The Redwood National and State Parks and Lassen Volcanic National Park Map Data Sets

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More than Just Color-coded Type Maps

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My Perspective

- **Background**
  - Licensed Registered Professional Forester in California
  - Natural resource inventory/planning background
  - Have used inventory and remote sensing techniques over **the last 38 years** to map over 50 million acres in California, PNW, and Alaska
  - Software developer/programmer
  - Modeler
- **Have skepticism about the development and use of ...**
  - Overly generalized map data
  - Ocular estimates and type calls

My Experience

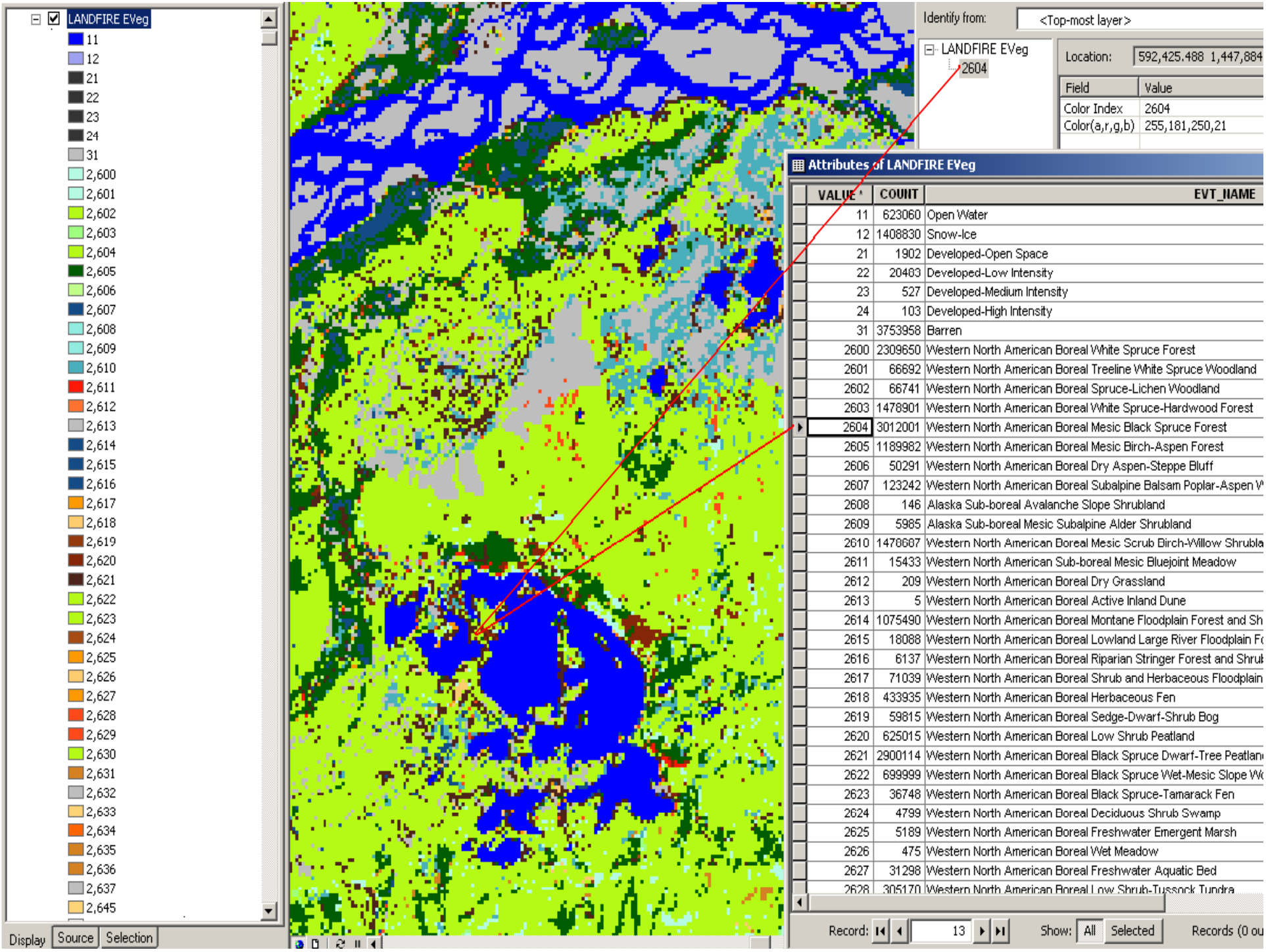
- **Numerous significant technological advancements over the last 38 years**
  - High resolution imagery, Lidar, and multi-spectral data
  - Memory and storage capacity
  - Processing speed
- **But the standard for most of our major national mapping programs is still a color-coded type map**
  - NVCS standardizes names, but has not improved information content

Geographic Resource Solutions™

National Map Data Sets

- **Color-coded lookup tables**
- **Indicate frequency (count) and type name**
- **May include general density class estimate**
  - Sparse Woodland (10-24% cover)
  - Woodland (25-59% cover)
  - Forest (≥ 60% cover)
- **Joined to list of type names**
- **Examples …**

GEOGRAPHIC RESOURCE SOLUTIONS


LANDFIRE EVeg
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Display
Source
Selection
Identify from:
<Top-most layer>
LANDFIRE EVeg
2604
Location:
592,425.488 1,447,884
Field
Value
Color Index
2604
Color(a,r,g,b)
255,181,250,21
Attributes of LANDFIRE EVeg
VALUE
COUNT
EVT_NAME
11 623060 Open Water
12 1408830 Snow-Ice
21 1902 Developed-Open Space
22 20483 Developed-Low Intensity
23 527 Developed-Medium Intensity
24 103 Developed-High Intensity
31 3753958 Barren
2600 2309650 Western North American Boreal White Spruce Forest
2601 66692 Western North American Boreal Treeline White Spruce Woodland
2602 66741 Western North American Boreal Spruce-Lichen Woodland
2603 1478901 Western North American Boreal White Spruce-Hardwood Forest
2604 3012001 Western North American Boreal Mesic Black Spruce Forest
2605 1189982 Western North American Boreal Mesic Birch-Aspen Forest
2606 50291 Western North American Boreal Dry Aspen-Steppe Bluff
2607 123242 Western North American Boreal Subalpine Balsam Poplar-Aspen W
2608 146 Alaska Sub-boreal Avalanche Slope Shrubland
2609 5985 Alaska Sub-boreal Mesic Subalpine Alder Shrubland
2610 1478687 Western North American Boreal Mesic Scrub Birch-Willow Shrubla
2611 15433 Western North American Sub-boreal Mesic Bluejoint Meadow
2612 209 Western North American Boreal Dry Grassland
2613 5 Western North American Boreal Active Inland Dune
2614 1075490 Western North American Boreal Montane Floodplain Forest and Sh
2615 18088 Western North American Boreal Lowland Large River Floodplain F
2616 6137 Western North American Boreal Riparian Stringer Forest and Shrub
2617 71039 Western North American Boreal Shrub and Herbaceous Floodplain
2618 433935 Western North American Boreal Herbaceous Fen
2619 59815 Western North American Boreal Sedge-Dwarf-Shrub Bog
2620 625015 Western North American Boreal Low Shrub Peatland
2621 2900114 Western North American Boreal Black Spruce Dwarf-Tree Peatlan
2622 699999 Western North American Boreal Black Spruce Wet-Mesic Slope W
2623 36748 Western North American Boreal Black Spruce-Tamarack Fen
2624 4799 Western North American Boreal Deciduous Shrub Swamp
2625 5189 Western North American Boreal Freshwater Emergent Marsh
2626 475 Western North American Boreal Wet Meadow
2627 31298 Western North American Boreal Freshwater Aquatic Bed
2628 305170 Western North American Boreal Low Shrub-Tussock Tundra
Record:
13
Show:
All
Selected
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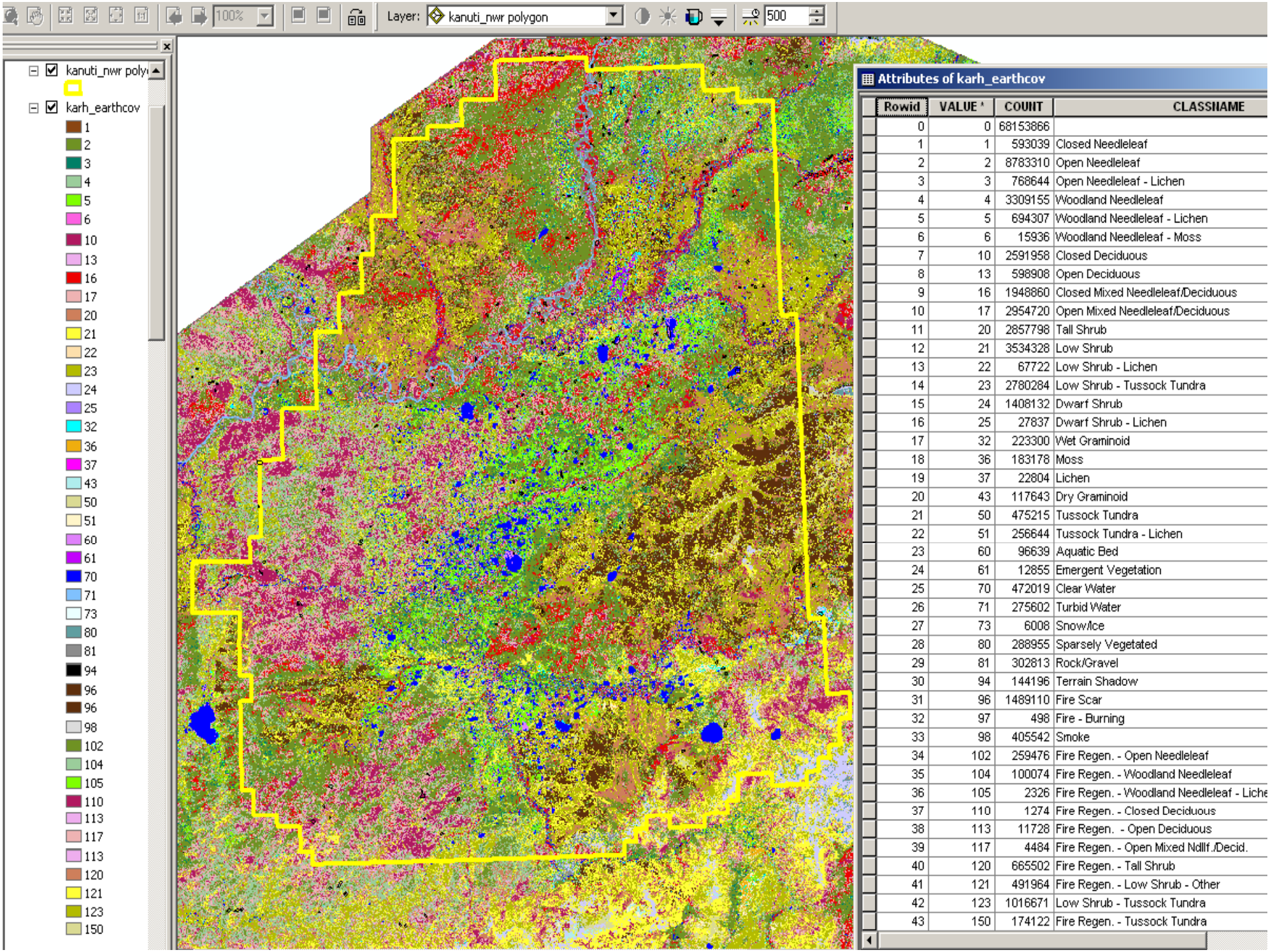
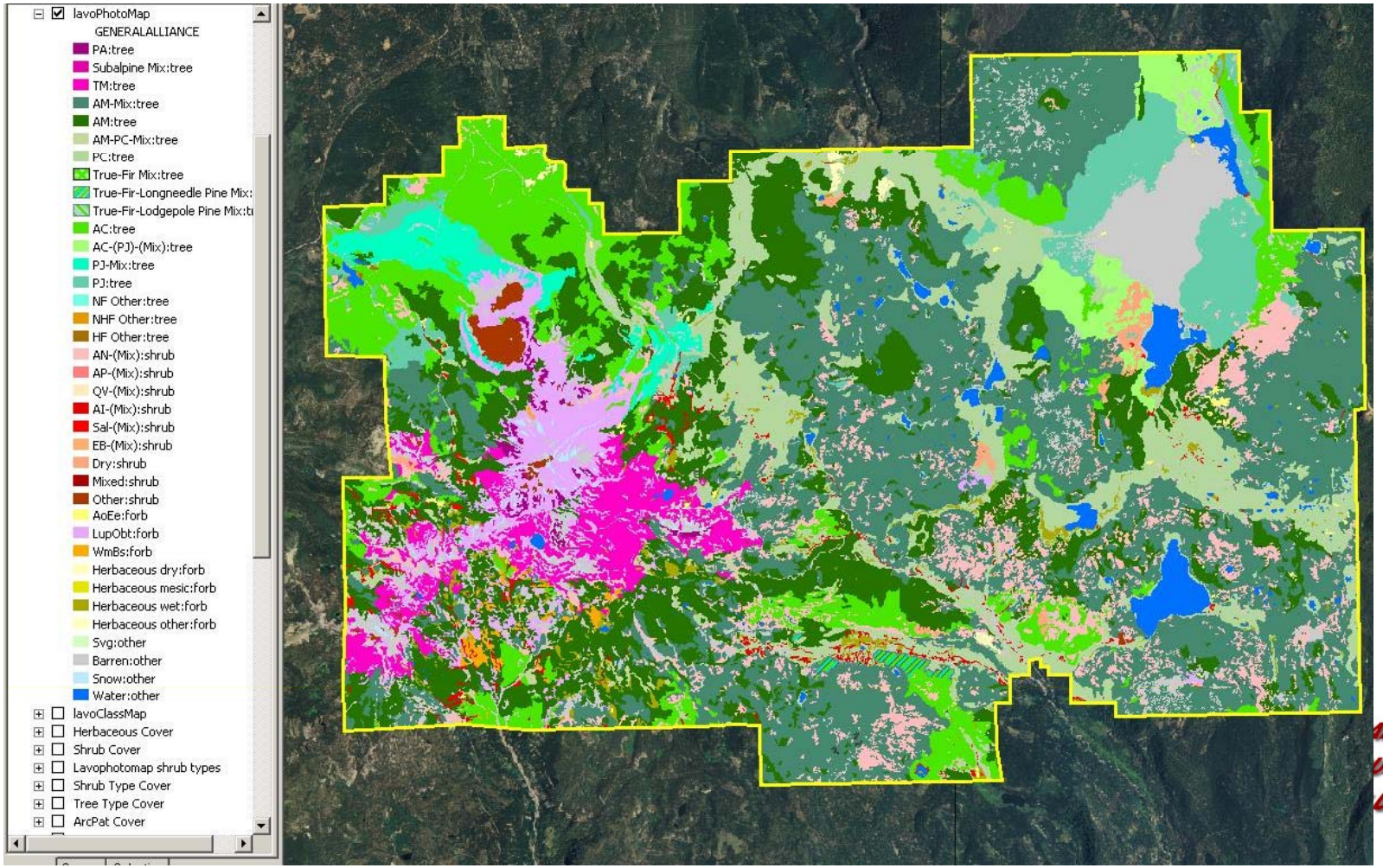


Attributes of karh_earthcov

Rowid	VALUE *	COUNT	CLASSNAME
0	0	68153866	
1	1	593039	Closed Needleleaf
2	2	8783310	Open Needleleaf
3	3	768644	Open Needleleaf - Lichen
4	4	3309155	Woodland Needleleaf
5	5	694307	Woodland Needleleaf - Lichen
6	6	15936	Woodland Needleleaf - Moss
7	10	2591958	Closed Deciduous
8	13	598908	Open Deciduous
9	16	1948860	Closed Mixed Needleleaf/Deciduous
10	17	2954720	Open Mixed Needleleaf/Deciduous
11	20	2857798	Tall Shrub
12	21	3534328	Low Shrub
13	22	67722	Low Shrub - Lichen
14	23	2780284	Low Shrub - Tussock Tundra
15	24	1408132	Dwarf Shrub
16	25	27837	Dwarf Shrub - Lichen
17	32	223300	Wet Graminoid
18	36	183178	Moss
19	37	22804	Lichen
20	43	117643	Dry Graminoid
21	50	475215	Tussock Tundra
22	51	256644	Tussock Tundra - Lichen
23	60	96639	Aquatic Bed
24	61	12855	Emergent Vegetation
25	70	472019	Clear Water
26	71	275602	Turbid Water
27	73	6008	Snow/Ice
28	80	288955	Sparsely Vegetated
29	81	302813	Rock/Gravel
30	94	144196	Terrain Shadow
31	96	1489110	Fire Scar
32	97	498	Fire - Burning
33	98	405542	Smoke
34	102	259476	Fire Regen. - Open Needleleaf
35	104	100074	Fire Regen. - Woodland Needleleaf
36	105	2326	Fire Regen. - Woodland Needleleaf - Liche
37	110	1274	Fire Regen. - Closed Deciduous
38	113	11728	Fire Regen. - Open Deciduous
39	117	4484	Fire Regen. - Open Mixed Ndllf./Decid.
40	120	665502	Fire Regen. - Tall Shrub
41	121	491964	Fire Regen. - Low Shrub - Other
42	123	1016671	Low Shrub - Tussock Tundra
43	150	174122	Fire Regen. - Tussock Tundra

Color-coded Type Maps – Useful for …

- **Visualization of results:**



Color-coded Type Maps – Useful for …

- Visualization of results
- **Summarization of area by type:**

Table 2: LAVO PI Land Cover Map Data Set - Area Summary by Generalized and Crosswalked Type

Generalized Alliance	Stands	Acres	Hectares	% Total Area	Cumulative % Area	Detailed Alliance - PI Typename	Stands	Acres	Hectares	% Total Area	Cumulative % Area
PA:tree	43	324.0	131.1	0.3%	0.3%	PA:tree	43	324.0	131.1	0.3%	0.3%
Subalpine Mix:tree	-	-	-	0.0%	0.3%	PA-TM:tree	-	-	-	0.0%	0.3%
TM:tree	220	3,495.6	1,414.7	3.3%	3.6%	TM:tree					
						TM	65	370.3	149.9	0.3%	0.6%
						TM/AN	49	681.6	275.8	0.6%	1.3%
						TM/HOX	106	2,443.8	989.0	2.3%	3.6%
AM:tree	778	18,707.2	7,570.7	17.4%	21.0%	AM:tree					
						AM	575	13,943.9	5,643.0	13.0%	16.6%
						AM/AoEe	200	4,755.2	1,924.4	4.4%	21.0%
						AM/HDX	3	8.1	3.3	0.0%	21.0%
AM-Mix:tree	363	30,613.2	12,389.0	28.5%	49.6%	AM-Mix:tree					
						AM-TM	5	32.7	13.2	0.0%	21.0%
						AM/AN	358	30,580.5	12,375.8	28.5%	49.6%
AM-PC-Mix:tree	47	333.6	135.0	0.3%	49.9%	AM-(PM)-PC:tree					
						AM/HMM	47	333.6	135.0	0.3%	49.9%
True-Fir Mix:tree	-	-	-	0.0%	49.9%	AM-AC:tree	-	-	-	0.0%	49.9%
True-Fir-Lodgepole Pine Mix:tree	-	-	-	0.0%	49.9%	AM-AC-PC:tree	-	-	-	0.0%	49.9%
True-Fir-Longneedle Pine Mix:tree	5	255.5	103.4	0.2%	50.1%	AM-AC-PJ:tree					
						AM-AC-CD	5	255.5	103.4	0.2%	50.1%

Color-coded Type Maps – Useful for …

- Visualization of results
- Summarization of area by type
- **Monitoring major change(s):**
  - Forest/timber harvest operations
  - Road construction and urban development
  - Fire
  - Volcanic eruption
  - Landslides
  - Change in water levels

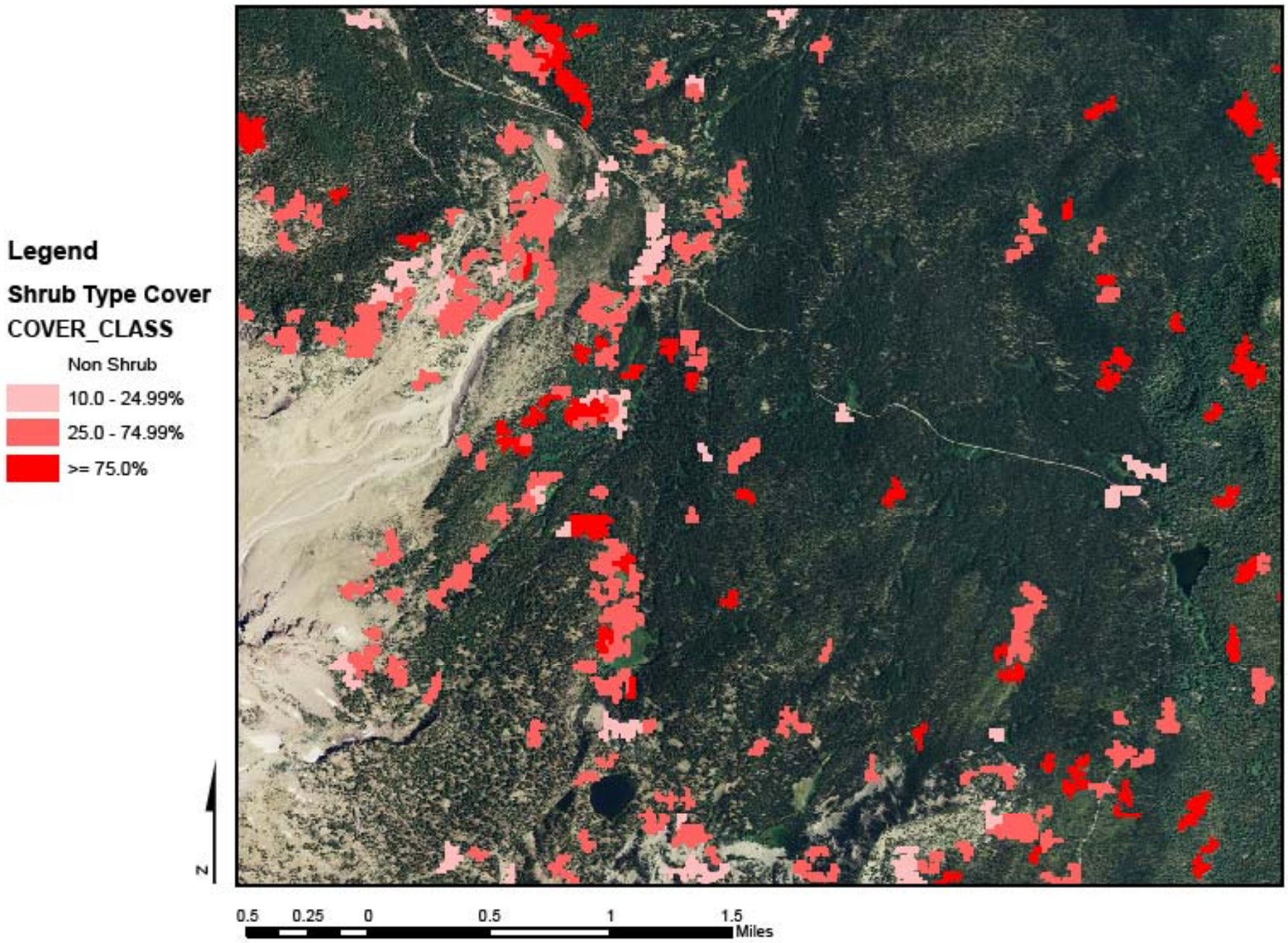
Color Coded Type Map(s)

- **Useful for displaying natural resource information, but extremely limited in their information content**
- **Useful for Stratification**
- **Useful for resource management …**
  - Inventory ?
  - Analysis ?
  - Monitoring change?
  - Modeling ?
  - Planning ?

Critical Habitat Example

- **Type Map**
  - Shrub Alliances and Associations
    - Map Shrub Cover

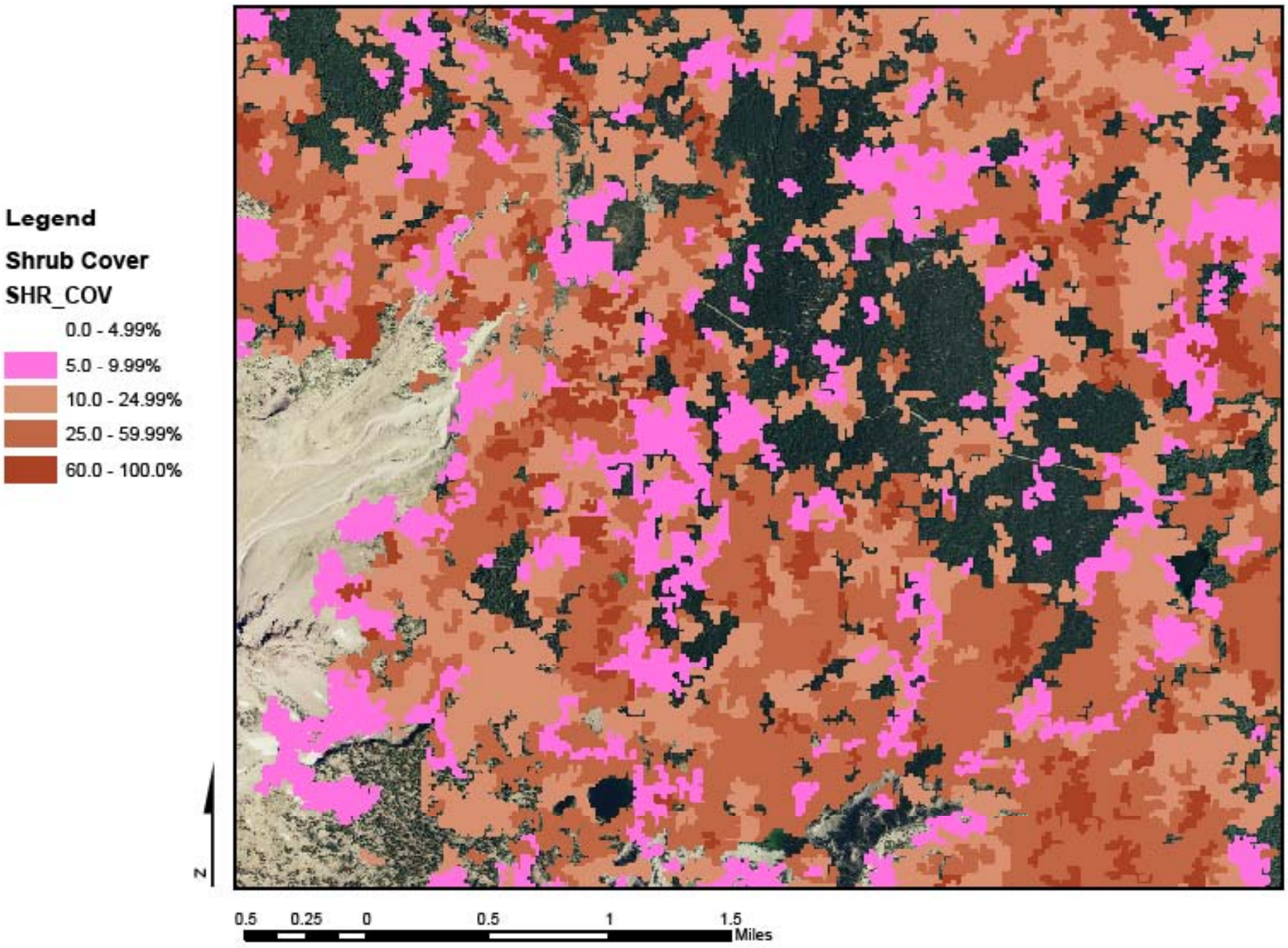
Figure 1: Lassen Volcanic National Park Classification Map Results - Shrub Type Cover



Critical Habitat Example

- **Type Map**
  - Shrub Alliances and Associations
    - Map Shrub Cover
- **Map Data Set with Cover Components**
  - Map shrub cover as a component of
    - Tree types
    - Shrub types
    - Herbaceous types
    - Other types

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



A Different Approach

But now let's suppose we are going to use a different data model and different techniques to build a map data set of a different nature.

An approach based on discrete estimates of the components of the different ecosystems we can sample on the ground and recognize in the satellite imagery.

Cover Matrix Data Model

- **Develop and store estimates of the cover of species and landscape features that comprise the plant communities and landscape features we are mapping**
  - By size – diameter and/or height
  - By canopy layer/position including the ground surface
  - By status – alive, dead, stunted, …
- **Cover values represent the continuum of cover**
- **Cover values support the assignment of a "type" or a "class"**

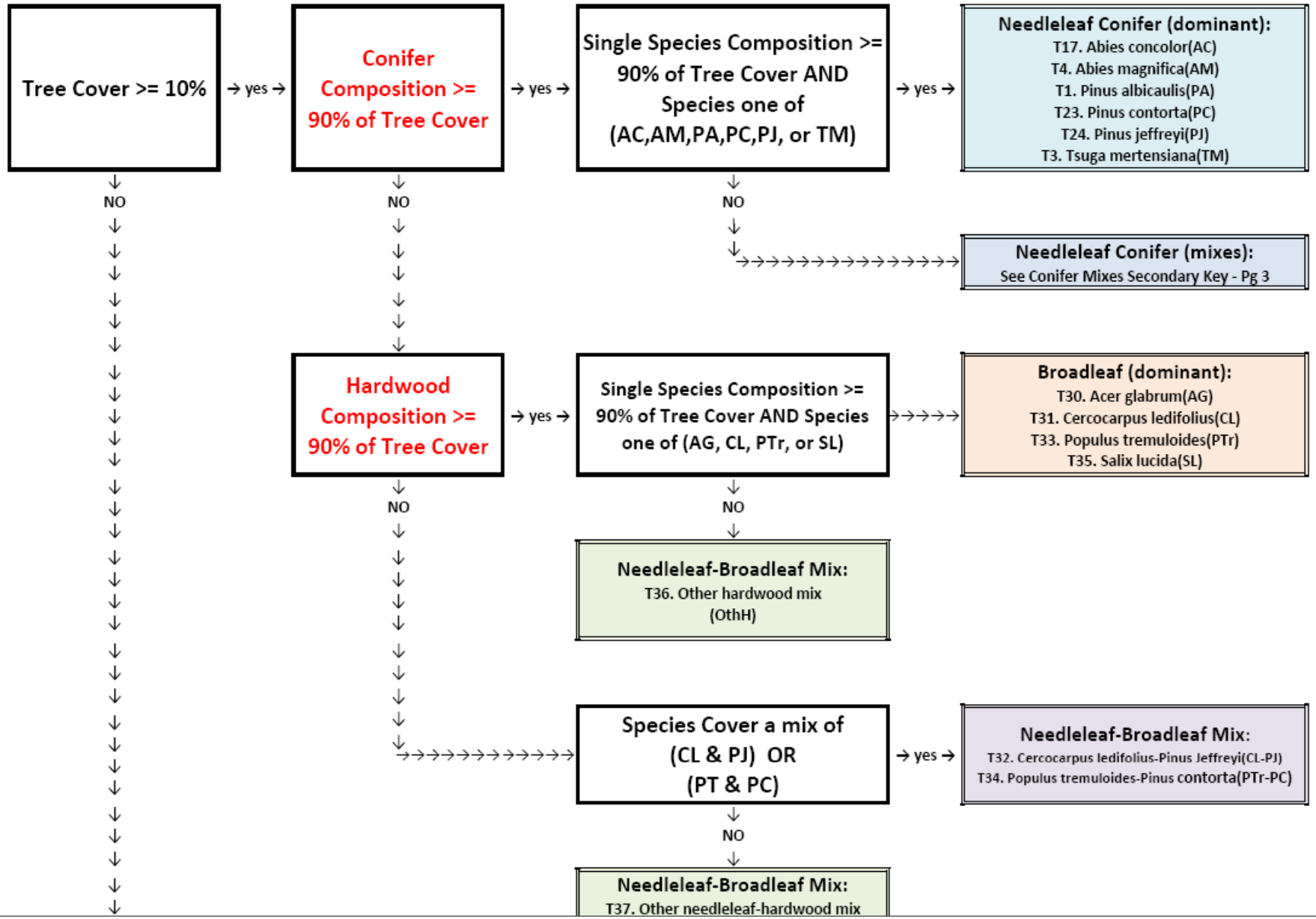
Percent Cover Summary for All Layers:
Site/Polygon Id: 80201
Number of Sites/Pixels: 1

Species	<= 5.95"	> 5.95" <=11.95"	>11.95" <=17.95"	>17.95" <=29.95"	>29.95"	Tree Cover	Non-Tree Cover	Total Cover
Doug-fir	0.0	2.0	0.0	0.0	0.0	2.0		2.0
Ponderosa pine	0.0	1.0	0.0	0.0	0.0	1.0		1.0
Jeffrey pine	2.0	5.0	0.0	0.0	0.0	7.0		7.0
Sugar pine	1.0	0.0	0.0	0.0	0.0	1.0		1.0
Wst white pine	3.0	2.0	2.0	0.0	0.0	7.0		7.0
White fir	4.5	0.0	0.0	0.0	0.0	4.5		4.5
Sm lf creambsh							0.5	0.5
PYRPIC							1.0	1.0
BarRoc							77.0	77.0
FWD							2.0	2.0
LitDuf							20.0	20.0
undescribed							1.0	1.0
Totals	10.5	10.0	2.0	0.0	0.0	22.5	101.5	124.0

Tree Cover Composition Summary for All Layers 22.5 Cover:

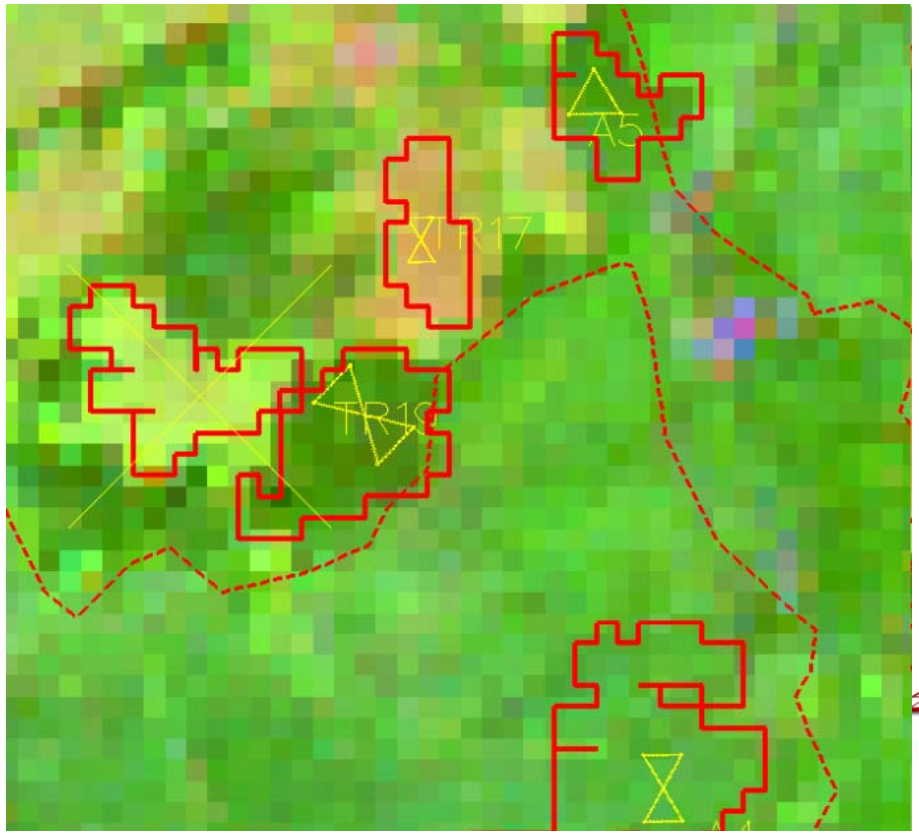
Species	<= 5.95"	> 5.95" <=11.95"	>11.95" <=17.95"	>17.95" <=29.95"	>29.95"	All Sizes
Doug-fir	0.0	8.9	0.0	0.0	0.0	8.9
Ponderosa pine	0.0	4.4	0.0	0.0	0.0	4.4
Jeffrey pine	8.9	22.2	0.0	0.0	0.0	31.1
Sugar pine	4.4	0.0	0.0	0.0	0.0	4.4
Wst white pine	13.3	8.9	8.9	0.0	0.0	31.1
White fir	20.0	0.0	0.0	0.0	0.0	20.0
Totals	46.7	44.4	8.9	0.0	0.0	100.0

LAVO Land Cover Alliance/Assoc. - Primary Key

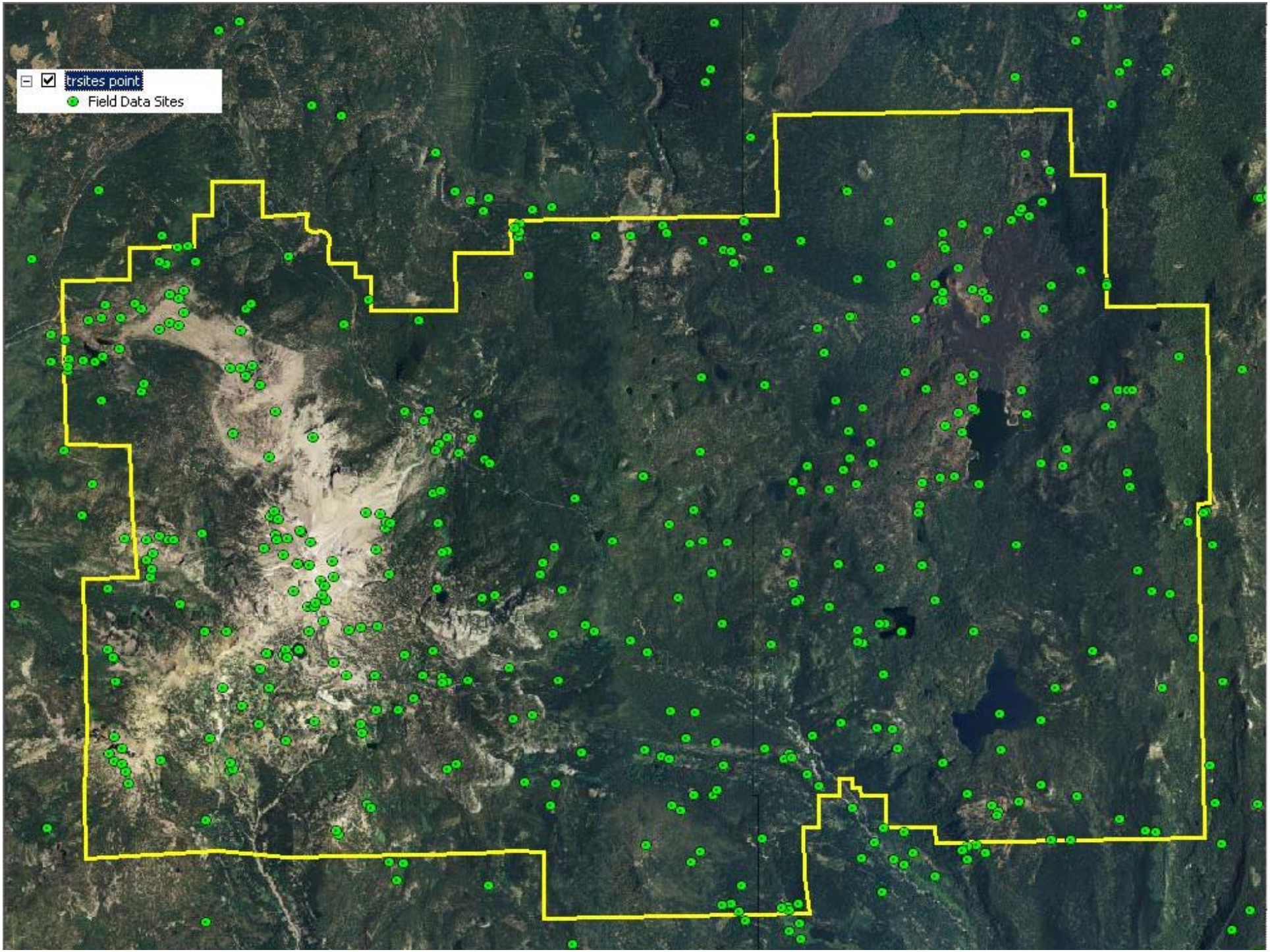


Field Data Collection Results

- LAVO – 493 Field Sample Areas
- RNSP – 445 Field Sample Areas
- Comparable or lower cost of $200/area including all costs and overhead



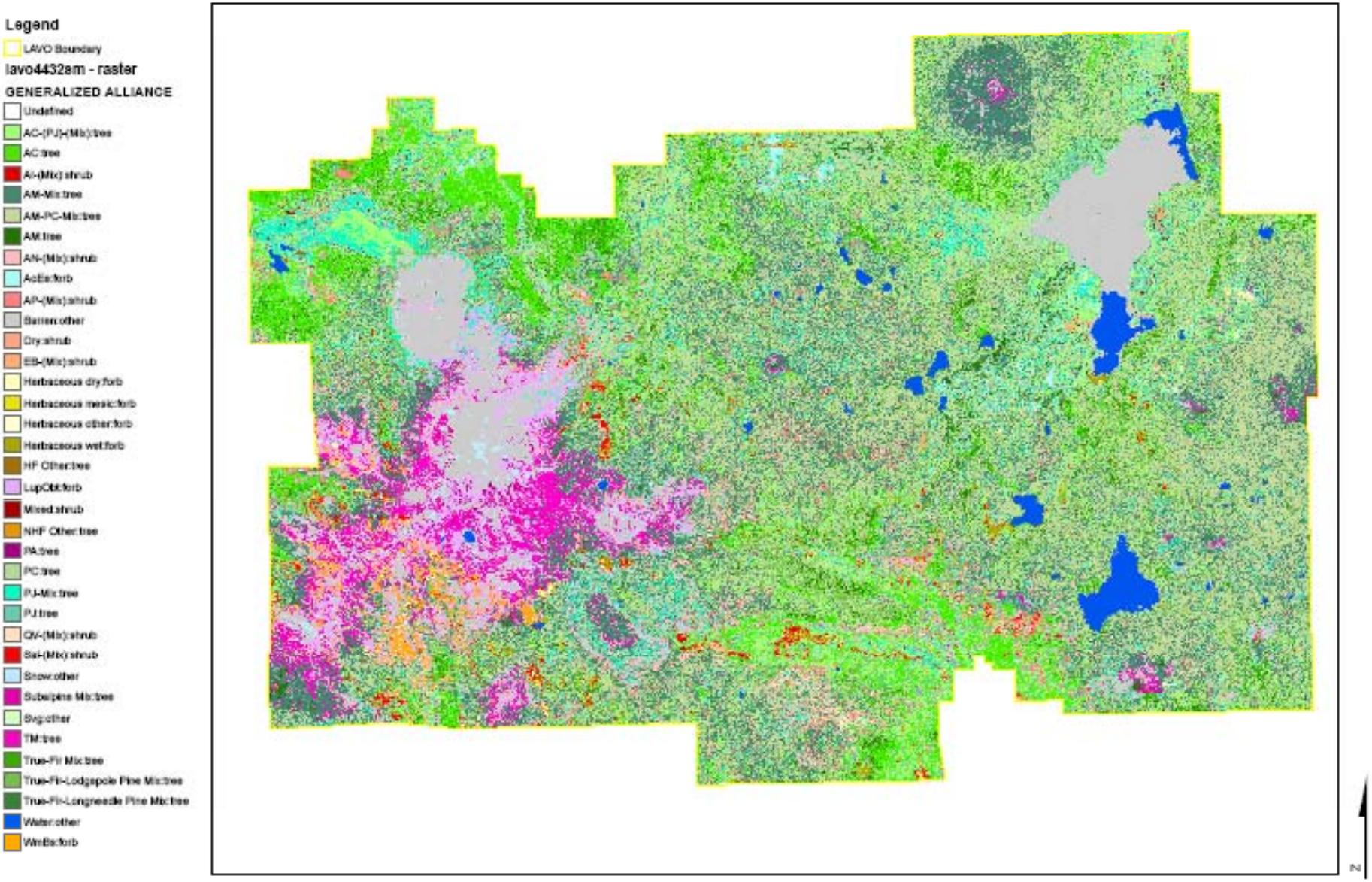
GEOGRAPHIC RESOURCE SOLUTIONS


trsites point
Field Data Sites

Perform “Discrete” Image Classification

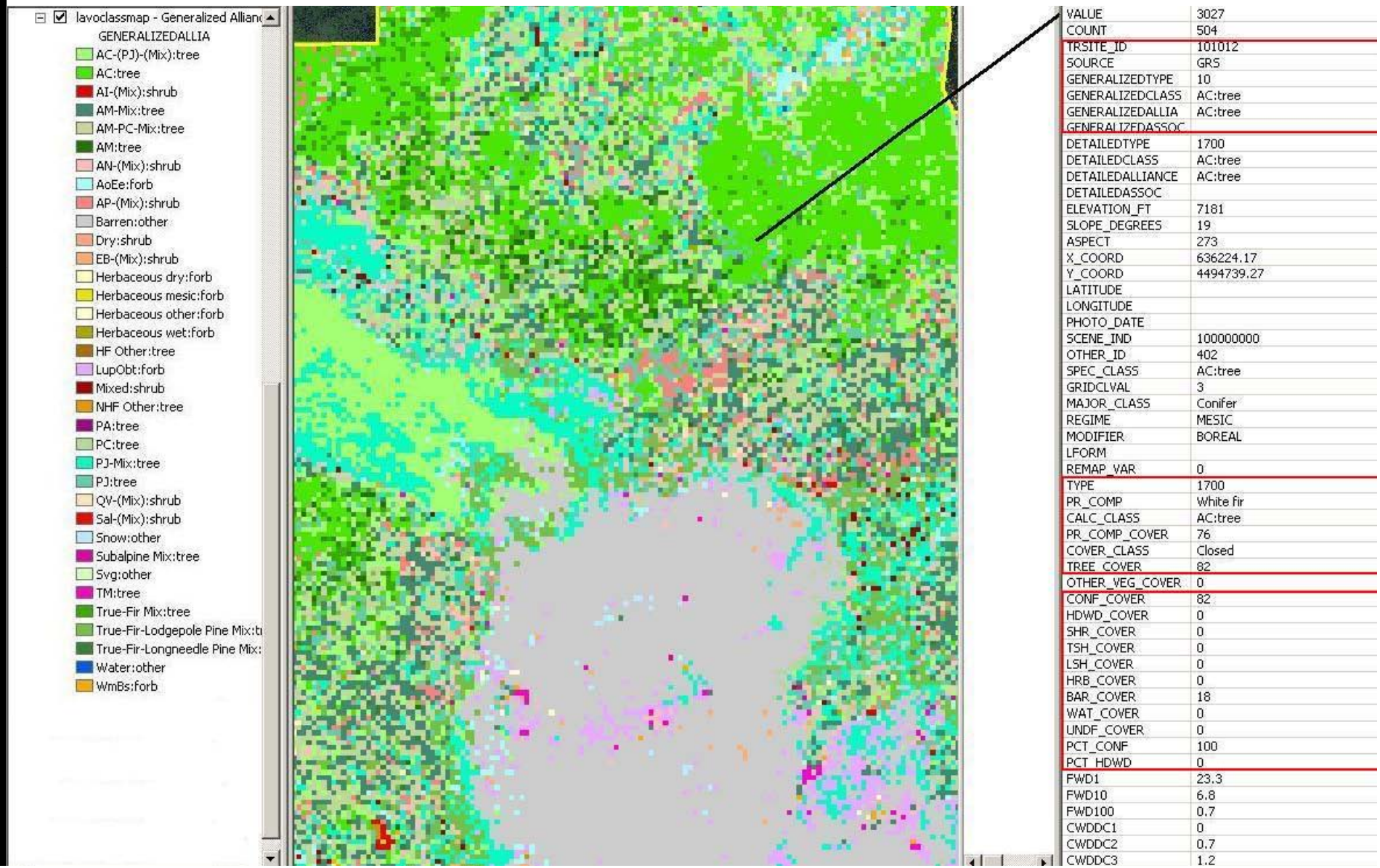
- Develop a 1:1 correspondence of a ground truth field sample area to a spectral training class
- Map shades-of-gray rather than distinctly different classes
- Use confusion and “mapping fidelity” to verify the shades-of gray represent the continuums of related plant communities and/or landscape features
- Can be performed using any image processing package, as it is a variation of supervised classification techniques.

Lassen Volcanic National Park Comparative Mapping Project

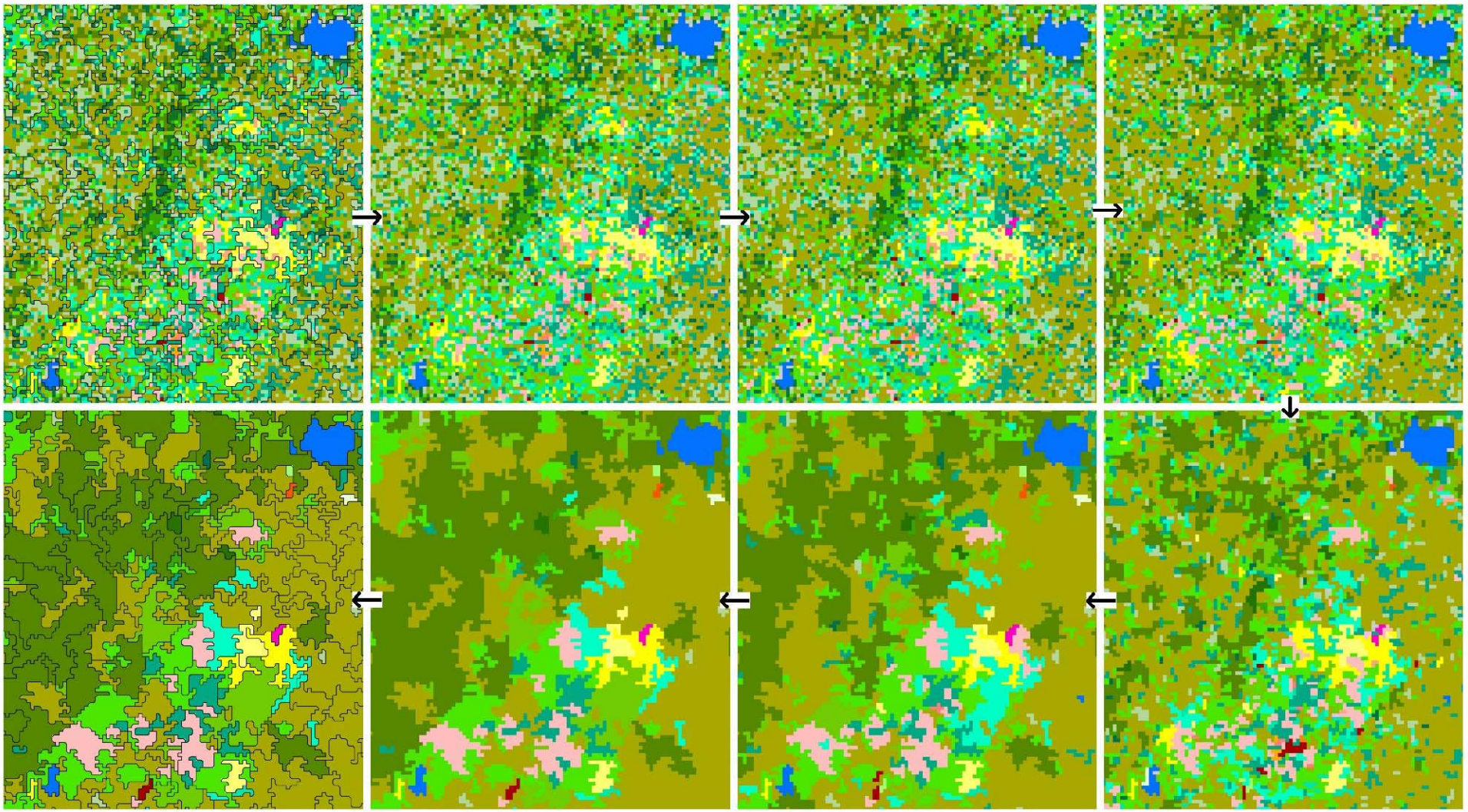


Lassen Volcanic National Park - Image Classification Pixel Map

“Discrete” Image Classification Data



Pixel Aggregation => Stands/Polygons

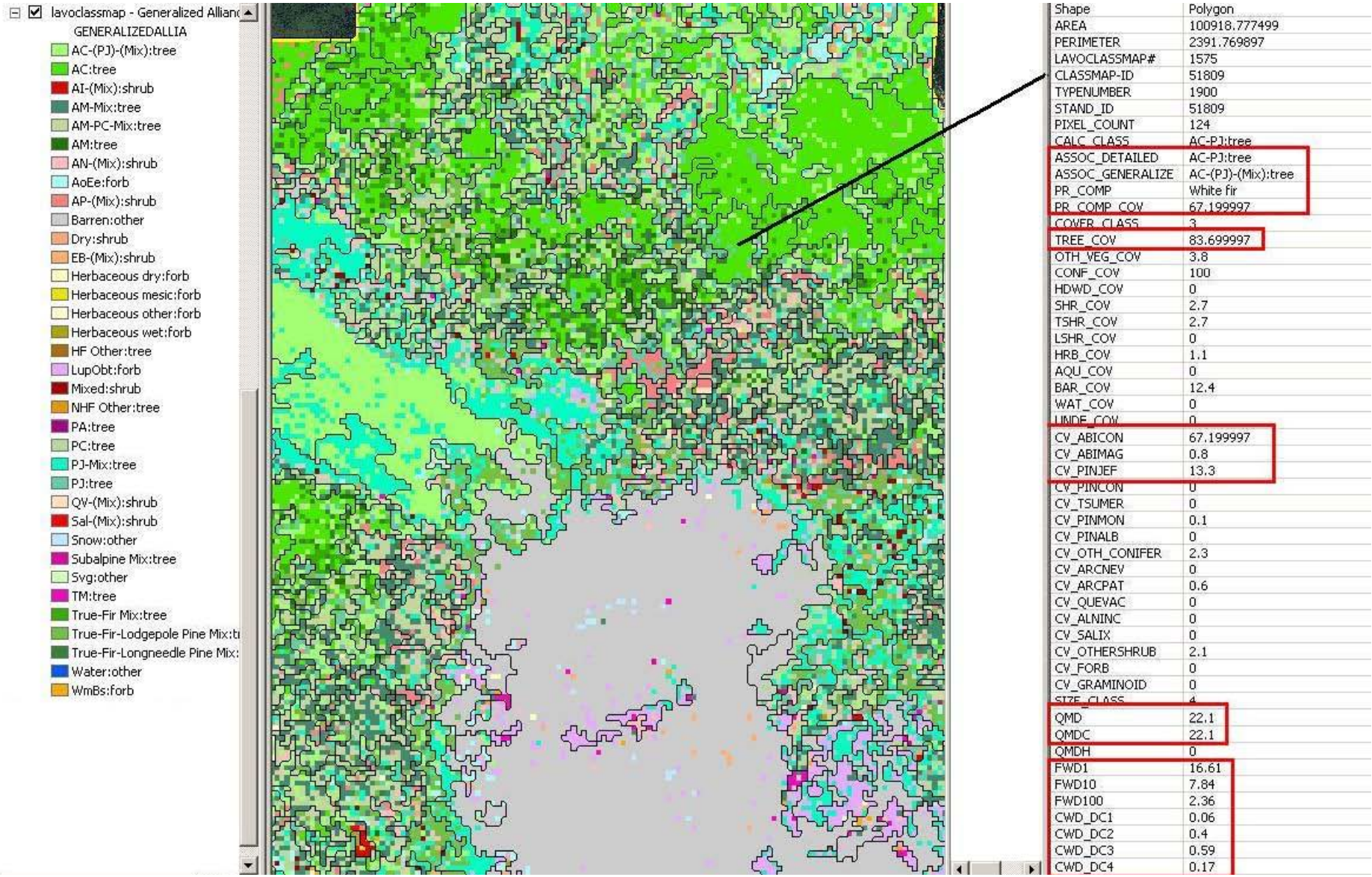


Generation of Stand Values

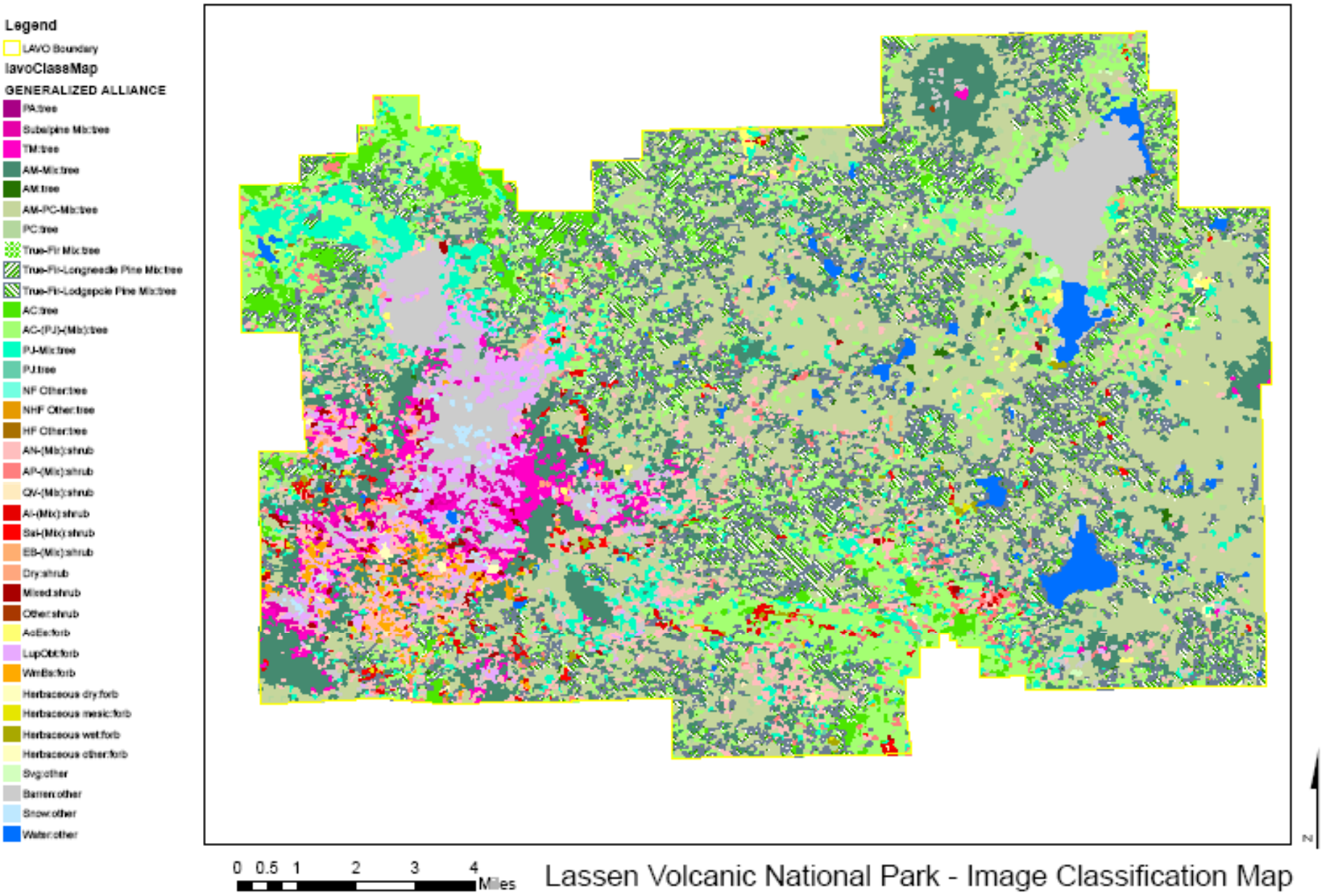
- Develop frequency distribution of pixel classes by individual polygon
- Generate the stand values by calculating the weighted average of the pixel class values
- Generate stand categorical estimates by processing discrete estimates using software (key) and sql statements

GEOGRAPHIC RESOURCE SOLUTIONS

“Discrete” Classification Stands

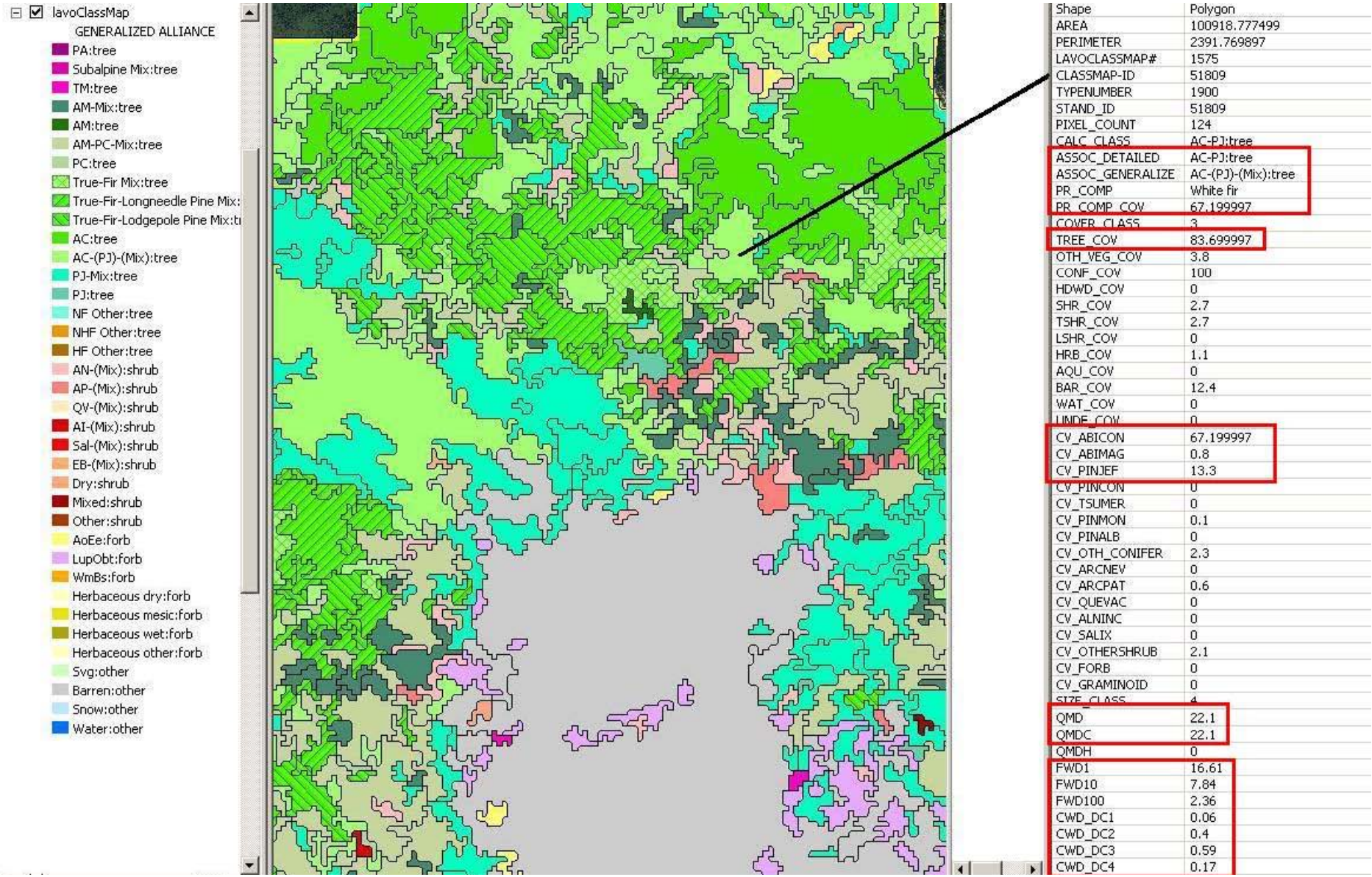


Lassen Volcanic National Park Comparative Mapping Project



Lassen Volcanic National Park - Image Classification Map

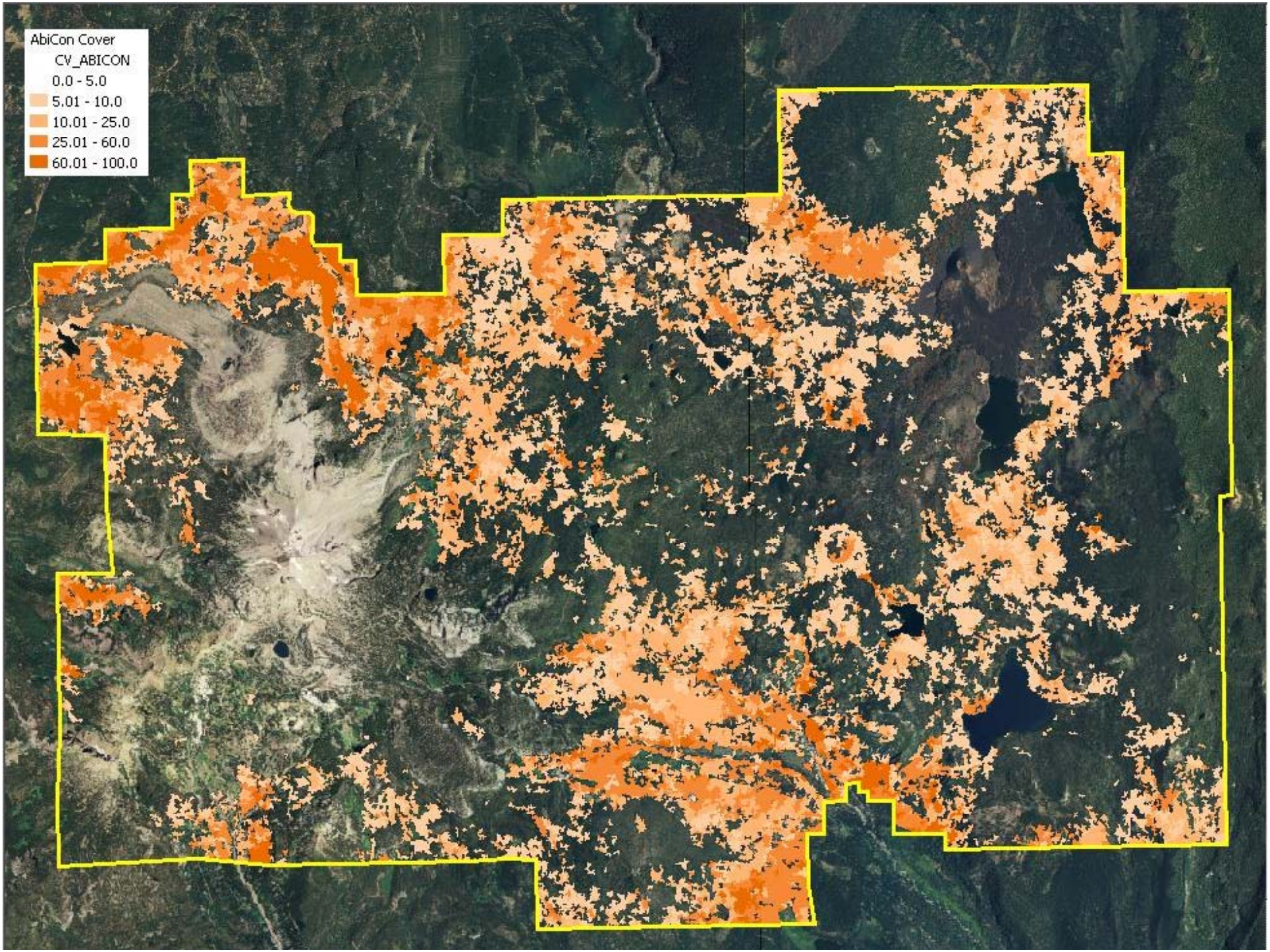
Map Data Set - Stand Map and Attributes



Pixel and Polygon Map Data Set Uses

- **National Vegetation Classification System Type**
  - Detailed Alliance/Association
  - Generalized Alliance
- **Extent and cover by species and landscape feature**
  - Can species group by lifeform
  - Can group species by major or minor groups
  - Can group landscape features by major or minor groups
- **Size**
- **Calculated woody debris values – dry tons/acre**
- **Accuracy assessment based upon statistical tests**

Geographic Resource Solutions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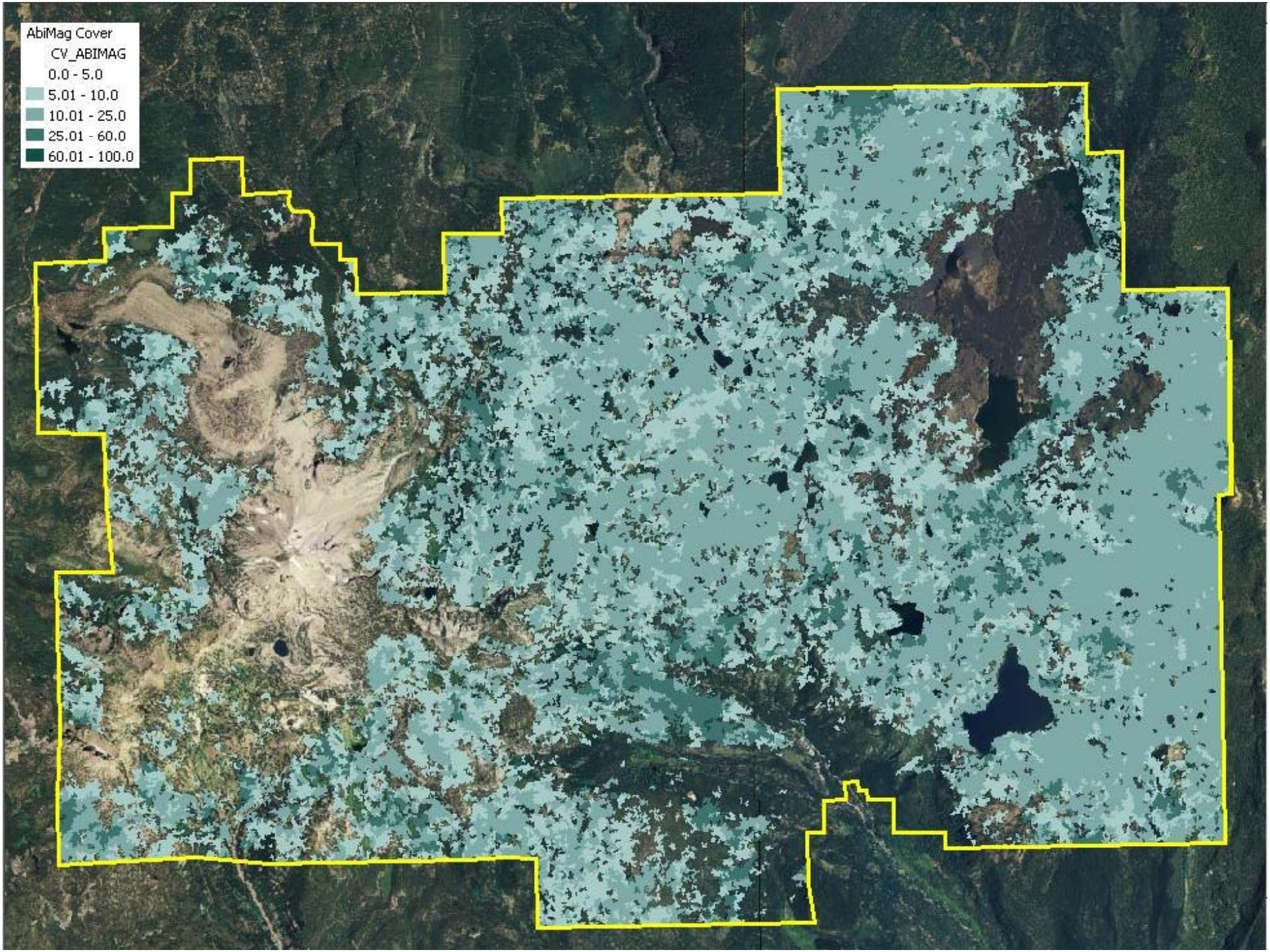
10.01 - 25.0
25.01 - 60.0
60.01 - 100.0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CV_ABIMAG
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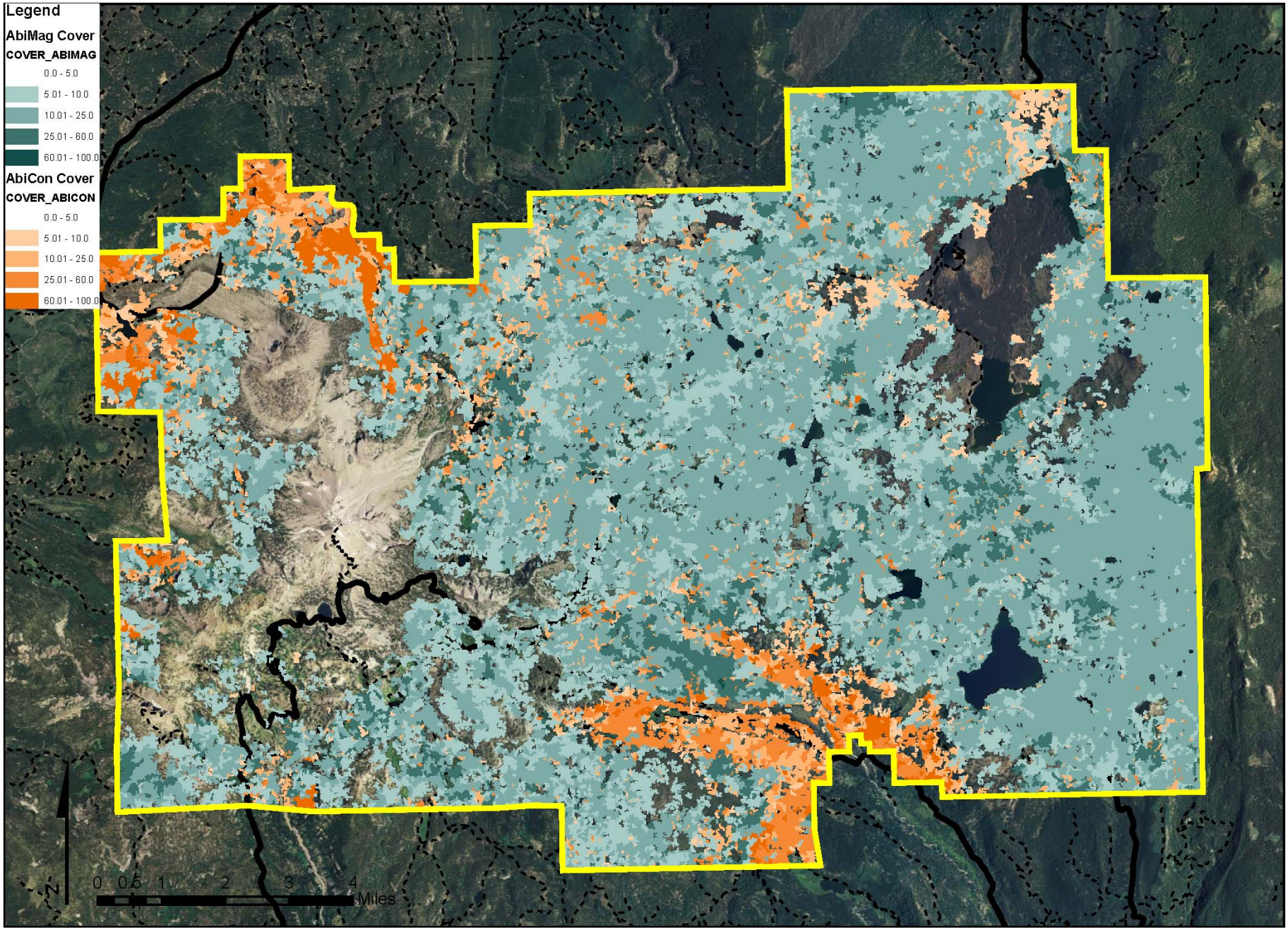
10.01 - 25.0
25.01 - 60.0
60.01 - 100.0


Legend
AbiMag Cover
COVER_ABIMAG
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5.01 - 10.0
10.01 - 25.0
25.01 - 60.0
60.01 - 100.0
AbiCon Cover
COVER_ABICON
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5.01 - 10.0
10.01 - 25.0
25.01 - 60.0
60.01 - 100.0
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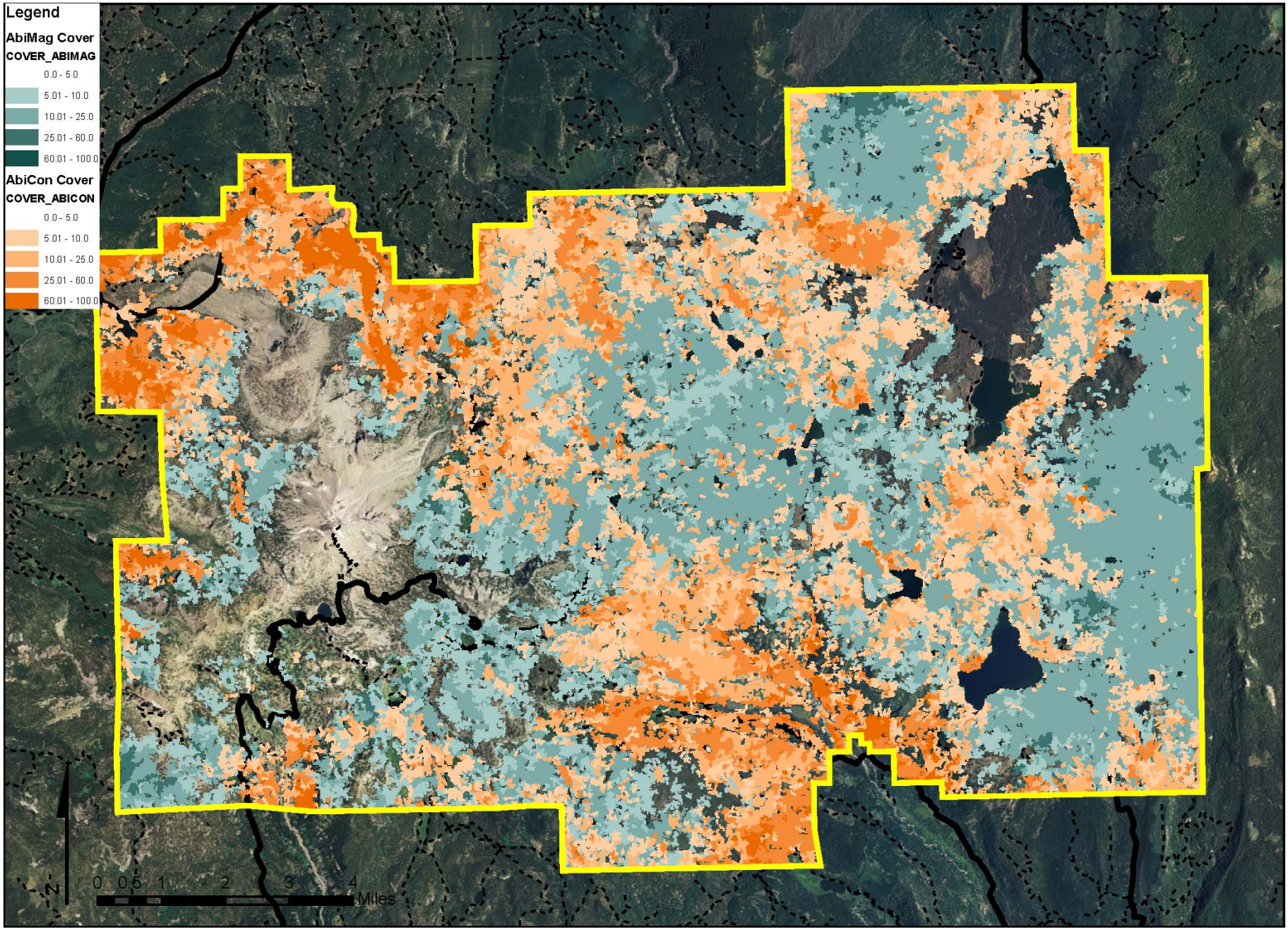
Miles


Legend
AbiMag Cover
COVER_ABIMAG
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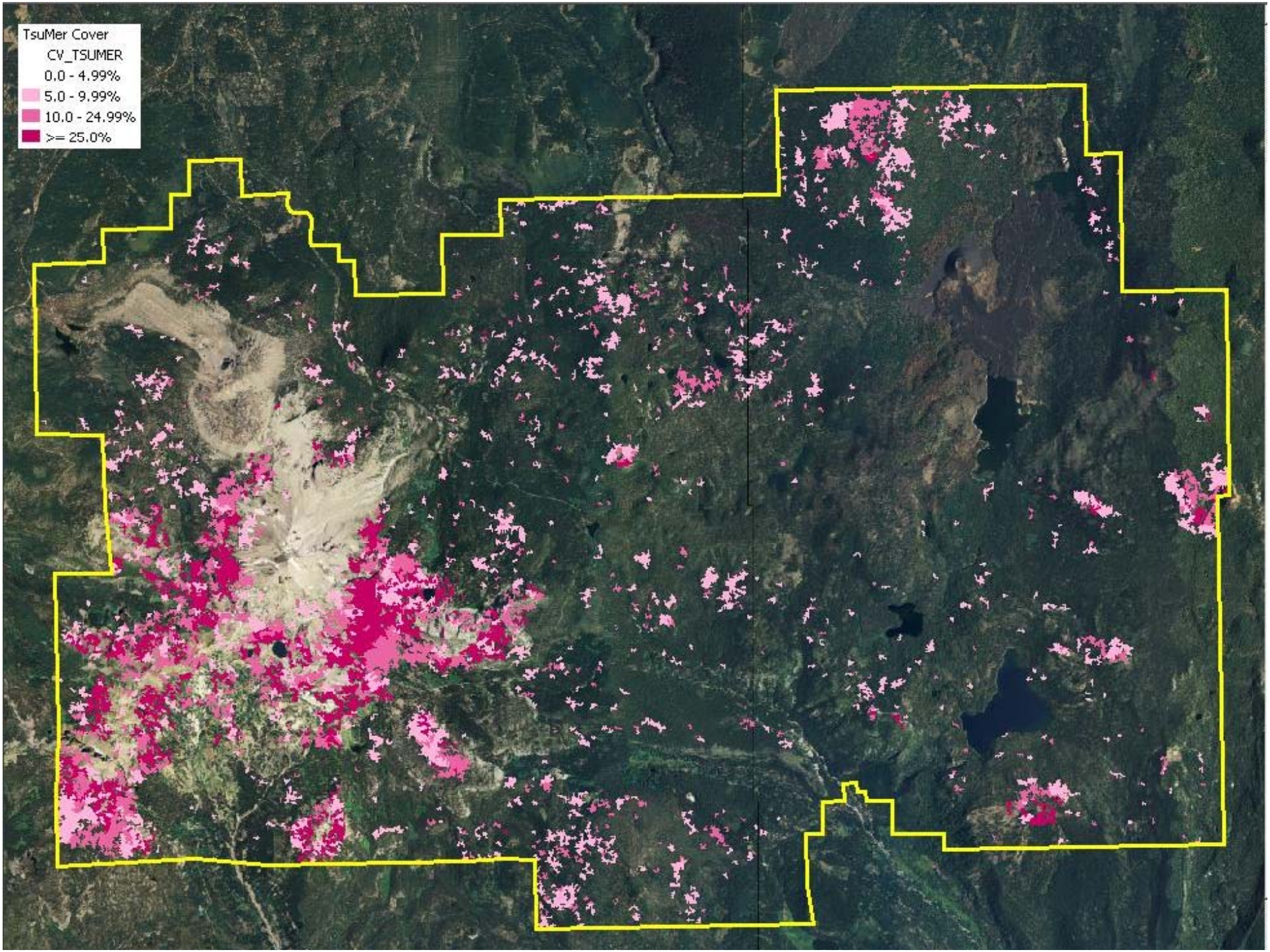
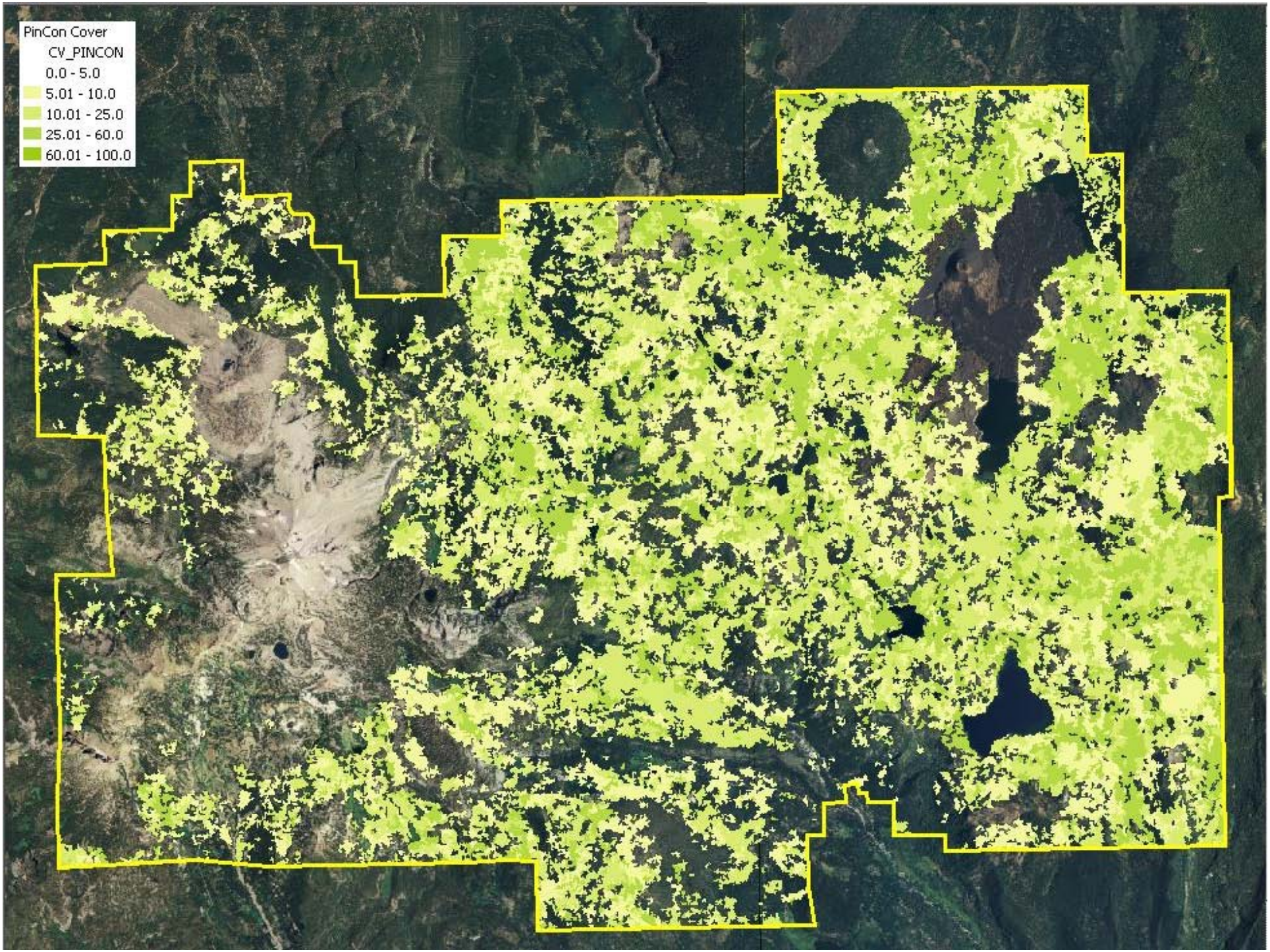
10.01 - 25.0
25.01 - 60.0
60.01 - 100.0
AbiCon Cover
COVER_ABICON
0.0 - 5.0
5.01 - 10.0
10.01 - 25.0
25.01 - 60.0
60.01 - 100.0
N
0 0.5 1 2 3 4
Miles


TsuMer Cover
CV_TSUMER
0.0 - 4.99%
5.0 - 9.99%
10.0 - 24.99%
>= 25.0%


PinCon Cover
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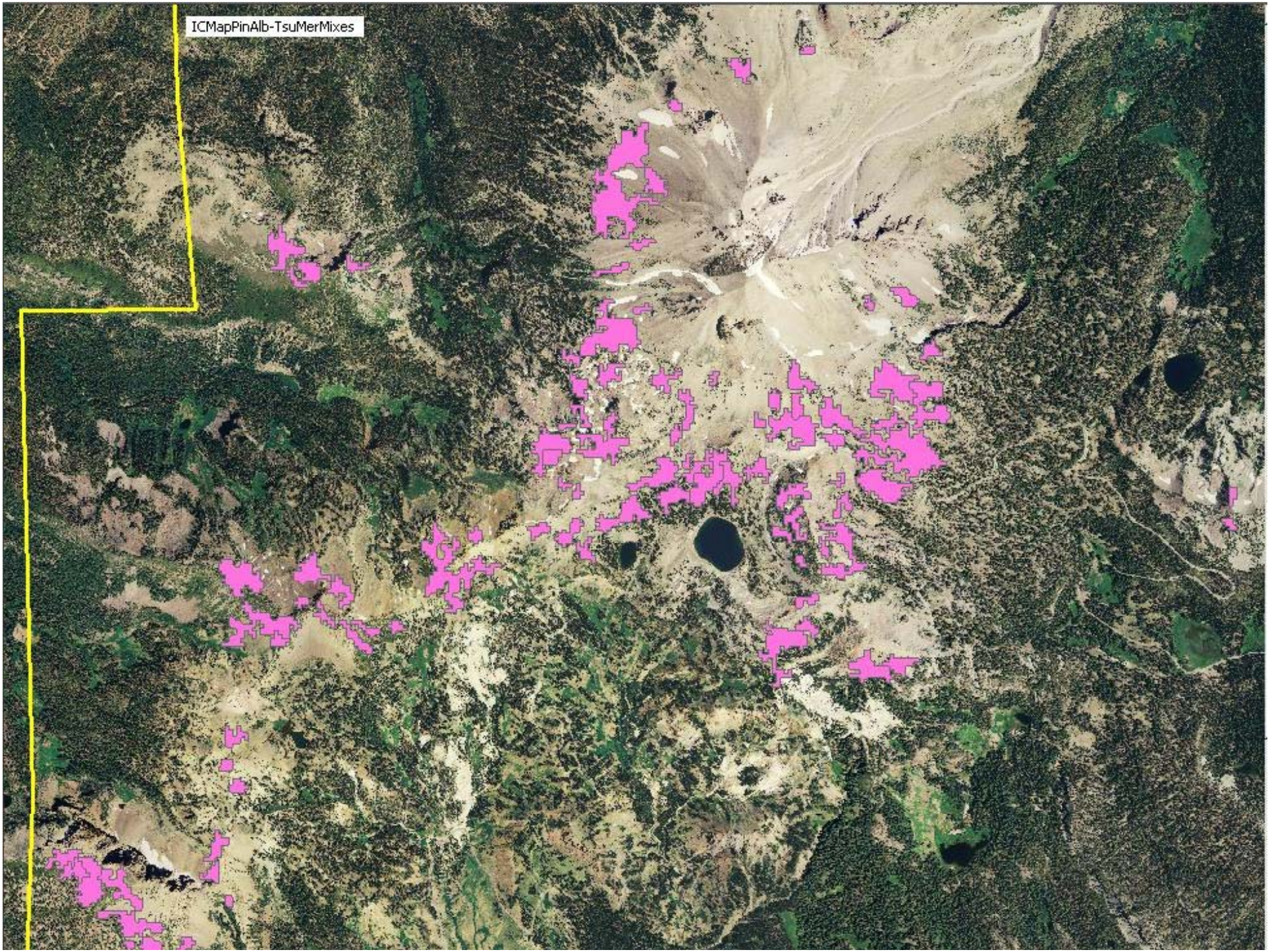
0.0 - 5.0
5.01 - 10.0
10.01 - 25.0
25.01 - 60.0
60.01 - 100.0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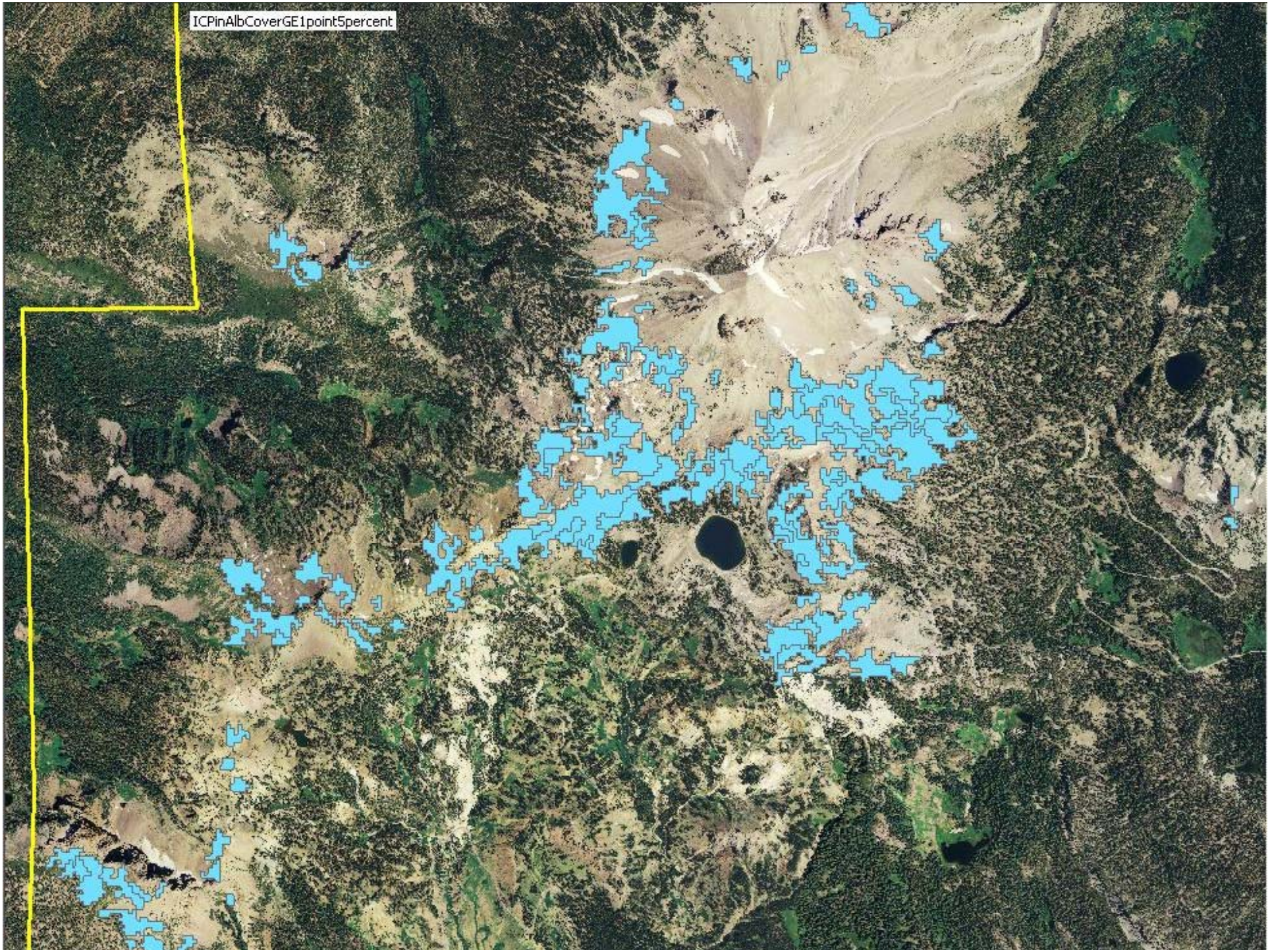
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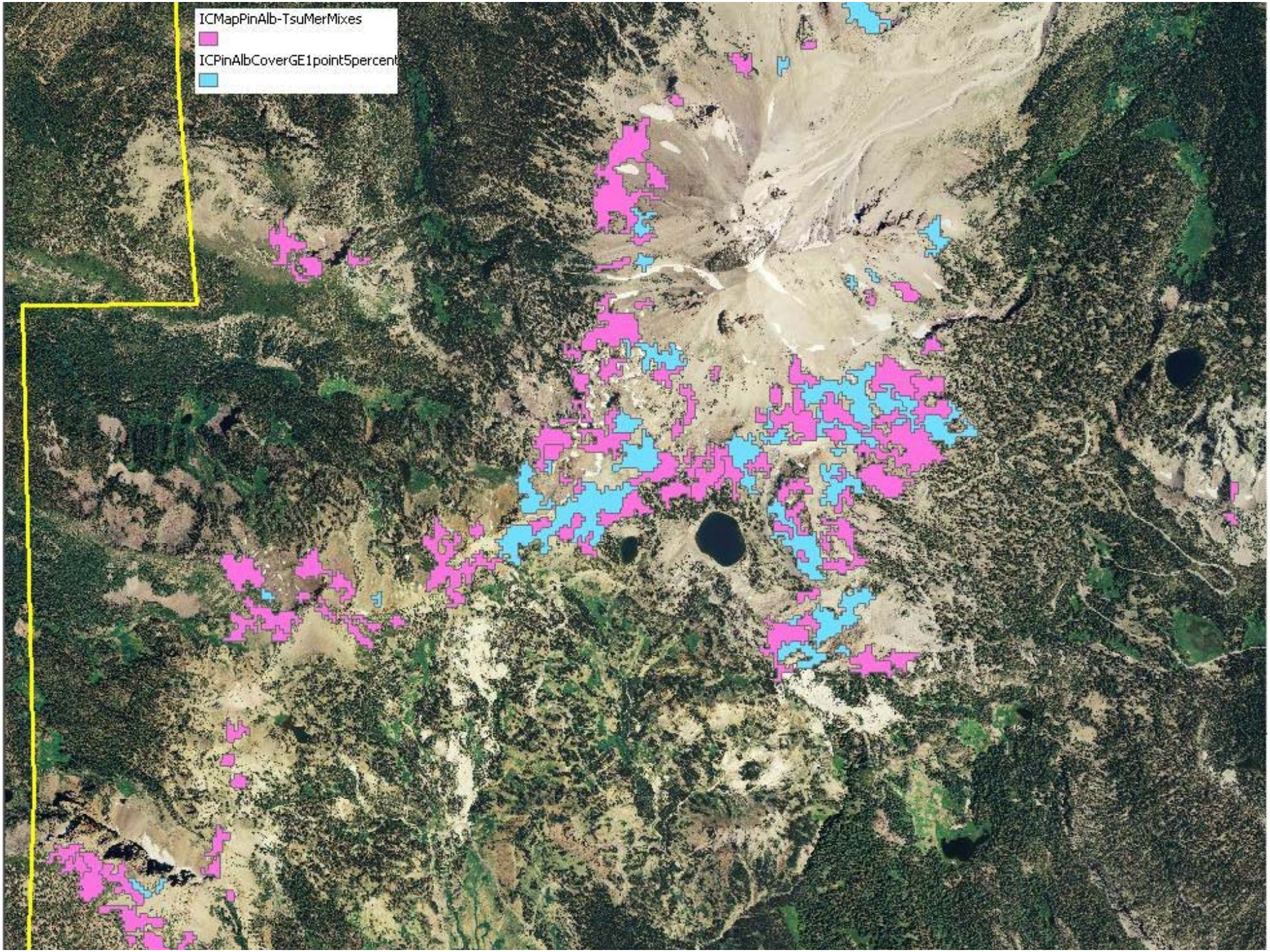
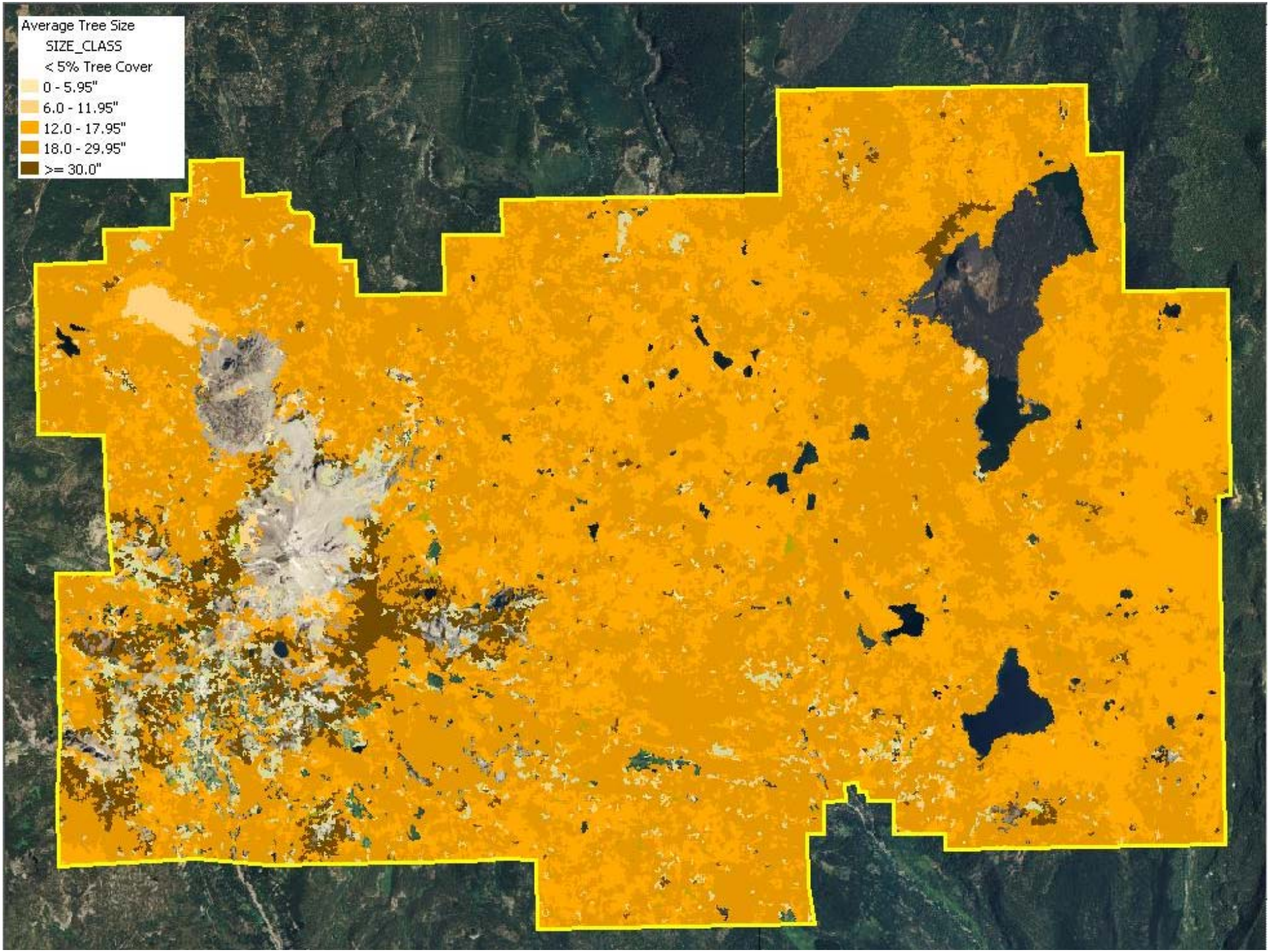
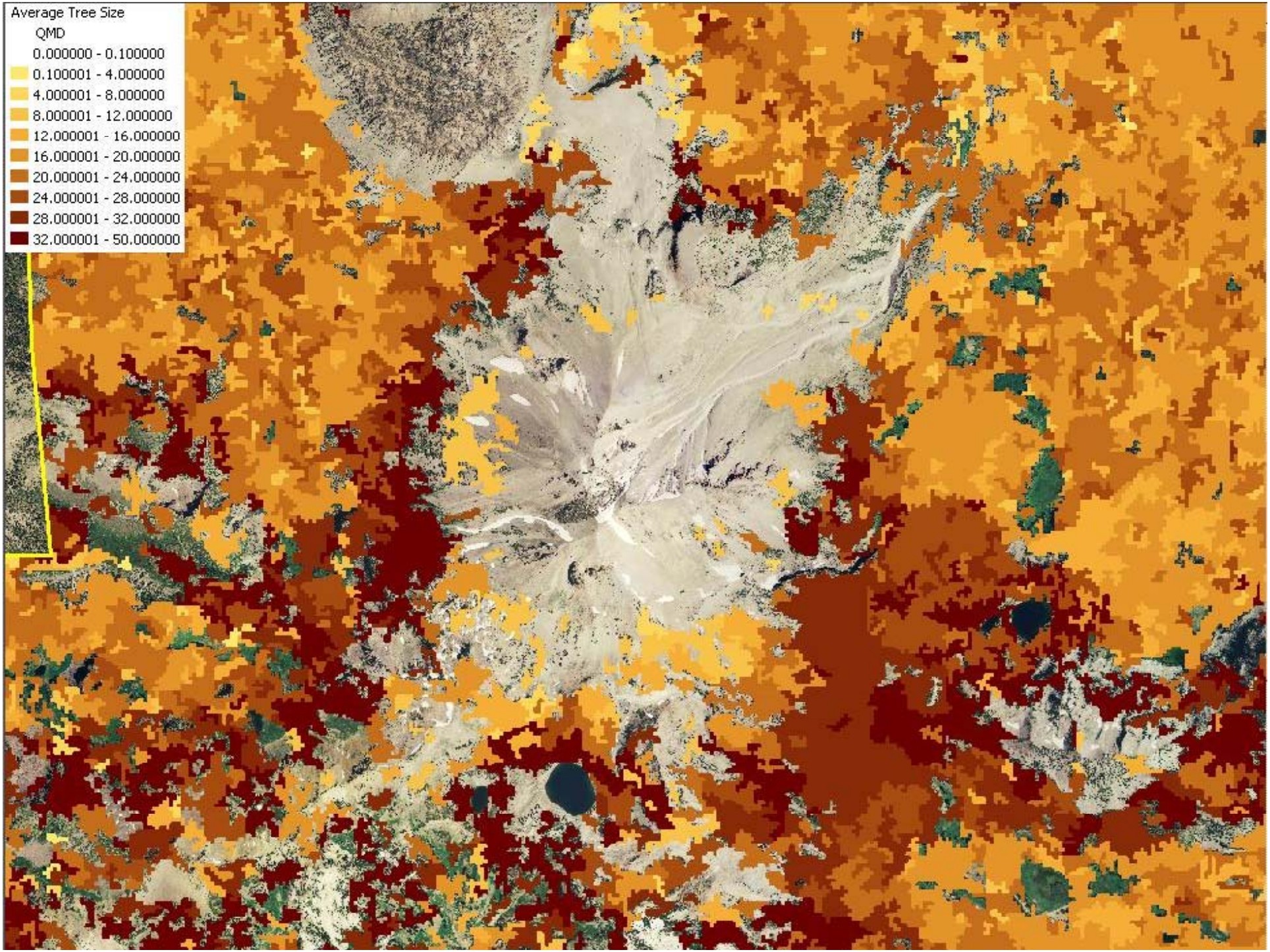
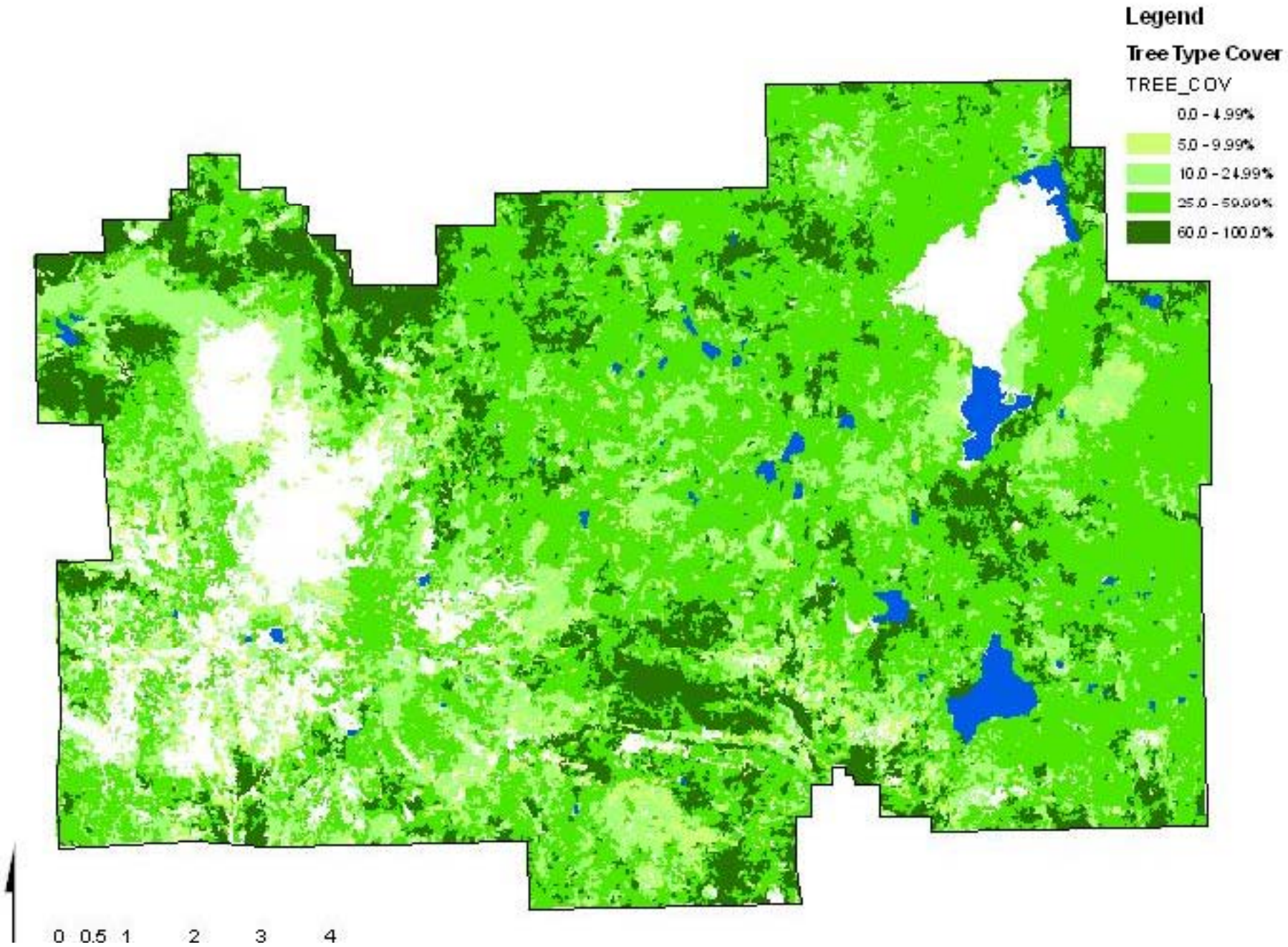

ICMapPinAlb-TsuMerMixes
ICPinAlbCoverGE1point5percent

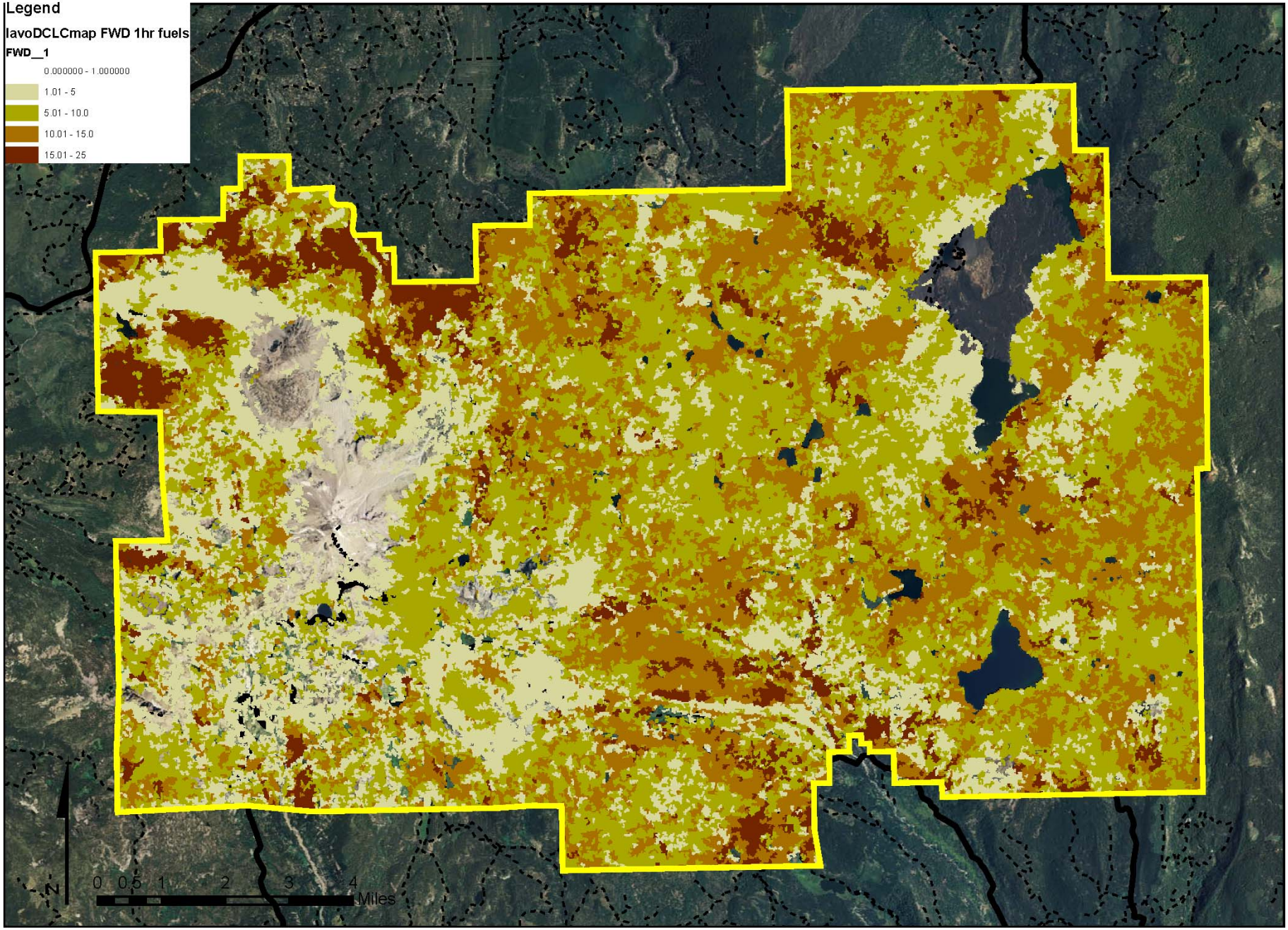

Average Tree Size
SIZE_CLASS
< 5% Tree Cover
0 - 5.95"
6.0 - 11.95"
12.0 - 17.95"
18.0 - 29.95"
>= 30.0"

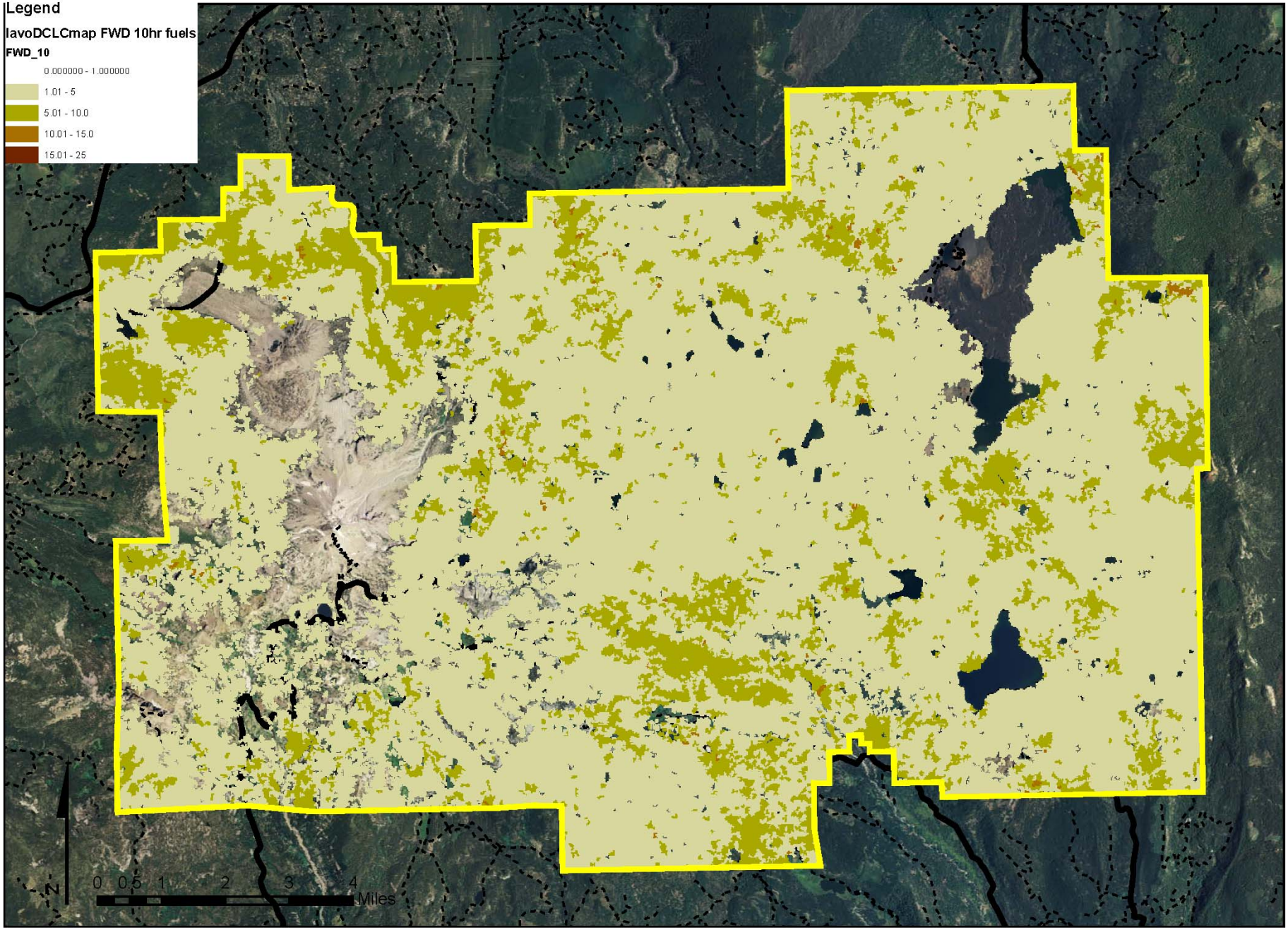

Average Tree Size
QMD
< 5% Tree Cover
0 - 5.95"
6.0 - 11.95"
12.0 - 17.95"
18.0 - 29.95"
>= 30.0"

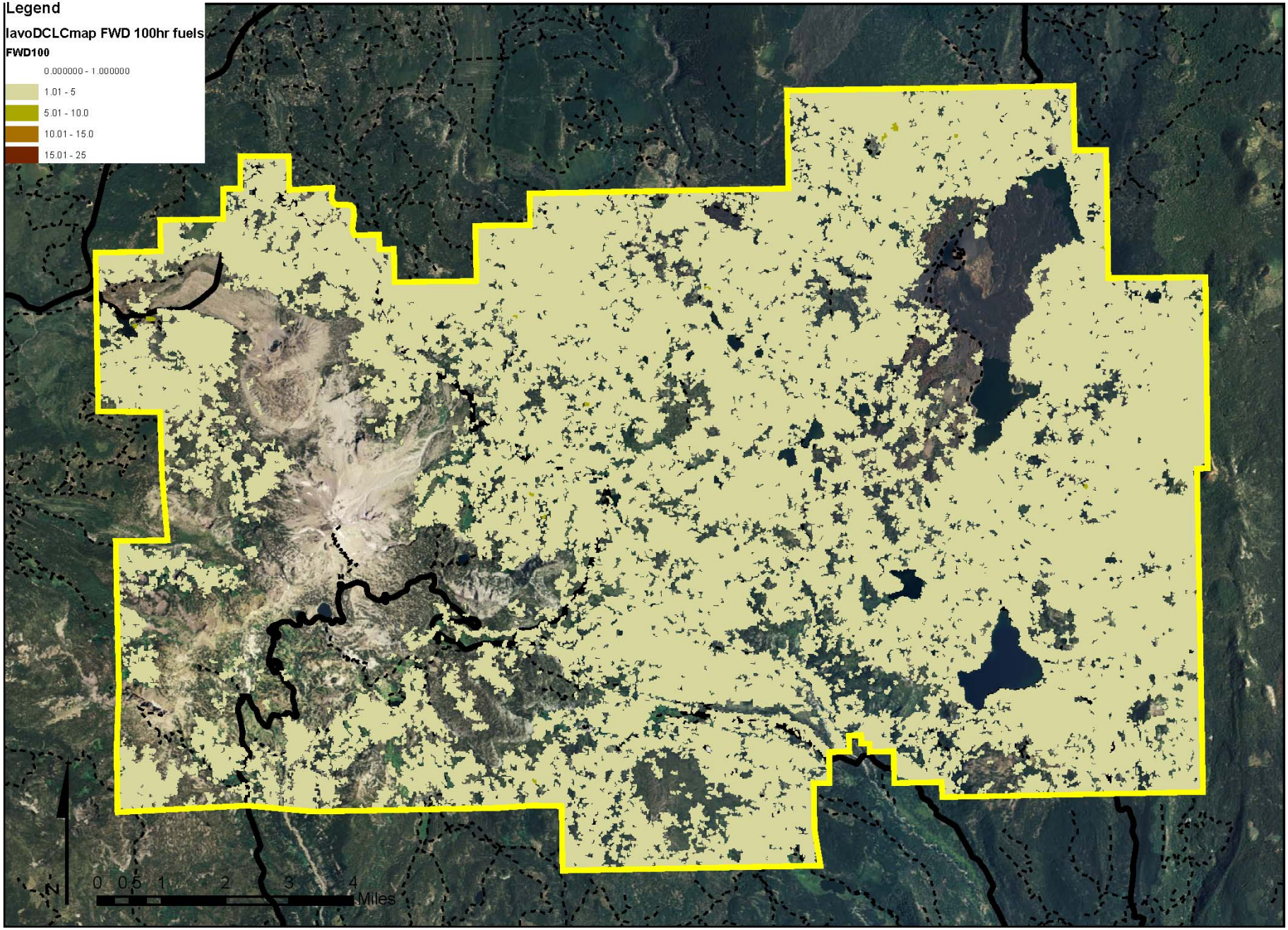

Average Tree Size
QMD
0.000000 - 0.100000
0.100001 - 4.000000
4.000001 - 8.000000
8.000001 - 12.000000
12.000001 - 16.000000
16.000001 - 20.000000
20.000001 - 24.000000
24.000001 - 28.000000
28.000001 - 32.000000
32.000001 - 50.000000

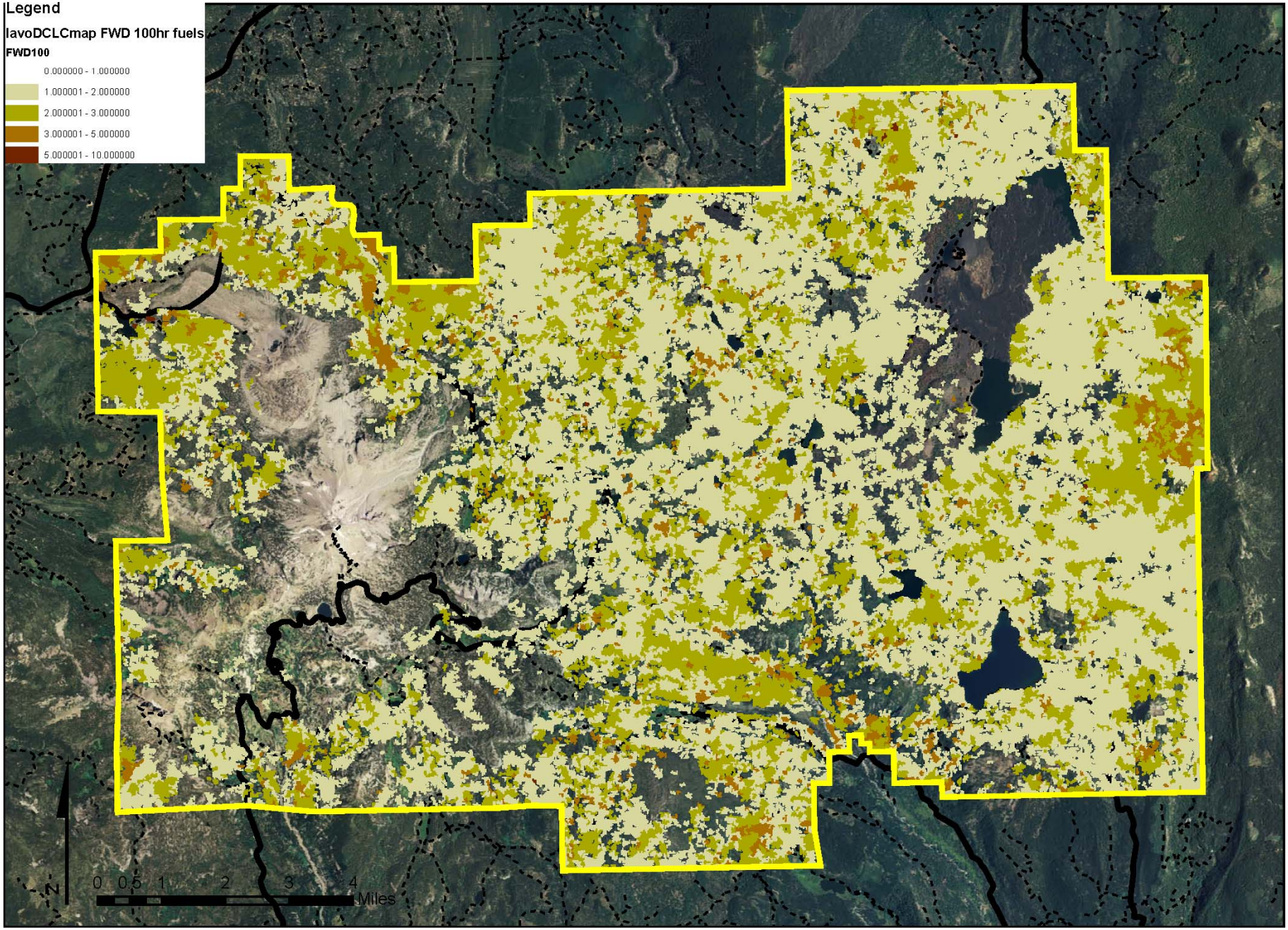
Lassen Volcanic National Park Comparative Mapping Project




Legend
lavoDCLCmap FWD 1hr fuels
FWD__1
0.000000 - 1.000000
1.01 - 5
5.01 - 10.0
10.01 - 15.0
15.01 - 25
N
0 0.5 1 2 3 4
Miles


Legend
lavoDCLCmap FWD 10hr fuels
FWD_10
0.000000 - 1.000000
1.01 - 5
5.01 - 10.0
10.01 - 15.0
15.01 - 25
N
0 0.5 1 2 3 4
Miles

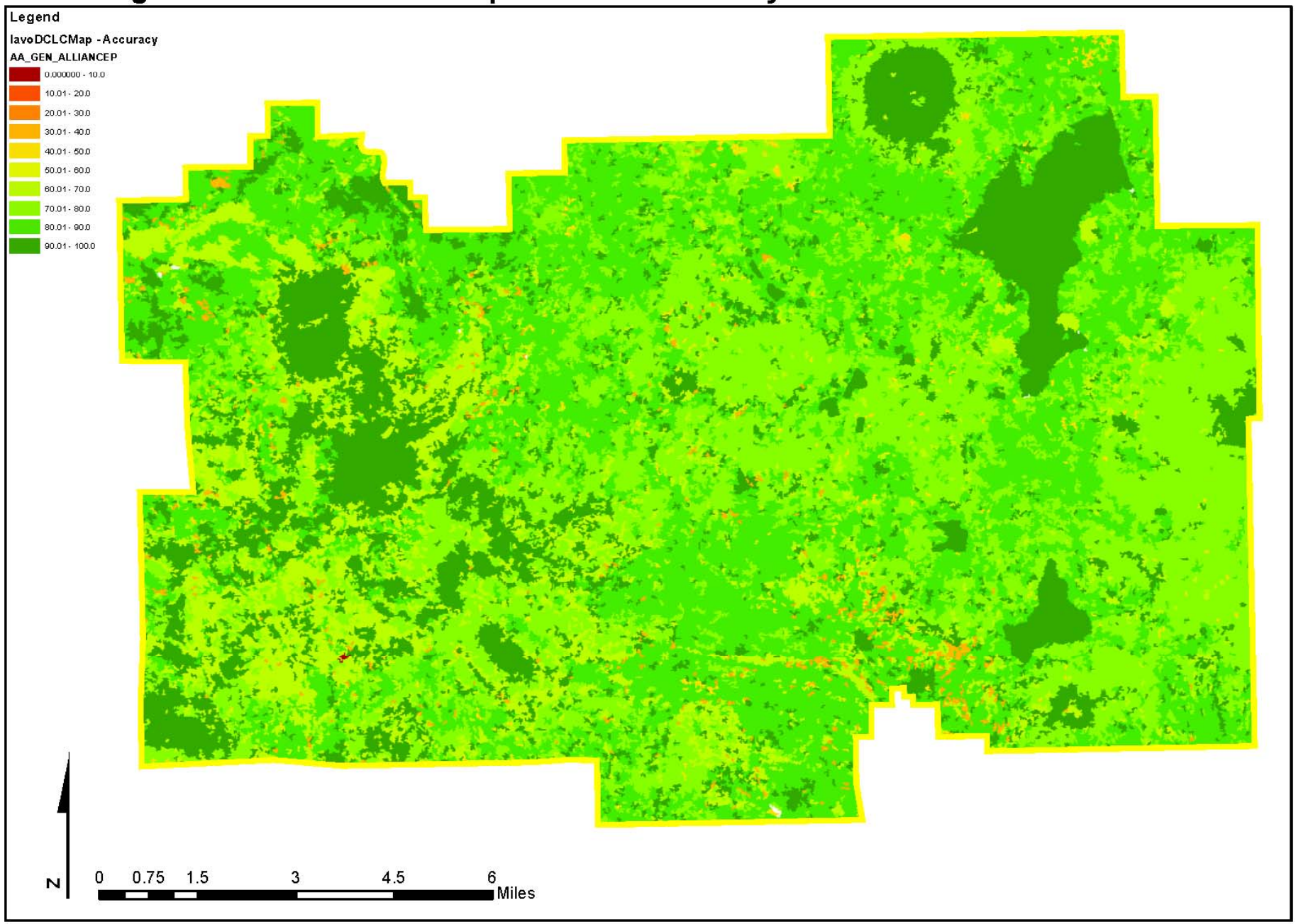

Legend
lavoDCLCmap FWD 100hr fuels
FWD100
0.000000 - 1.000000
1.01 - 5
5.01 - 10.0
10.01 - 15.0
15.01 - 25
N
0 0.5 1 2 3 4
Miles


Legend
lavoDCLCmap FWD 100hr fuels
FWD100
0.000000 - 1.000000
1.000001 - 2.000000
2.000001 - 3.000000
3.000001 - 5.000000
5.000001 - 10.000000
N
0 0.5 1 2 3 4
Miles

“But Wait Just a Minute …”

- **“You are classifying Landsat imagery with 30m resolution”**
  - “You can’t see trees ?”
  - “You can’t see individual species ?”
  - “You can’t see the understory and ground surface ?”
  - “You can’t see tree sizes and stems per acre ?”
  - “You can’t see woody debris size and debris classes ?”

Figure 14: LAVO DCMM Map Percent Correct by NVCS Generalized Alliance



The Discrete Classification Map Data Set Provides

- **A solid foundation of resource information for**
  - Inventory
  - Monitoring major and minor changes
  - Analyses
  - Planning applications
  - Modeling applications
- **A color coded type map and summary info**
  - Make these data products by-products of the process rather than the products!

Geographic Resource Solutions™

Questions and Comments