant with High Woody Debris Component

These few maps represent the type of information that GRS has been producing since 1990 using our proprietary methodology that is different from any other contractor's methodology. Many other maps may be developed depending on the data included in the map data set. For example, frequency of occurrence data from vegetation descriptions can be joined to these data sets and individual species occurrence can be mapped, if one is attempting to represent where a certain species is likely to be found. All of these examples demonstrate the type of accurate, detailed, quantitative information GRS is capable of developing in areas like those that you are responsible for managing. If GRS's approach to land cover/vegetation mapping generates the types of information that you would like to have produced during your projects, then we would like to meet with you to demonstrate the many capabilities and advantages of implementing our unique mapping methodology. If interested in discussing GRS's mapping capabilities further, please contact:

Ken Stumpf
Director, Remote Sensing Applications
Geographic Resource Solutions
1125 16th Street, Ste. 213
Arcata, CA 95521
(707)822-8005
stumpfk@grsgis.com