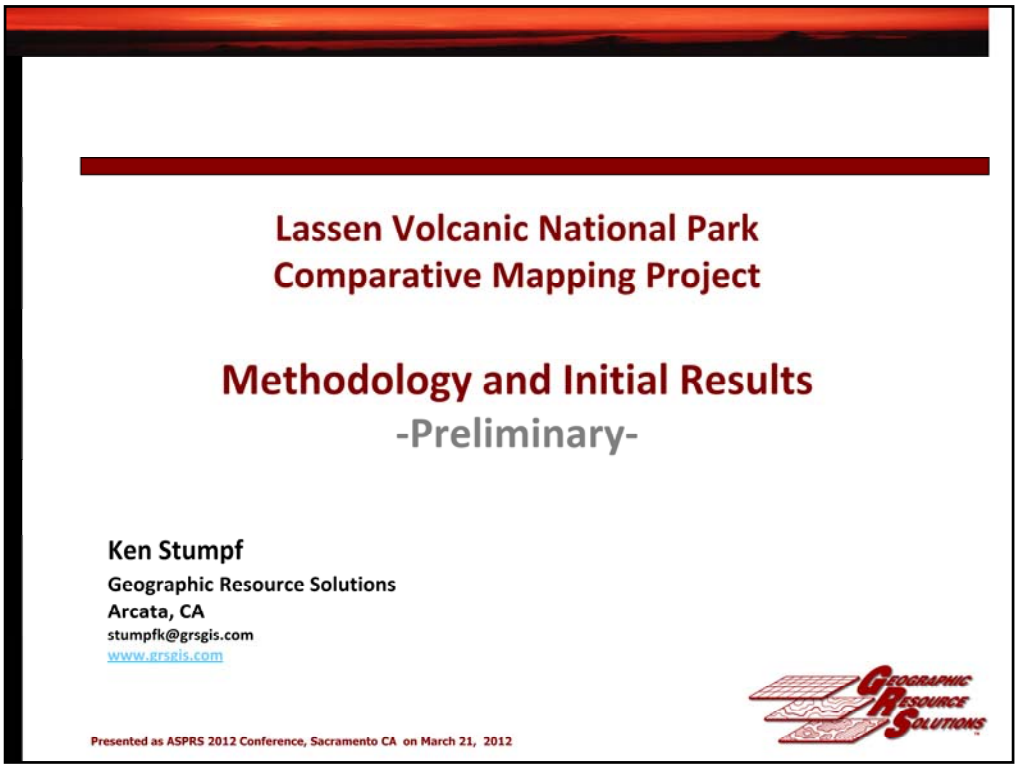


Will talk primarily about our image processing mapping efforts and not the photo interpreted data set.

I am going to move quickly and touch on major points. If I picque your curiosity about something, catch me later and we can talk about it more than I have time to discuss it here.

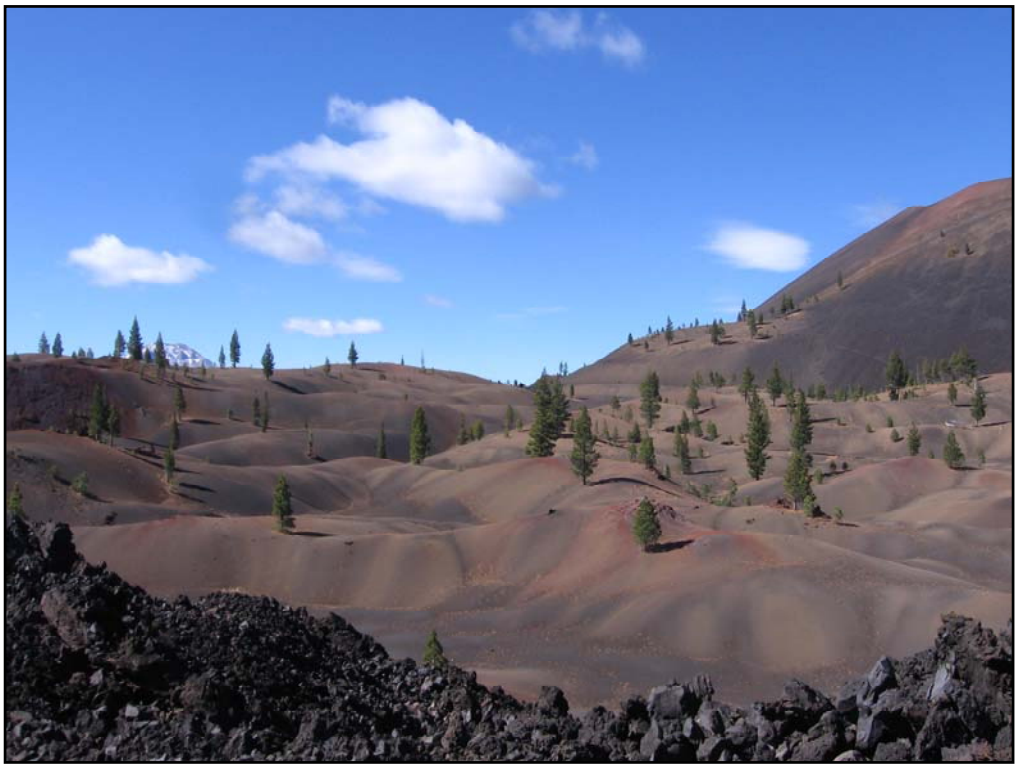
The Park is about a 2-3 hours drive north of Sacramento.

Lassen is mostly known for it's geologic features … All four types of volcanoes found in the entire world are represented in Lassen Volcanic National Park.

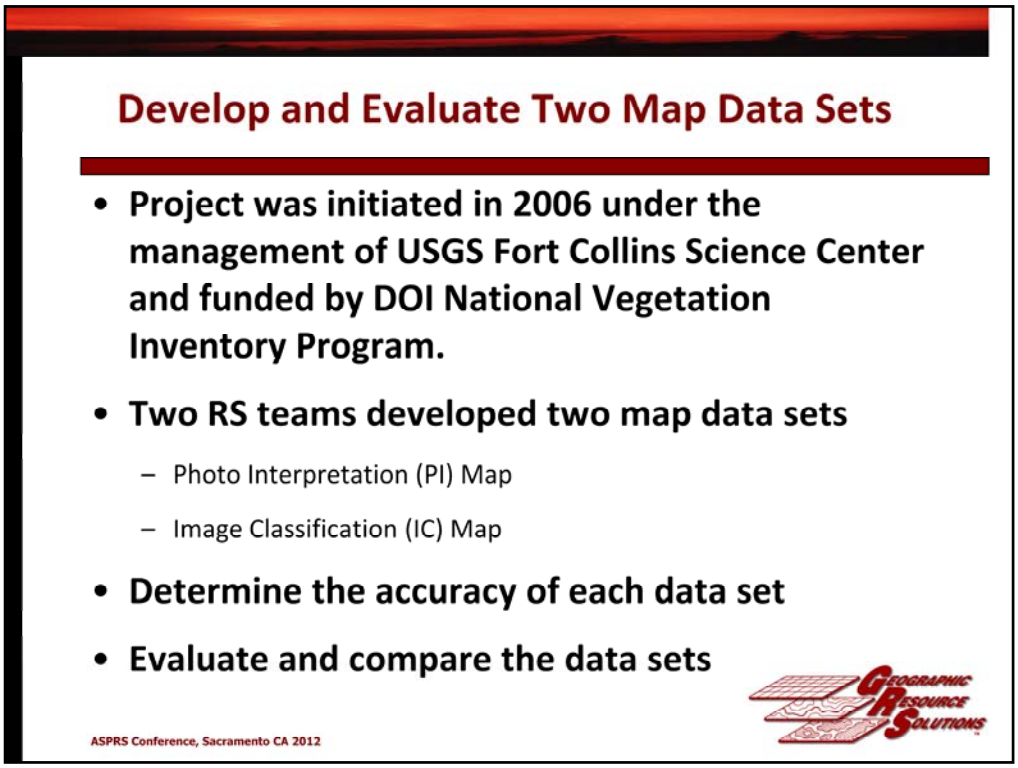
Volcanoes found in the park include **shield** (Prospect Peak), **plug dome** (Lassen Peak), **cindercone** (Cinder Cone), and **composite** (Brokeoff Mountain) volcanoes.

The vegetation at LAVO is extremely diverse as the Park is located at the confluence of the north end of the Sierra Nevada's, the south end of the Cascades, and the western extent of the Great Basin. As a forester I would describe this Park as the "Bermuda Triangle" of vegetation mapping. There were some pretty unbelievable combinations of tree species that I never expected to find.

This particular area is an oddity as the conifers were the first plant species to revegetate this barren rocky area following the collapse of the Crags about 500 years ago. Amazingly, field crews found up to six different conifer species on some of field sites in this area. Each of these conifers is also found in pure stands somewhere in the park.

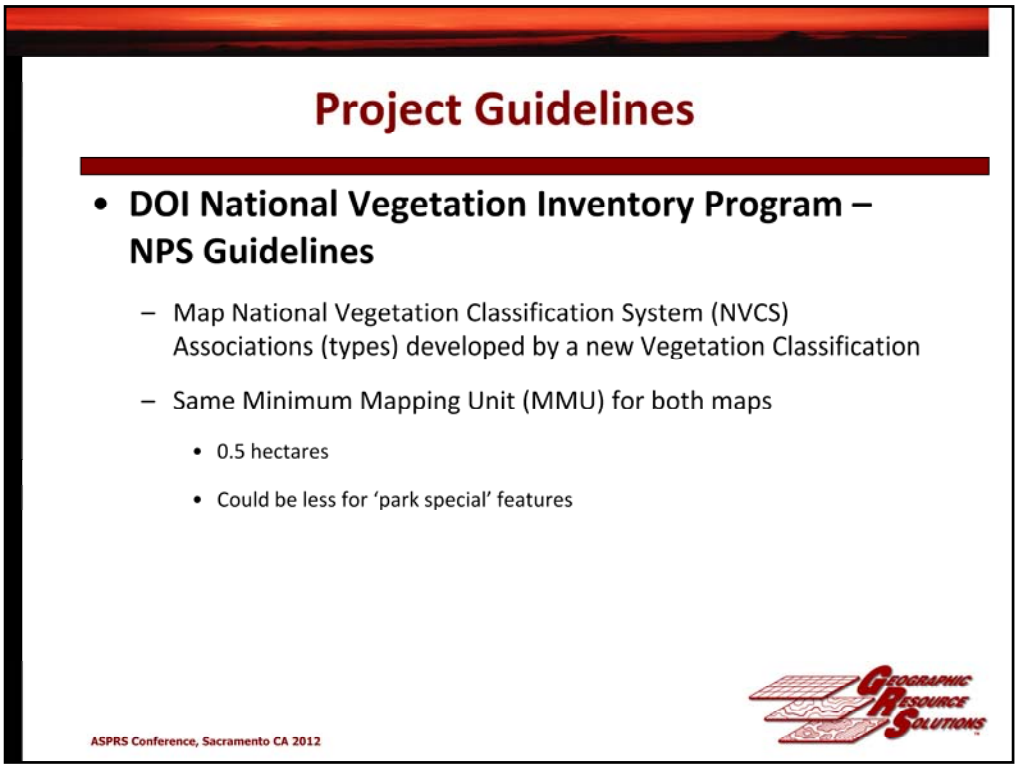


.. There are some amazing places in which we collected field data.

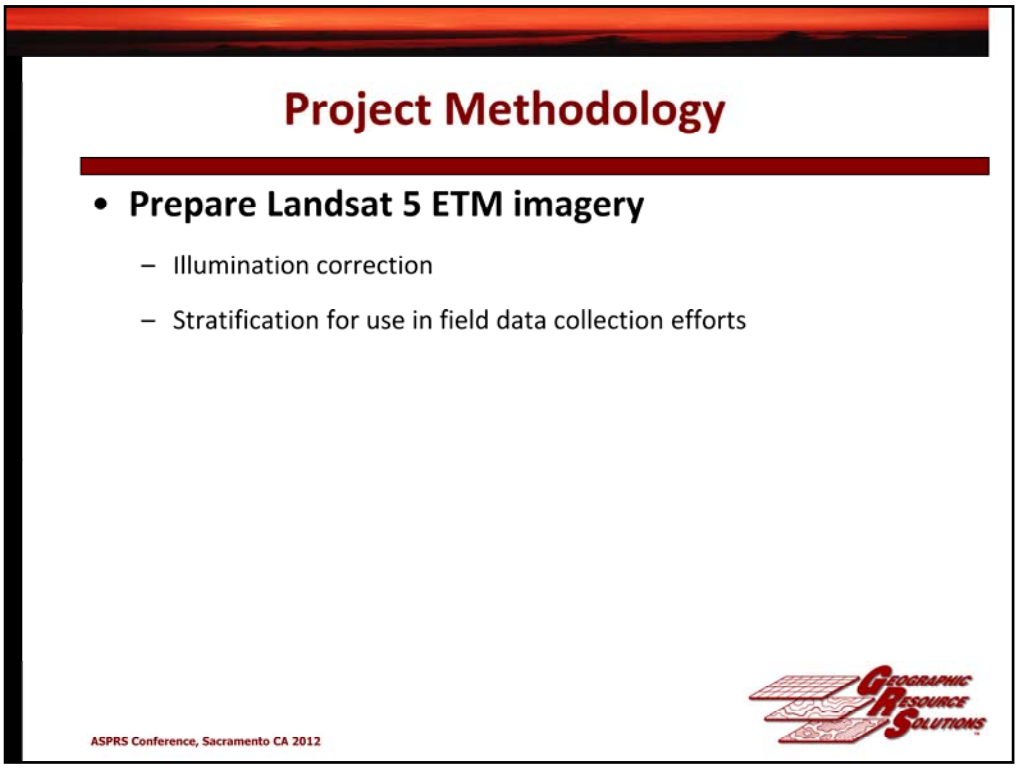


Major Purpose of the Project - Develop and Evaluate Two Map Data Sets

Compare the resulting map data sets in terms of utility with respect to different types of applications

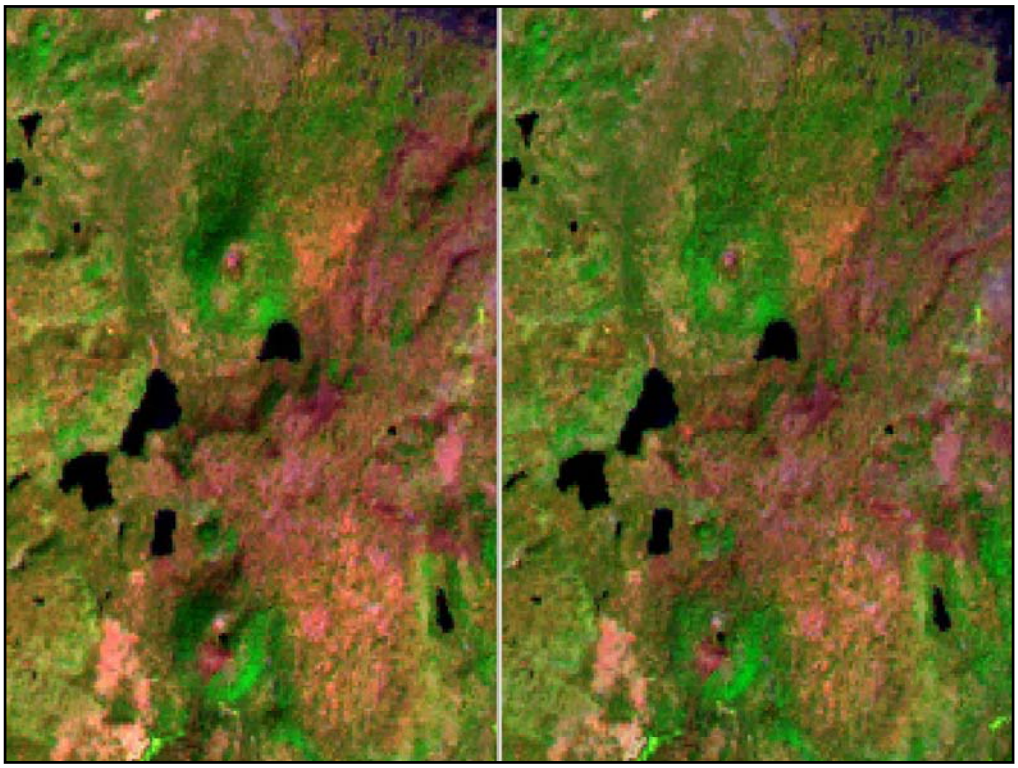


So let me talk about the methodology used in the Project …

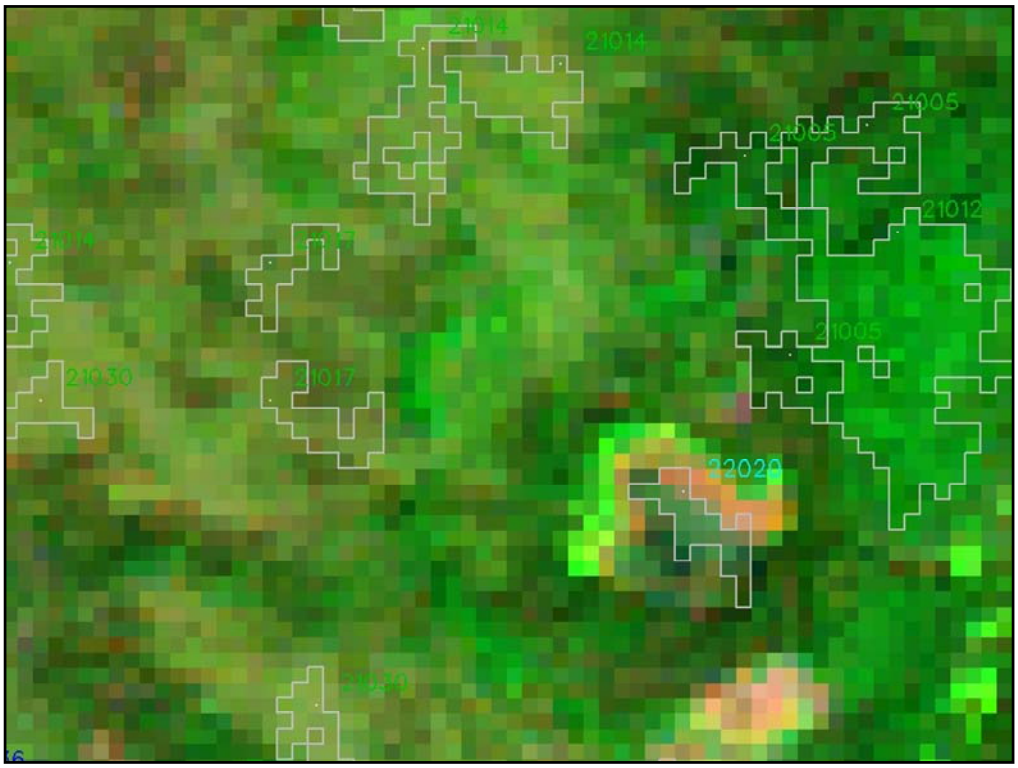


1. **Illumination correction** - Adjust the imagery for differential illumination due to the difference in spectral reflectance caused by slope, aspect, and the sun angel at the time of acquisition. This is a whole other presentation... ***We have found it reduces the confusion in our spectral data and reduces the number of field sites we need to visit and use it as part of every project!***

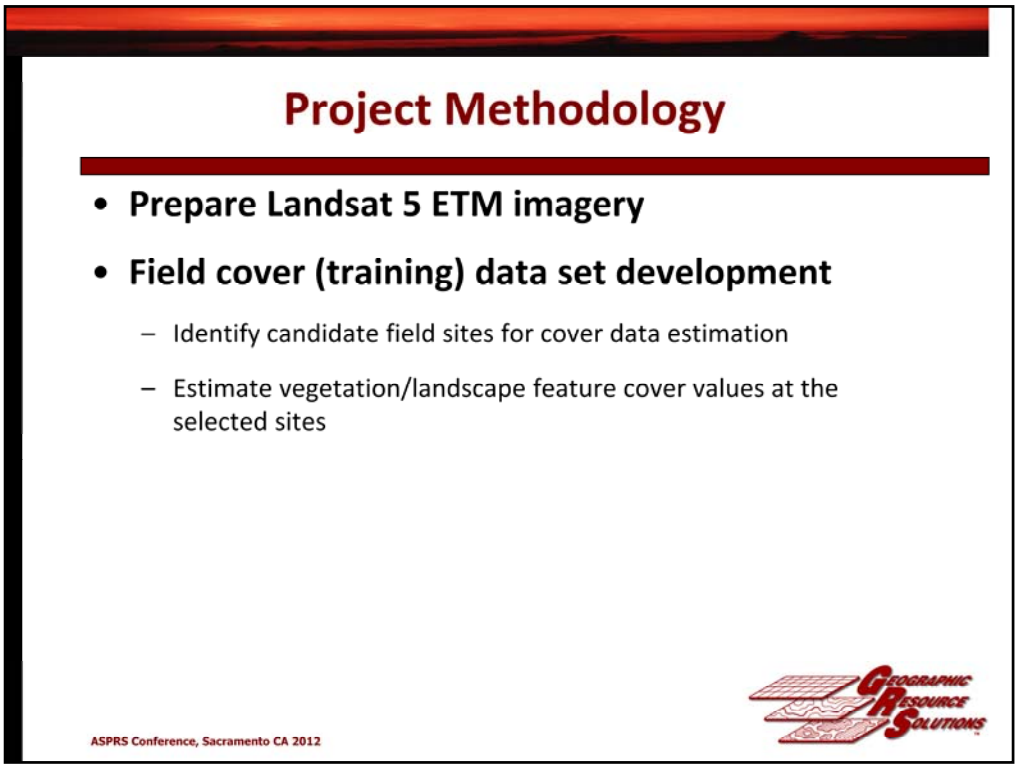
2. **Stratification** - Stratify the imagery to identify "spectrally homogeneous" areas that were large enough to sample as training sites



Our past efforts have shown that the illumination correction both reduces confusion, as well as the number of field sites necessary to classify an area.

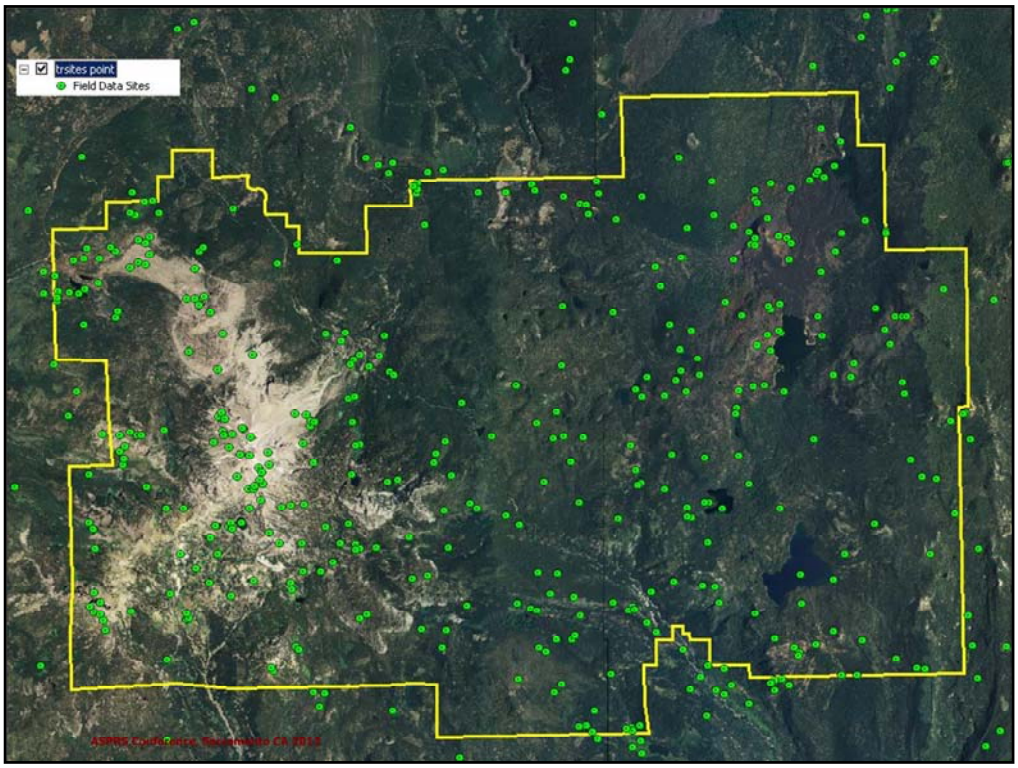


We used the stratification to guide our field data collection efforts … so we would concentrate training data collection activities in homogeneous areas that represent the diversity of the types across the landscape of the Park.



Objectives were to cover the extent of the Project Area and the diversity of the vegetation and landscape features present in the Project Area.

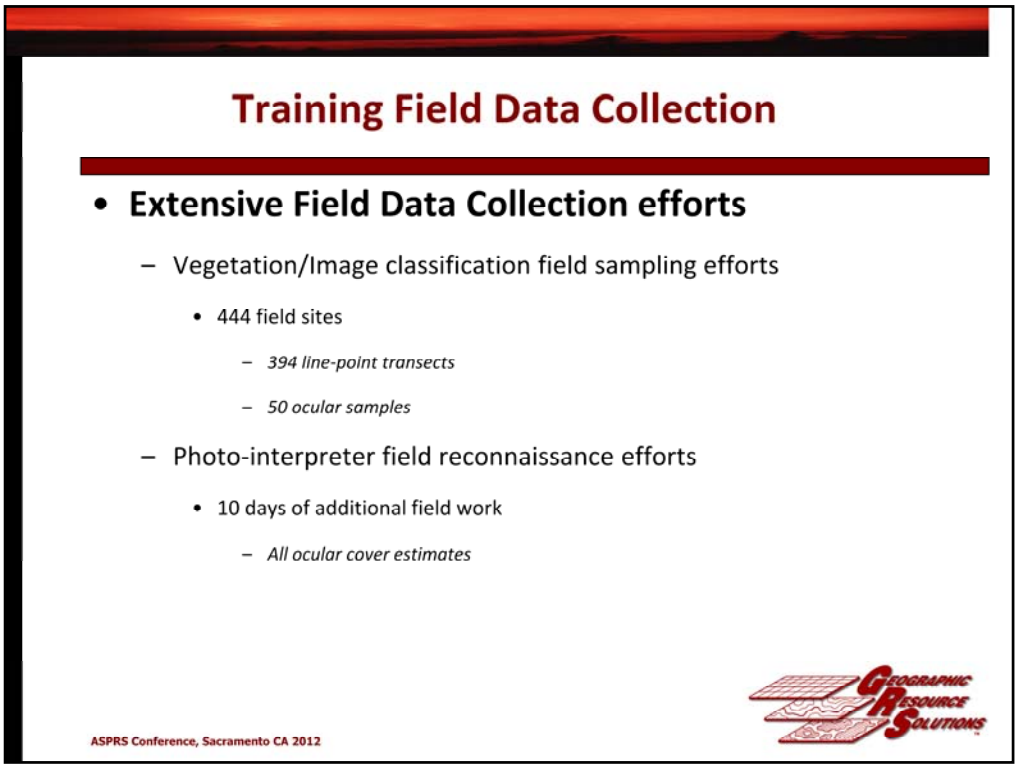
In this project we were going to develop a data set that could be used for both the Vegetation Classification, as well as the Remote Sensing efforts.



Site selection – plans were developed that were designed to assure that the extent of the Project Area and the diversity of the land cover types were sampled.

We aimed for multiple samples of every stratum in the stratification and limited repeat sampling of a class in the same “vicinity” unless that class was limited to that portion of the Project Area.

Sample plans were developed and implemented to visit and sample the areas that we thought best represented the diversity of the Park.



Field data collection efforts supported the development of the vegetation classification and the two map data sets …

444 sites for the Veg Classification and mapping.

We collected field data to create consistent data estimates between field crews

Used Ocular approach for “no-brainers”

In addition,,, the PhotoInterpreters spent 10 days developing their own set of training areas in support of their efforts.

Bird's-eye Cover Estimates By Species

Percent Cover Summary for Bird's-eye Layer:
Site/Polygon Id: 83001

Dbh Size Class:	<= 5.95"	> 5.95" <=11.95"	>11.95" <=17.95"	>17.95" <=29.95"	>29.95"	Tree Cover	Non-Tree Cover	Total Cover
Species								
West white pine	4.0	0.0	0.0	0.0	0.0	4.0		4.0
Red fir	4.0	8.0	16.0	22.0	0.0	50.0		50.0
Mtn hemlock	2.0	0.0	0.0	0.0	0.0	2.0		2.0
BarSoil							4.0	4.0
BarSGTA							9.0	9.0
FWD							6.0	6.0
Litter/Duff							25.0	25.0
Totals	10.0	8.0	16.0	22.0	0.0	56.0	44.0	100.0

Tree Cover Composition Summary for Bird's-eye Layer 56.0 Cover:

Dbh Size Class:	<= 5.95"	> 5.95" <=11.95"	>11.95" <=17.95"	>17.95" <=29.95"	>29.95"	All Sizes
Species						
West white pine	7.1	0.0	0.0	0.0	0.0	7.1
Red fir	7.1	14.3	28.6	39.3	0.0	89.3
Mtn hemlock	3.6	0.0	0.0	0.0	0.0	3.6
Totals	17.9	14.3	28.6	39.3	0.0	100.0

Percent conifer composition= 100.0
Percent hardwood composition= 0.0
Most common specie is Red fir with 89.3 percent cover composition

Species Cover and relative cover or species composition

Bird's-eye QMD and TPA By Species

Quadratic Mean DBH and TPA Summary for Bird's-eye Layer:
Weighted by Cover

Dbh Size Class:	<= 5.95"	> 5.95" <=11.95"	>11.95" <=17.95"	>17.95" <=29.95"	>29.95"	All Sizes
Species						
West white pine	3.0"	0.0"	0.0"	0.0"	0.0"	3.0"
cov_wt	4.0	0.0	0.0	0.0	0.0	4.0
tpa	299.9	0.0	0.0	0.0	0.0	299.9
Red fir	1.5"	8.3"	14.0"	22.5"	0.0"	17.2"
cov_wt	4.0	8.0	16.0	22.0	0.0	50.0
tpa	246.5	90.6	129.2	37.3	0.0	503.6
Mtn hemlock	0.0"	0.0"	0.0"	0.0"	0.0"	0.0"
cov_wt	2.0	0.0	0.0	0.0	0.0	2.0
tpa	123.2	0.0	0.0	0.0	0.0	123.2
Conifer	2.1"	8.3"	14.0"	22.5"	0.0"	16.3"
cov_wt	10.0	8.0	16.0	22.0	0.0	56.0
tpa	669.6	90.6	129.2	37.3	0.0	926.7
All Species	2.1"	8.3"	14.0"	22.5"	0.0"	16.3"
cov_wt	10.0	8.0	16.0	22.0	0.0	56.0
tpa	669.6	90.6	129.2	37.3	0.0	926.7

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Size and Trees/Acre

Total Cover Estimates By Species

Percent Cover Summary for All Layers:
Site/Polygon Id: 83001

Dbh Size Class:	<= 5.95"	> 5.95" <=11.95"	>11.95" <=17.95"	>17.95" <=29.95"	>29.95"	Tree Cover	Non-Tree Cover	Total Cover
Species								
West white pine	4.0	0.0	0.0	0.0	0.0	4.0		4.0
Red fir	8.0	14.0	18.0	22.0	0.0	62.0		62.0
Mtn hemlock	4.0	2.0	2.0	0.0	0.0	8.0		8.0
BarSoil							4.0	4.0
BarSGTA							9.0	9.0
FWD							20.0	20.0
Litter/Duff							67.0	67.0
Traces:								
CARMUA, CALUMB, CHIMEN, Penstemon sp								
Totals	16.0	16.0	20.0	22.0	0.0	74.0	100.0	174.0

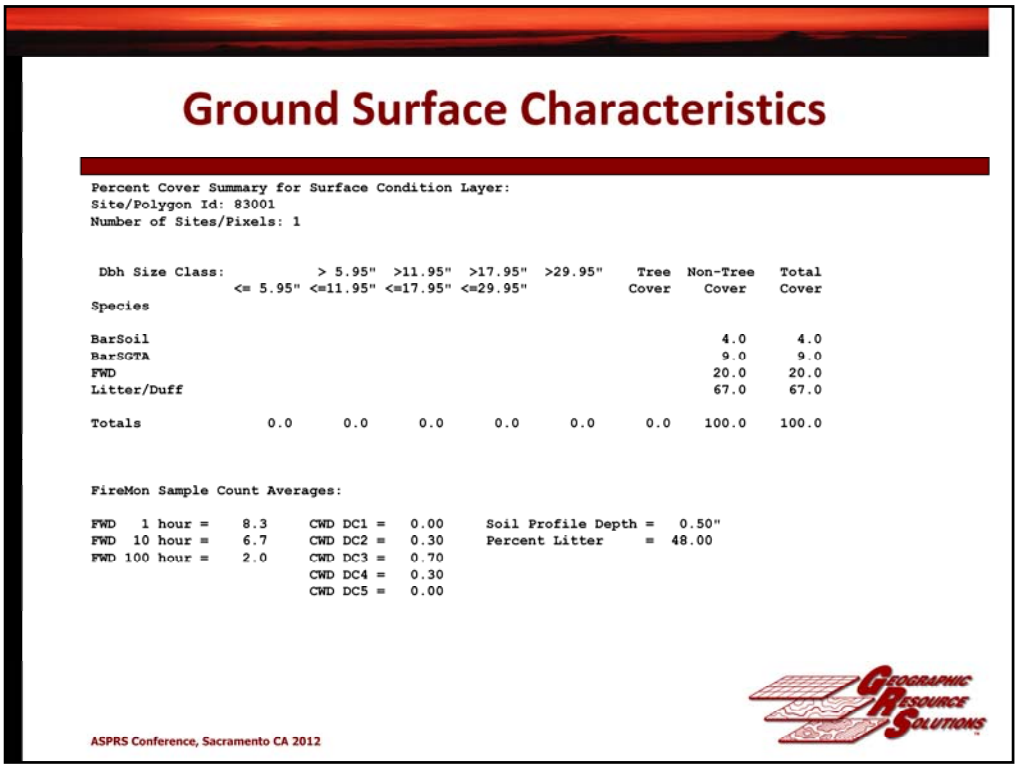
Tree Cover Composition Summary for All Layers 74.0 Cover:

Dbh Size Class:	<= 5.95"	> 5.95" <=11.95"	>11.95" <=17.95"	>17.95" <=29.95"	>29.95"	All Sizes
Species						
West white pine	5.4	0.0	0.0	0.0	0.0	5.4
Red fir	10.8	18.9	24.3	29.7	0.0	83.8
Mtn hemlock	5.4	2.7	2.7	0.0	0.0	10.8
Totals	21.6	21.6	27.0	29.7	0.0	100.0

Percent conifer composition= 100.0
Percent hardwood composition= 0.0
Most common specie is Red fir with 83.8 percent cover composition

While we can only “see” or detect the Bird’s-eye view in our remotely sensed imagery, we are really trying to map ecosytems.

The ecologists don’t rely on just the Bird’s-eye view, so we also developed estimates of total cover.

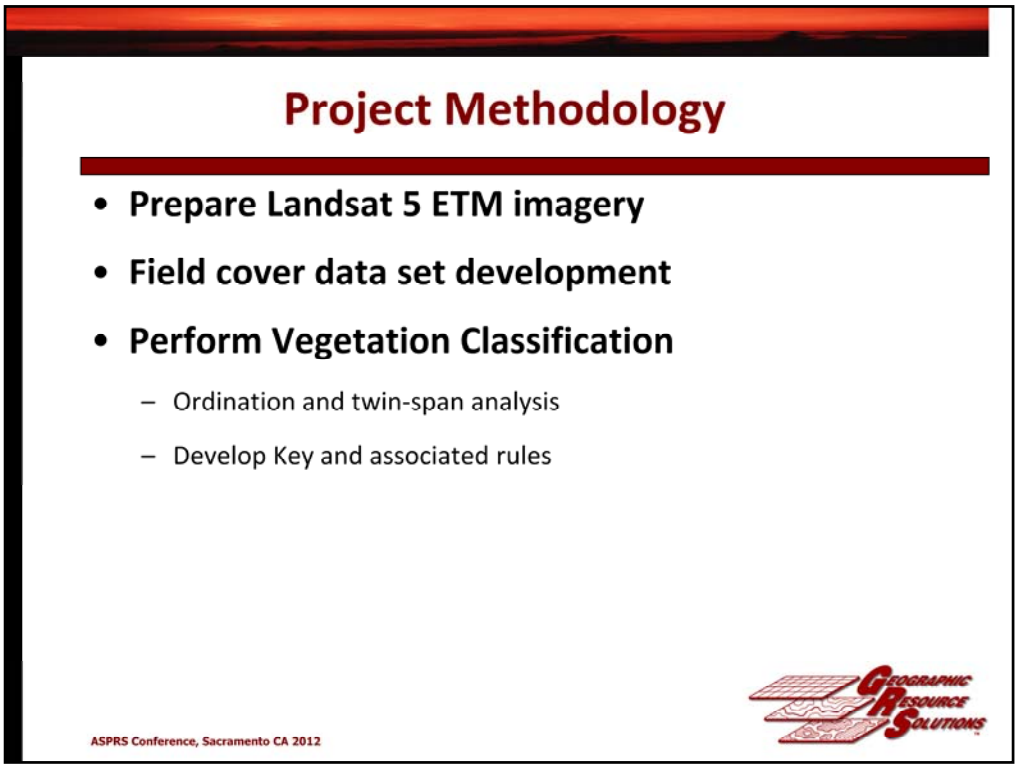


As part of these training site ecosystem assessments we also collected information describing the condition of the ground surface at each site.

We integrated the Fire Monitoring Sampling protocol into the field sampling effort with little additional effort.

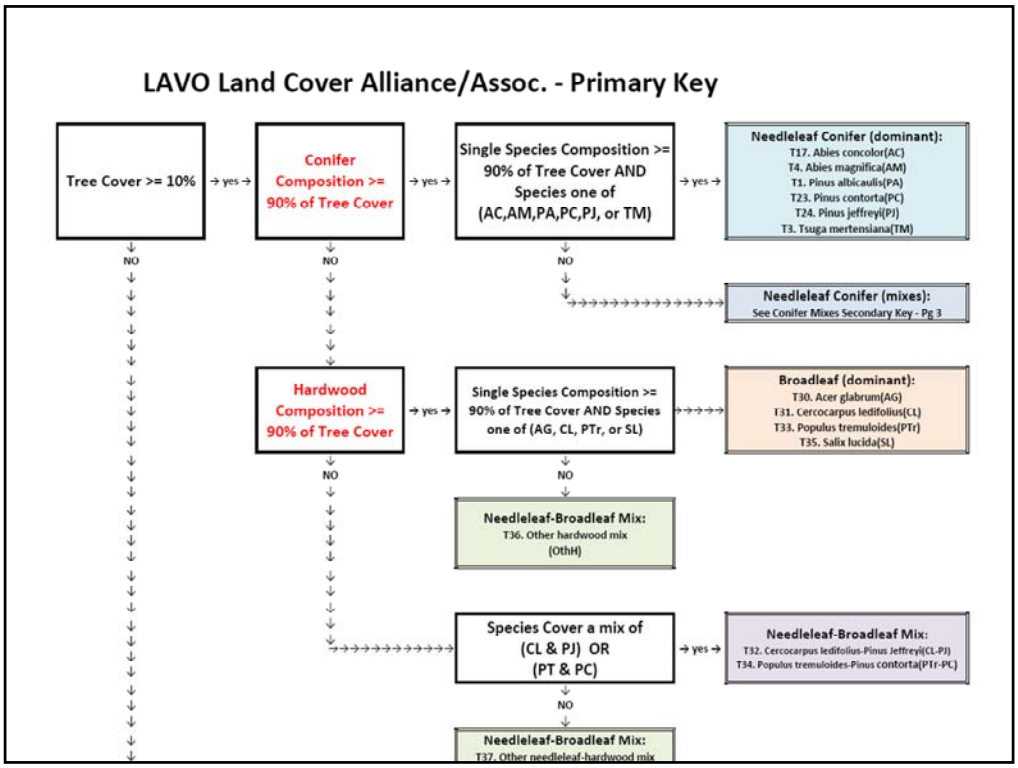
This resulted in counts of FWD and CWD information for each site that can be used to develop fire fuel estimates.

All veg data loaded into PLOTS data base



Next step of the methodology was the Vegetation Classification …

Ordination and twin-span analysis are forms of cluster analysis that assign field sites into groups or “types” based on the similarity of the species that are present and the relative cover of the different species



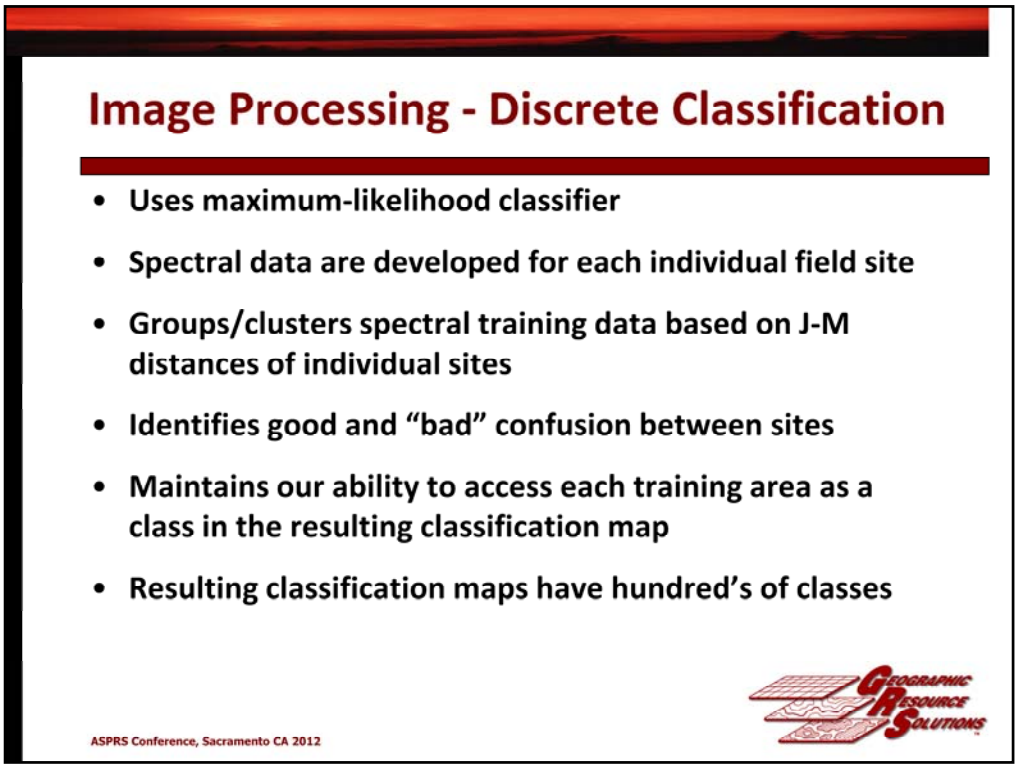
This is an portion of the Field Key developed from the Vegetation Classification efforts that was used to develop type calls based on Ground-truth.

The following table shows all species and associated features in this association and gives percent frequency, average percent cover, and range (minimum and maximum) in cover for the plots in which they occur.

Detailed Alliance Species	Bird's-Eye Frequency (%)	Bird's-Eye Average Cover	Bird's-Eye Minimum Cover	Bird's-Eye Maximum Cover	Total Frequency (%)	Total Average Cover	Total Minimum Cover	Total Maximum Cover
Tsuga mertensiana	100	12.8	8	16	100	14.1	8	22
Pinus albicaulis	100	9.3	2	15	100	9.8	2	15
Total tree		**22.1**				**23.9**		
Total shrub		**0**				**0**		
Lupinus obtusilobus	87.5	25	10	43	87.5	25.3	10	43
Polygonum davisiae	87.5	6.4	1	10	87.5	6.4	1	10
Carex species	25	1.5	2	10.2	25	1.5	2	10.2
Other Graminoids	37.5	0.8	1	3.1	37.5	0.8	1	3.1
Eriogonum marifolium	25	0.6	2	3.1	37.5	0.6	2	3.1
Calyptridium umbellatum	12.5	0.5	4	4	12.5	0.5	4	4
Carex leptalea	12.5	0.5	4.1	4.1	12.5	0.8	6.1	6.1
Carex straminiformis	12.5	0.3	2	2	12.5	0.3	2	2
Arabis species	12.5	0.1	1	1	12.5	0.1	1	1
Aster integrifolius	12.5	0.1	1	1	12.5	0.1	1	1
Castilleja species	P	T	T	T	12.5	T	T	T
Elymus Elymoides	P	T	T	T	12.5	T	T	T
Monardella odoratissima	P	T	T	T	12.5	T	T	T
Penstemon species	P	T	T	T	12.5	T	T	T
Polygonum shastense	P	T	T	T	12.5	T	T	T
Viola species	P	T	T	T	12.5	T	T	T
Total herbaceous		**35.8**				**36.4**		
Lichen	12.5	0.3	2	2	12.5	0.3	2	2
Total nonvascular		**0.3**				**0.3**		
Fine Gravelly Soil	87.5	12.3	9	20.4	87.5	18.3	9	58
Bare Rock	100	25.1	6	50	100	28.6	8	50
Bare Soil	25	1.8	2	12	25	3	4.1	20
Gravel	12.5	0.3	2	2	12.5	0.8	6.1	6.1
Fine Woody Debris	25	0.5	2	2	25	0.6	2	3.1
Litter	87.5	2	1	6	87.5	10.9	1	34
Total other		**42**				**62.2**		
Totals		**100**				**146**		

Frequency of Occurrence … and cover values – Average, min, and max for 8 Sites …

Bird's-eye and Total – All Layers …



The next step in the methodology concerns our classification efforts.

I am now going to focus on the Image Classification effort – it was based upon an application of what has been called "Discrete Classification."

1. Uses maximum-likelihood classifier

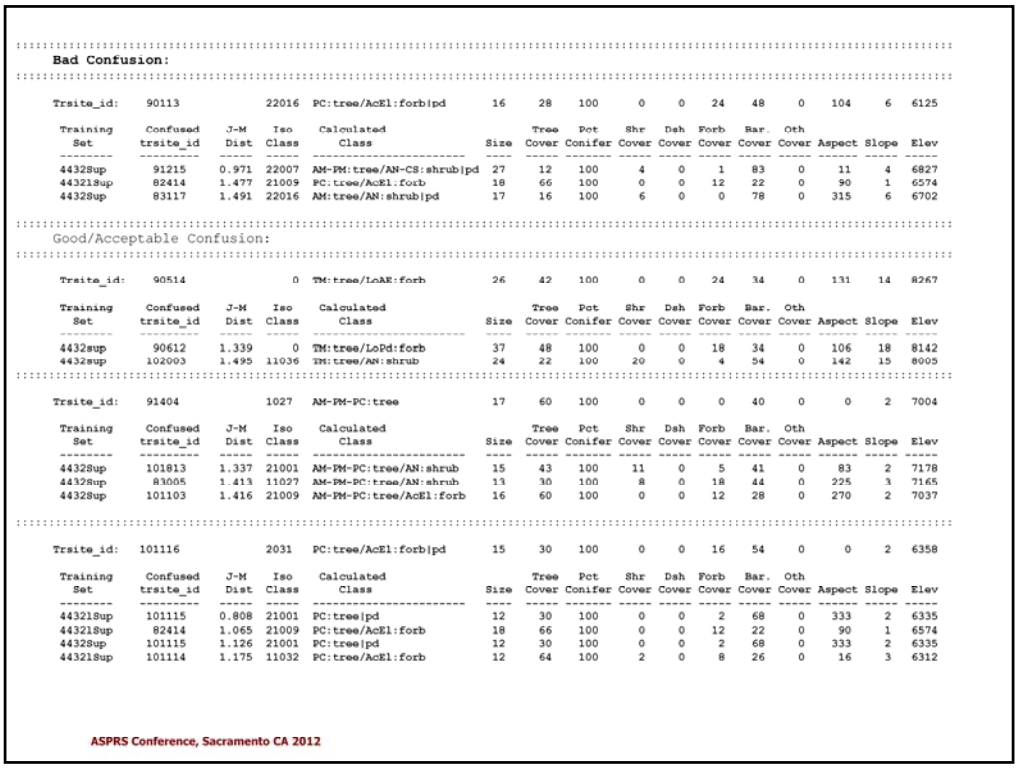
2. Spectral data are processed for each individual field site

3. Groups or clusters training data based on J-M distances of individual

4. Retains our ability to access each training area as a class in the resulting classification map

5. Classification maps have hundred's of classes

6. Confusion is identified and resolved



Bad Confusion:

Trsite_id:	90113		22016	PC:tree/AcEl:forb|pd	16	28	100	0	0	24	48	0	104	6	6125

Training Set	Confused trsite_id	J-M Dist	Iso Class	Calculated Class	Size	Tree Cover	Pct Conifer	Shr Cover	Dsh Cover	Forb Cover	Bar. Cover	Oth Cover	Aspect	Slope	Elev
4432Sup	91215	0.971	22007	AM-PM:tree/AN-CS:shrub|pd	27	12	100	4	0	1	83	0	11	4	6827
44321Sup	82414	1.477	21009	PC:tree/AcEl:forb	18	66	100	0	0	12	22	0	90	1	6574
4432Sup	83117	1.491	22016	AM:tree/AN:shrub|pd	17	16	100	6	0	0	78	0	315	6	6702

Good/Acceptable Confusion:

Trsite_id:	90514		0	TM:tree/LoAE:forb	26	42	100	0	0	24	34	0	131	14	8267

Training Set	Confused trsite_id	J-M Dist	Iso Class	Calculated Class	Size	Tree Cover	Pct Conifer	Shr Cover	Dsh Cover	Forb Cover	Bar. Cover	Oth Cover	Aspect	Slope	Elev
4432Sup	90612	1.339	0	TM:tree/LoPd:forb	37	48	100	0	0	18	34	0	106	18	8142
4432Sup	102003	1.495	11036	TM:tree/AN:shrub	24	22	100	20	0	4	54	0	142	15	8005

Trsite_id:	91404		1027	AM-PM-PC:tree	17	60	100	0	0	0	40	0	0	2	7004

Training Set	Confused trsite_id	J-M Dist	Iso Class	Calculated Class	Size	Tree Cover	Pct Conifer	Shr Cover	Dsh Cover	Forb Cover	Bar. Cover	Oth Cover	Aspect	Slope	Elev
4432Sup	101813	1.337	21001	AM-PM-PC:tree/AN:shrub	15	43	100	11	0	5	41	0	83	2	7178
4432Sup	83005	1.413	11027	AM-PM-PC:tree/AN:shrub	13	30	100	8	0	18	44	0	225	3	7165
4432Sup	101103	1.416	21009	AM-PM-PC:tree/AcEl:forb	16	60	100	0	0	12	28	0	270	2	7037

Trsite_id:	101116		2031	PC:tree/AcEl:forb|pd	15	30	100	0	0	16	54	0	0	2	6358

Training Set	Confused trsite_id	J-M Dist	Iso Class	Calculated Class	Size	Tree Cover	Pct Conifer	Shr Cover	Dsh Cover	Forb Cover	Bar. Cover	Oth Cover	Aspect	Slope	Elev
44321Sup	101115	0.808	21001	PC:tree|pd	12	30	100	0	0	2	68	0	333	2	6335
44321Sup	82414	1.065	21009	PC:tree/AcEl:forb	18	66	100	0	0	12	22	0	90	1	6574
4432Sup	101115	1.126	21001	PC:tree|pd	12	30	100	0	0	2	68	0	333	2	6335
44321Sup	101114	1.175	11032	PC:tree/AcEl:forb	12	64	100	2	0	8	26	0	16	3	6312

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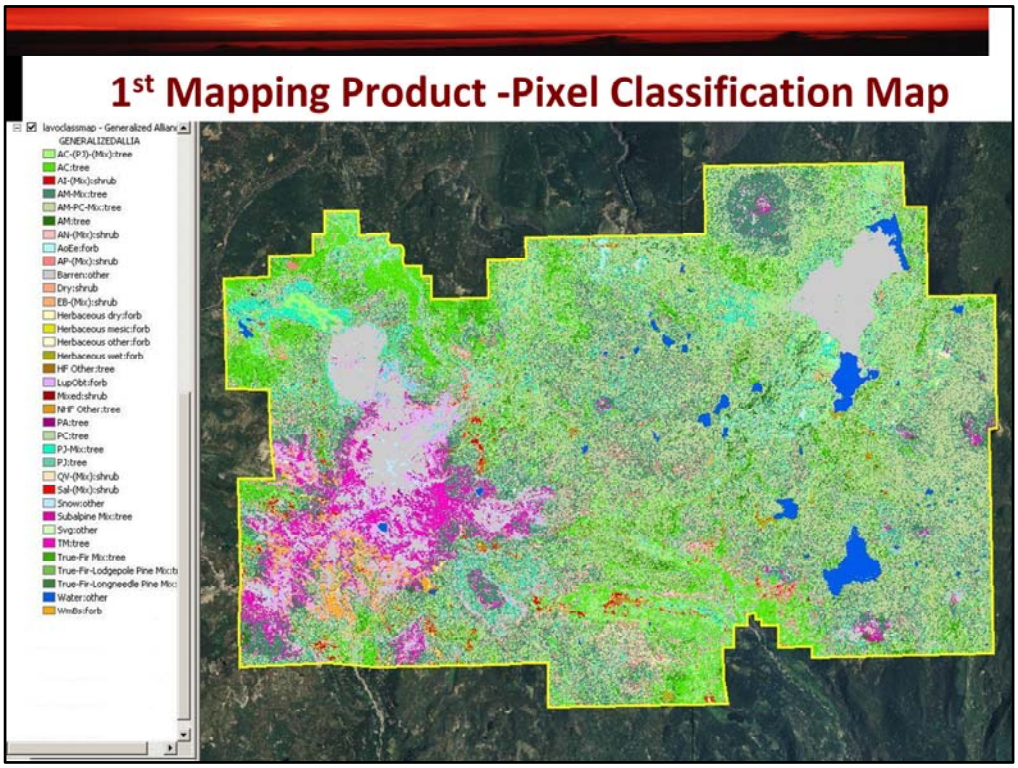
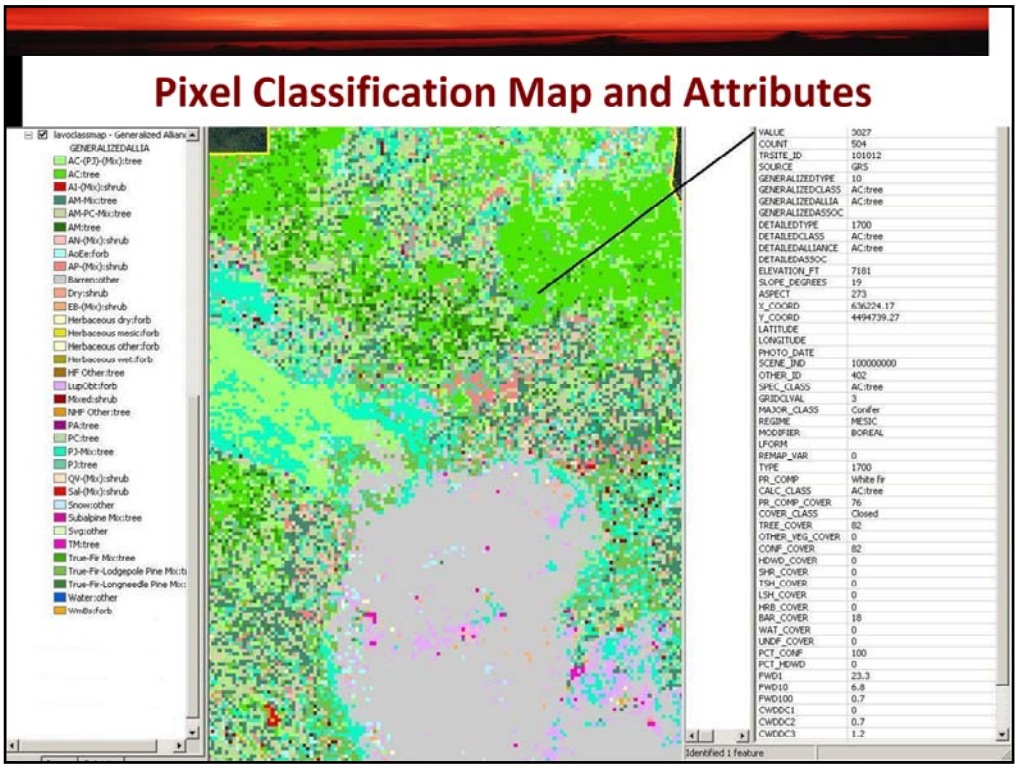
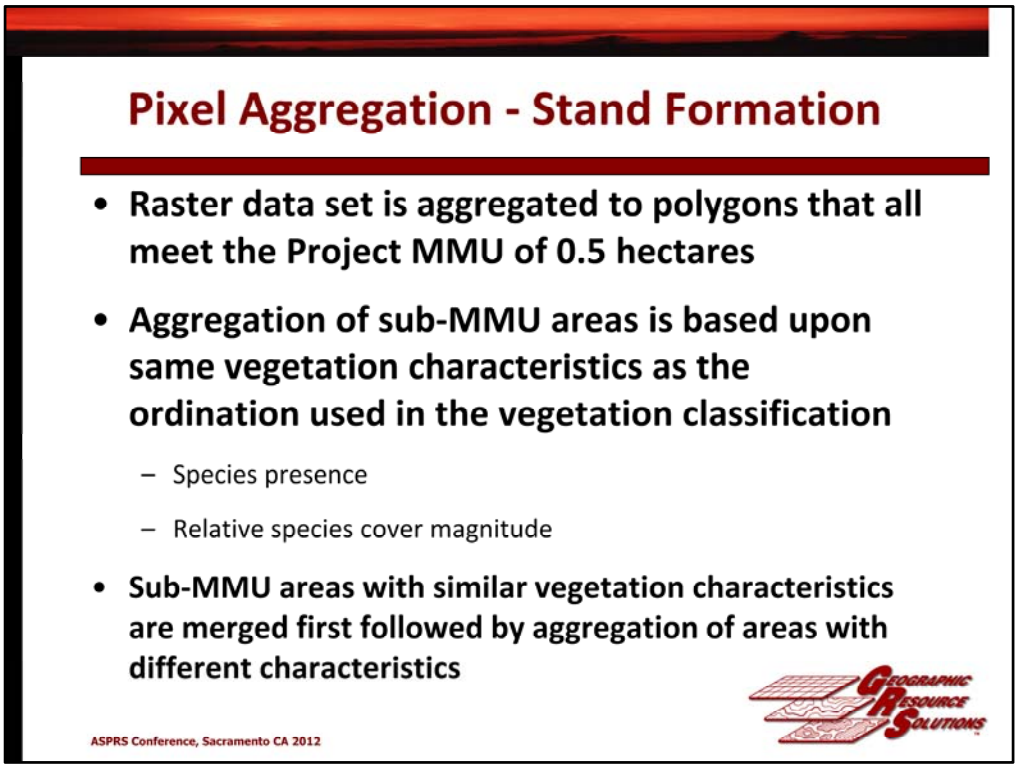
Example of “BAD” versus “GOOD” confusion



The pixel classmap

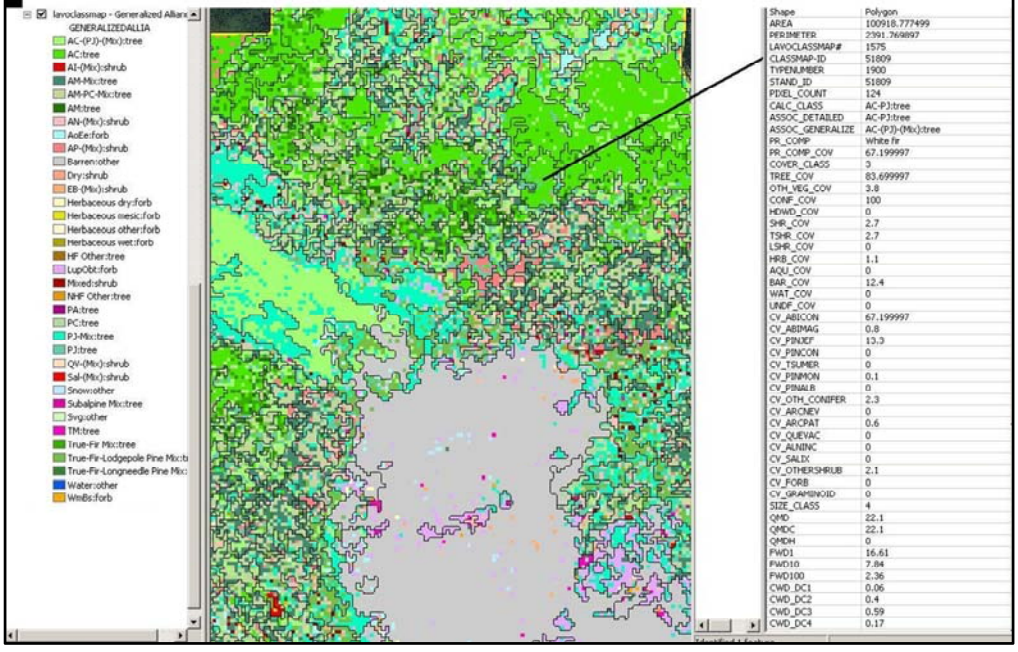


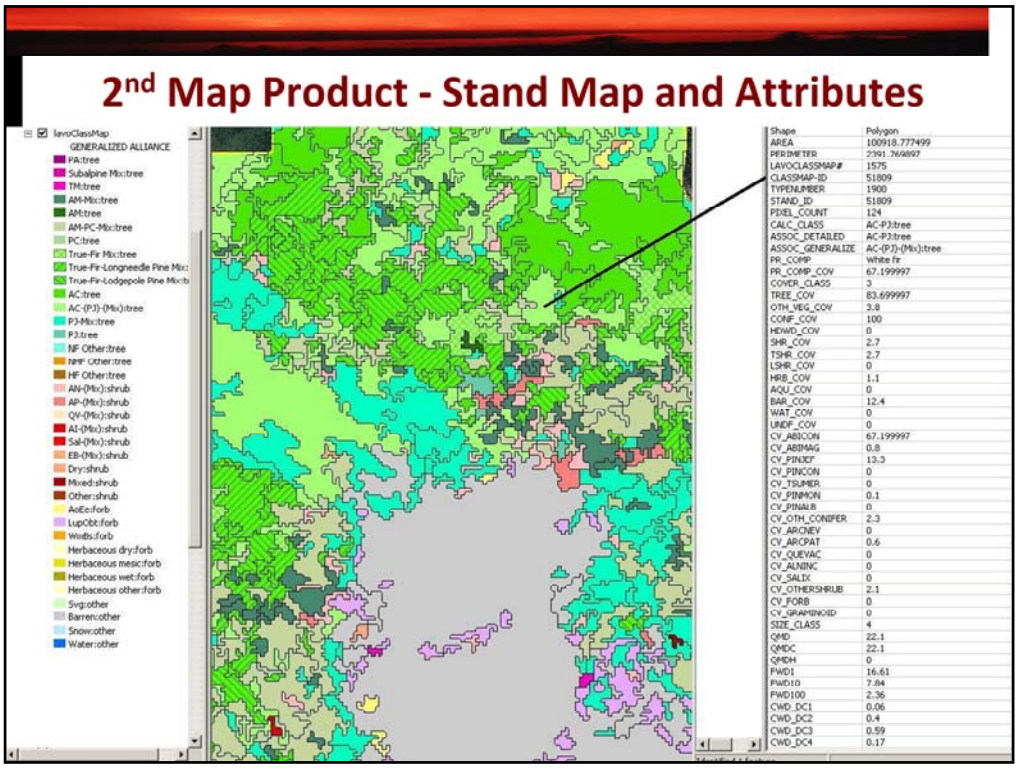
Each pixel has values that represent the features estimated to be at that pixel – 435 classes in LAVO map



Aggregation is based on vegetation and ecological principles – not spectral data!

Pixel Classification Map and Stand Boundaries



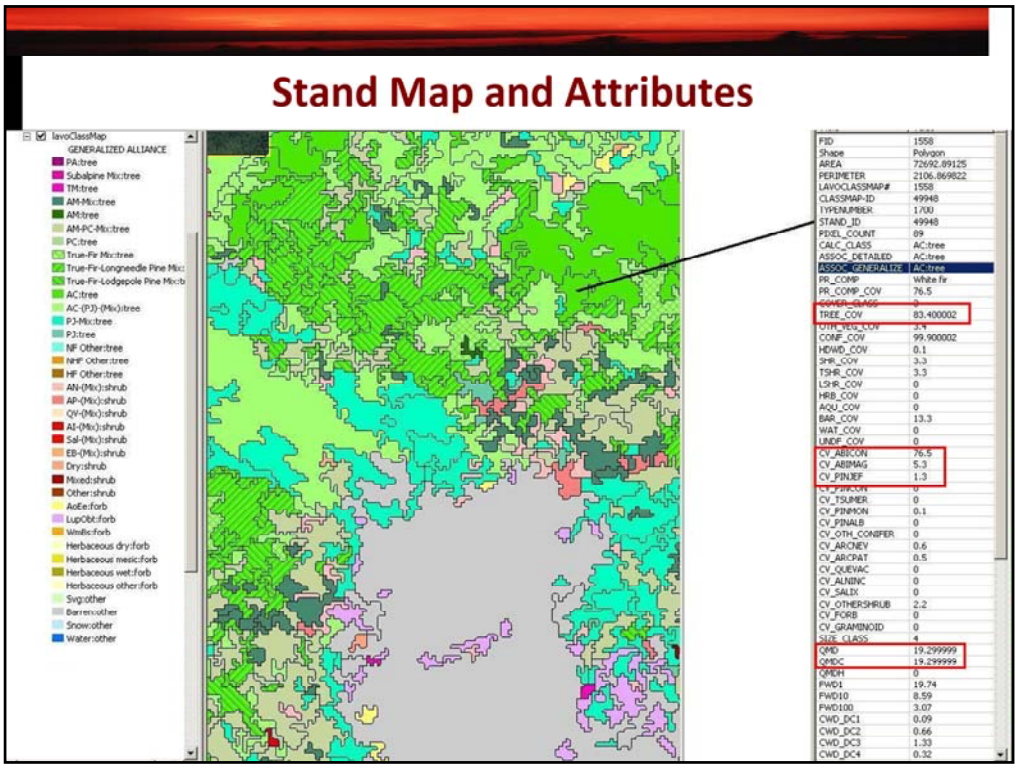


Draw the boundaries over the raster data …

Stand Attributes estimated as discrete estimates of continuous values –

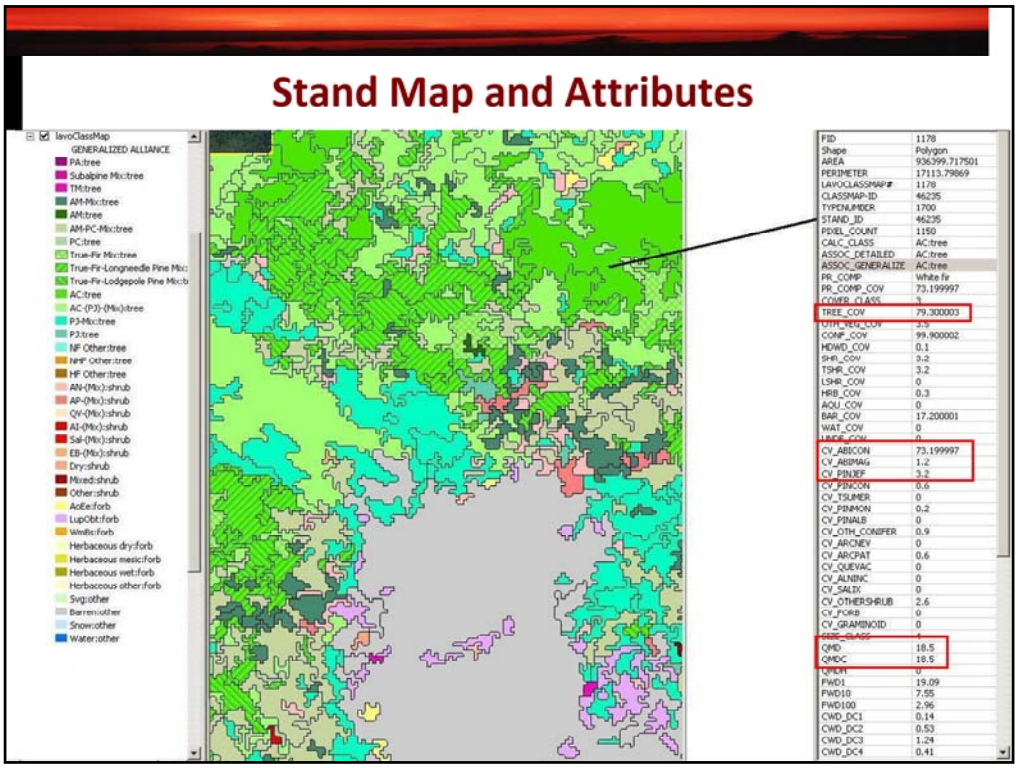
Based on weighted average of the pixel values present in the aggregated stand

This is an AC-PJ stand with species specific cover estimates

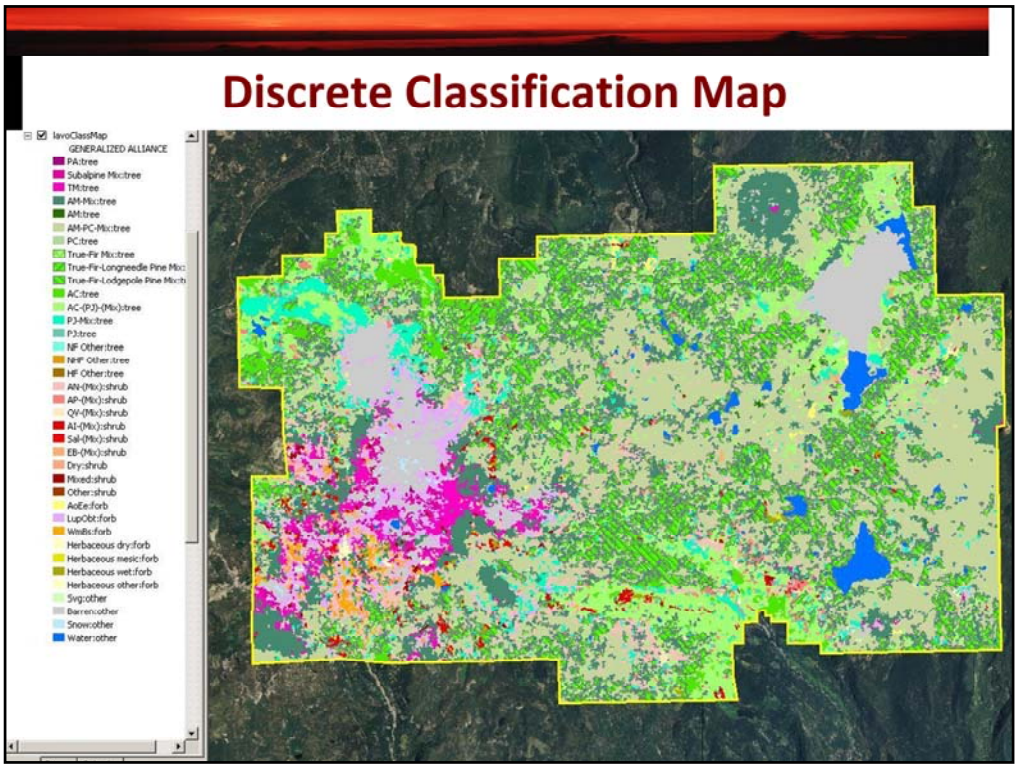


We develop discrete estimates for the continuous variables …

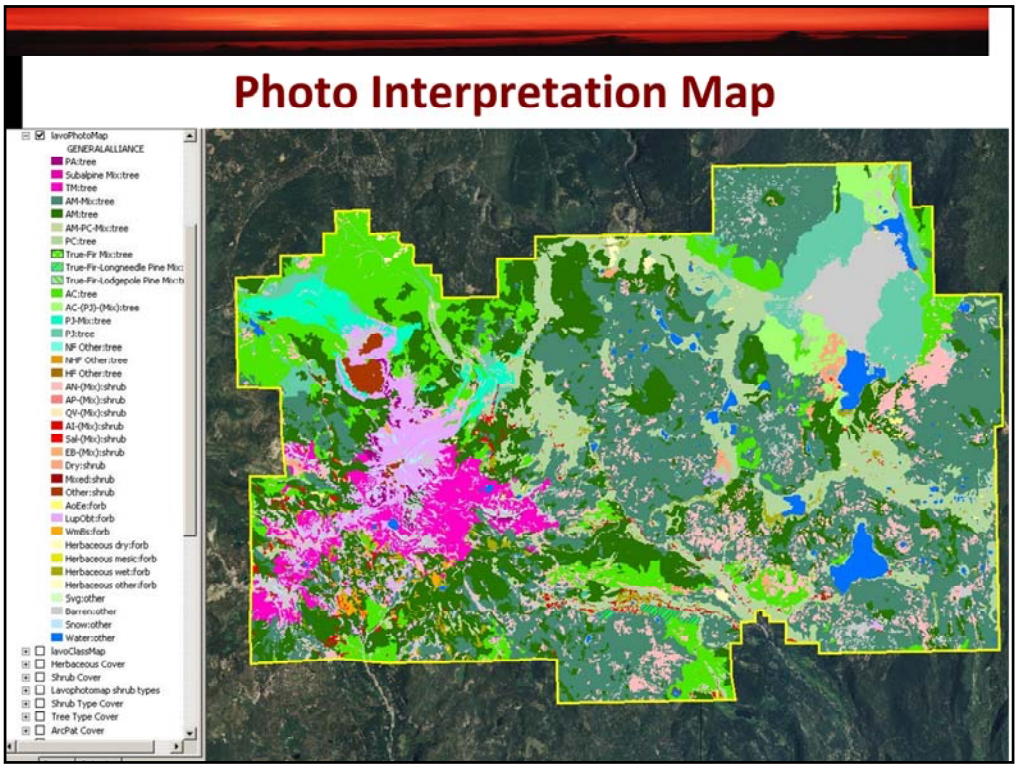
This AC type is slightly different than the next AC type …



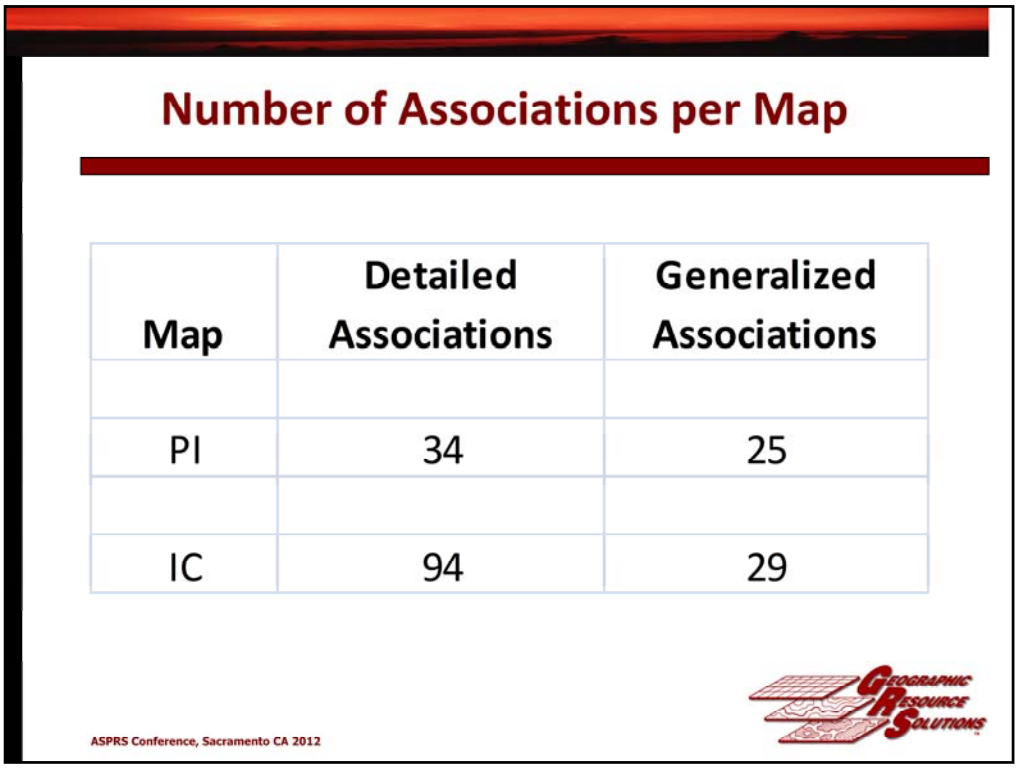
Same Association/type – slightly different species cover mix



Here is the Image Classification Map …



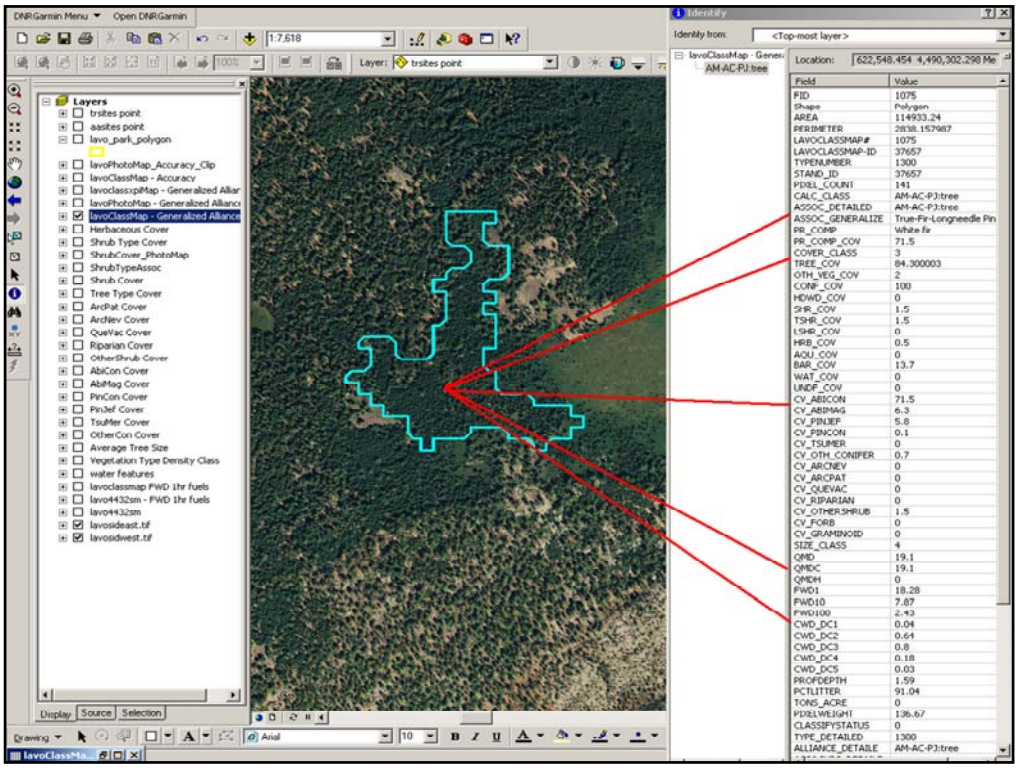
Here is the preliminary PI Map using the same Associations and colors/legend



End Result …

Number of Detailed Associations … Generalized to fewer numbers …

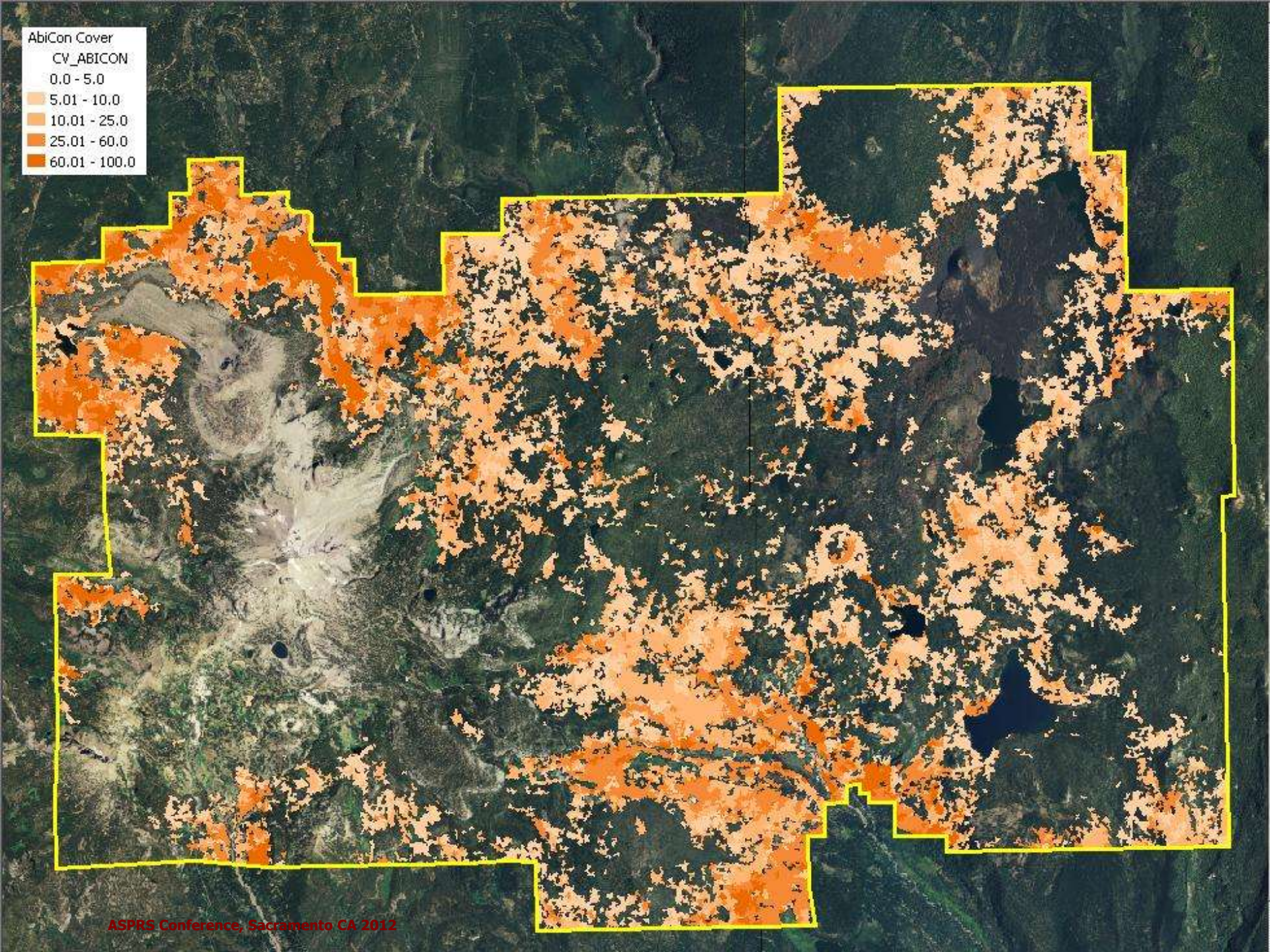
PI Map supports fewer Associations – hard for the PI to handle lots of classes.

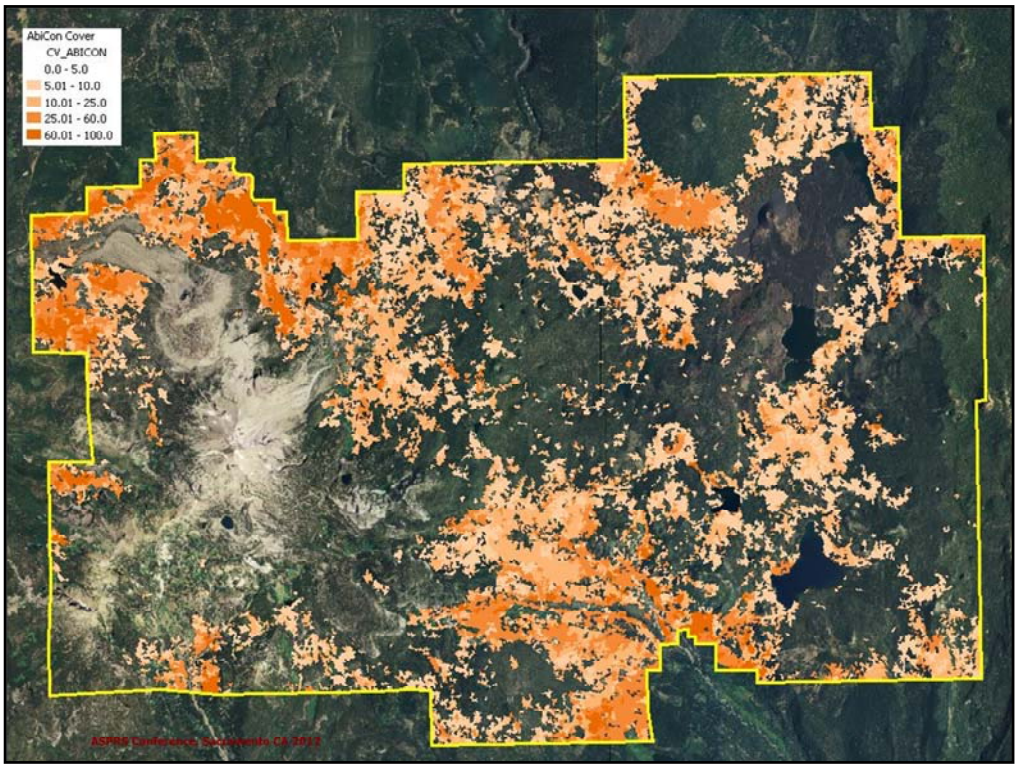


If you collect the quantitative data and process it correctly you can build a much more complete and descriptive data set …

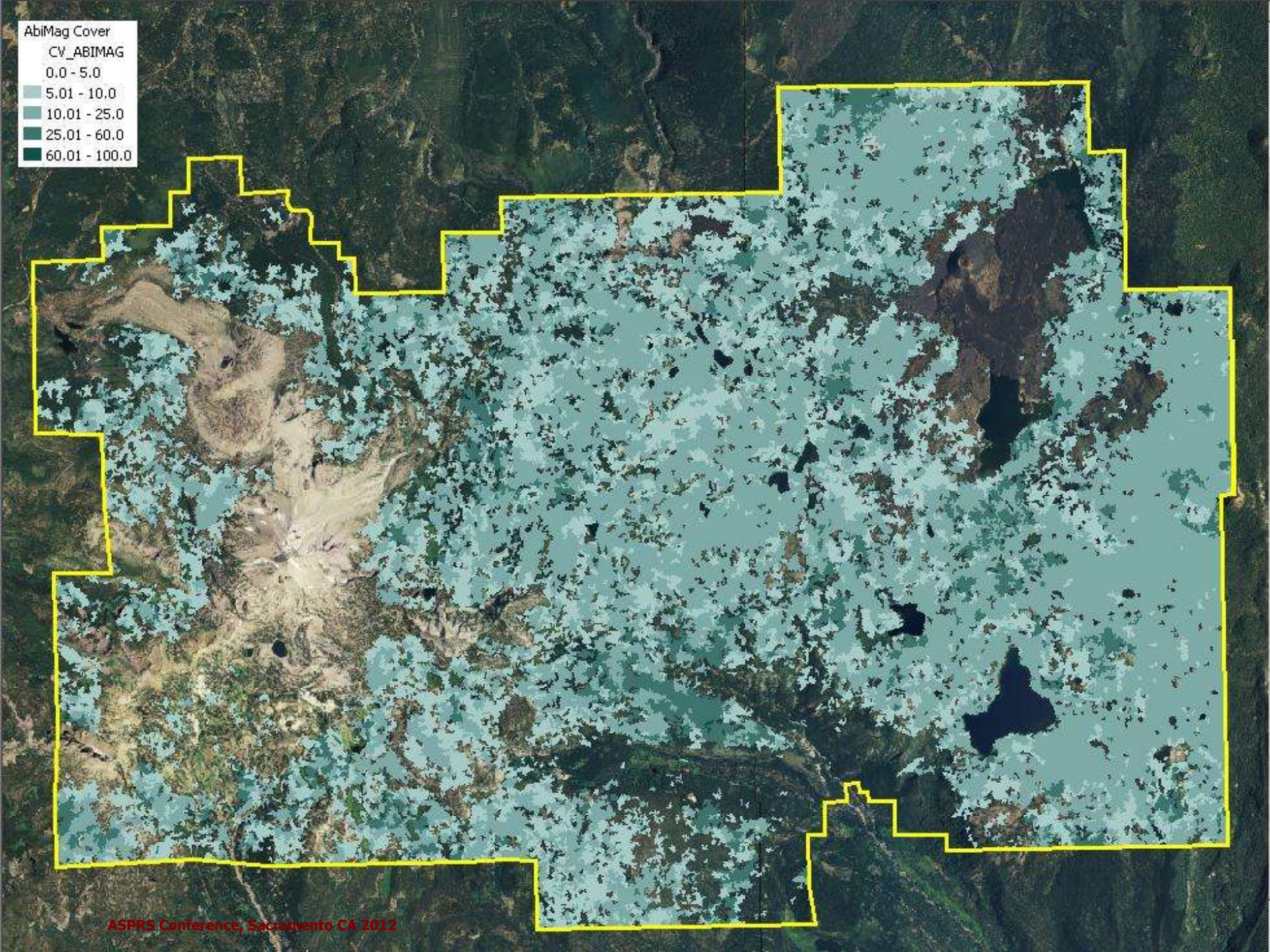
Because we have access to all these field data estimates for the continuous variable of cover, let's see what we can do ?

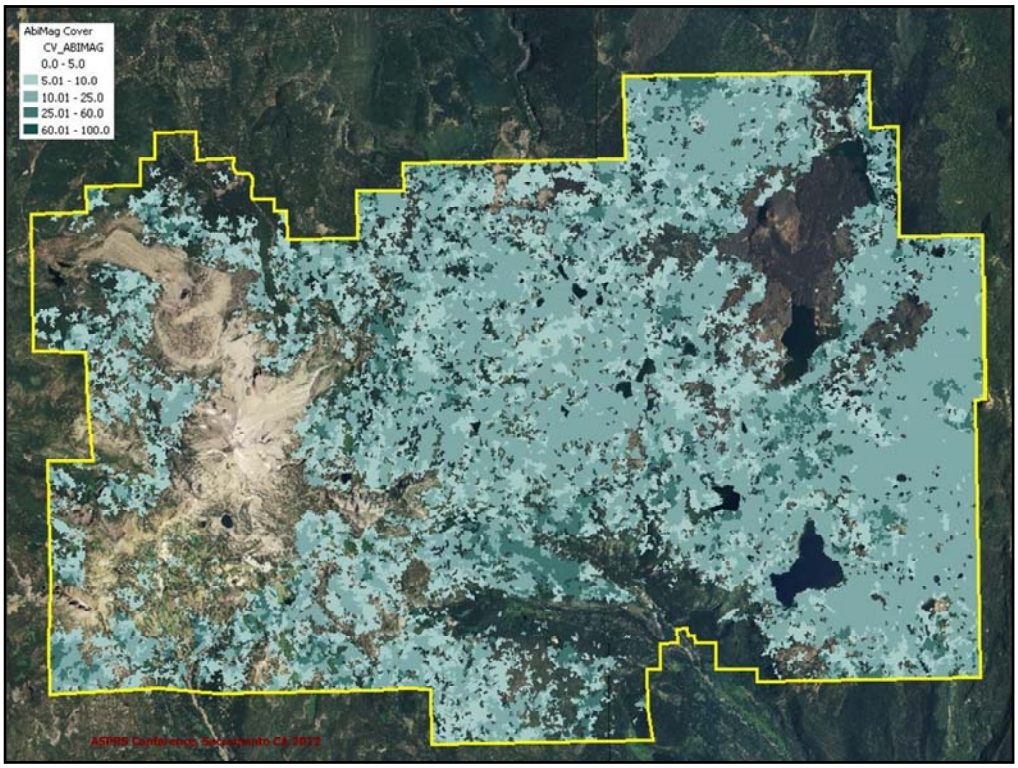
Mapping Species Components =➔ AM-AC-PJ


AbiCon Cover
CV_ABICON
0.0 - 5.0
5.01 - 10.0
10.01 - 25.0
25.01 - 60.0
60.01 - 100.0
ASPRS Conference, Sacramento CA 2012



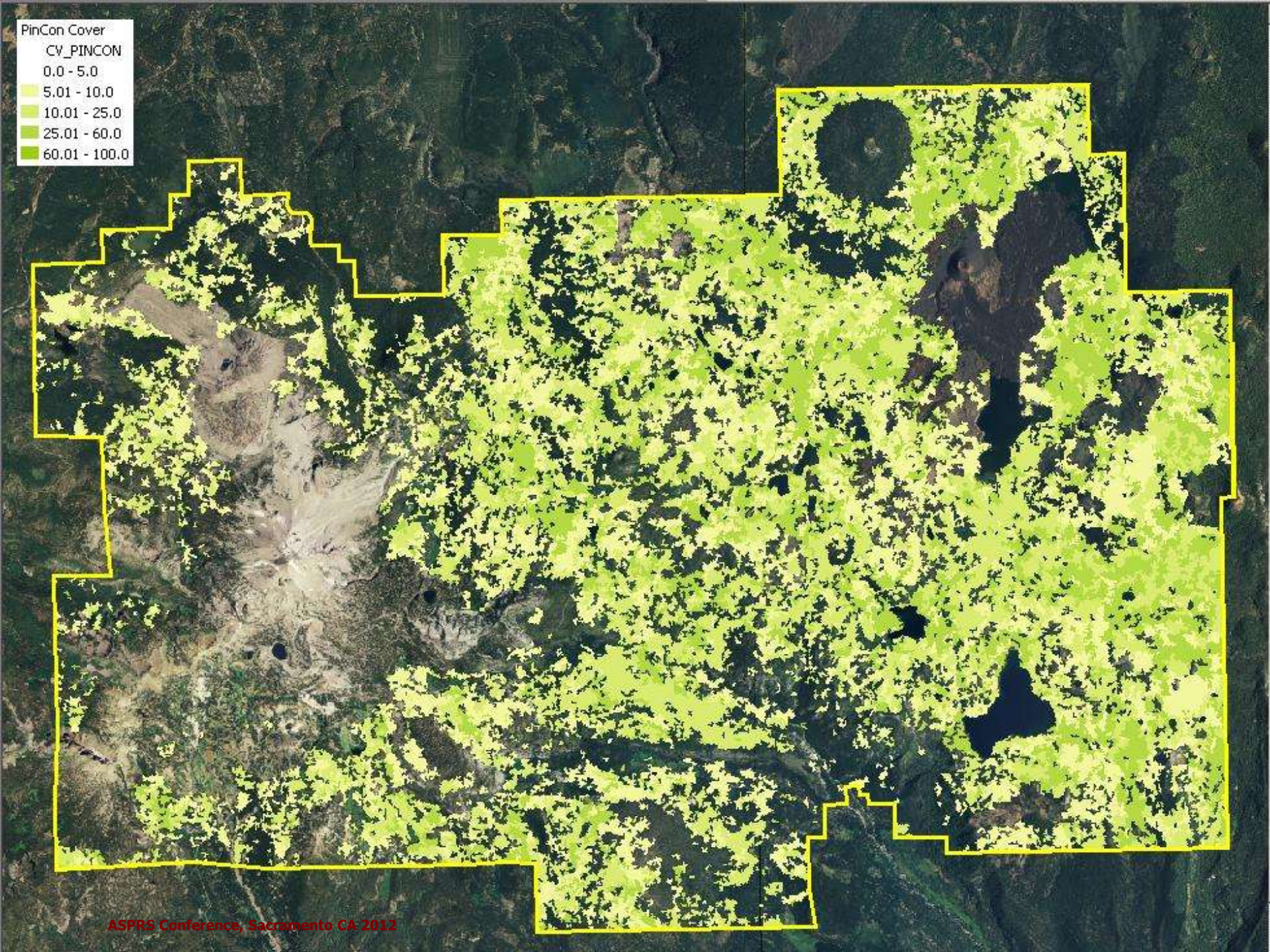
This is the cover distribution of Abies concolor …

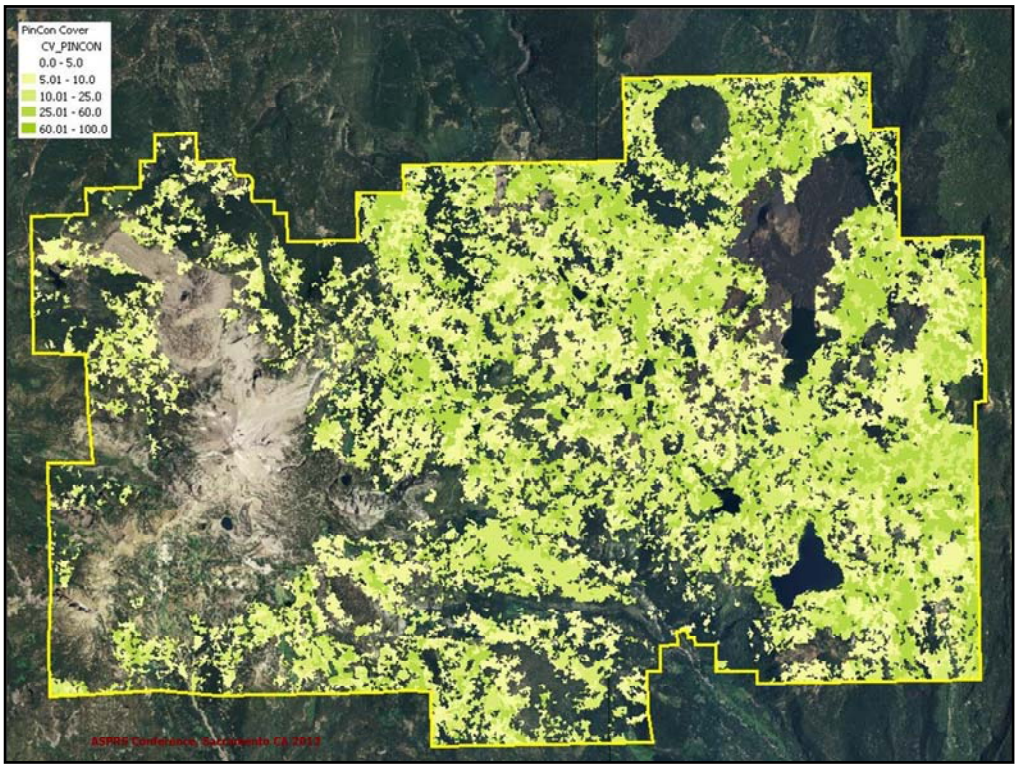

AbiMag Cover
CV_ABIMAG
0.0 - 5.0
5.01 - 10.0
10.01 - 25.0
25.01 - 60.0
60.01 - 100.0
ASPRS Conference, Sacramento CA 2012



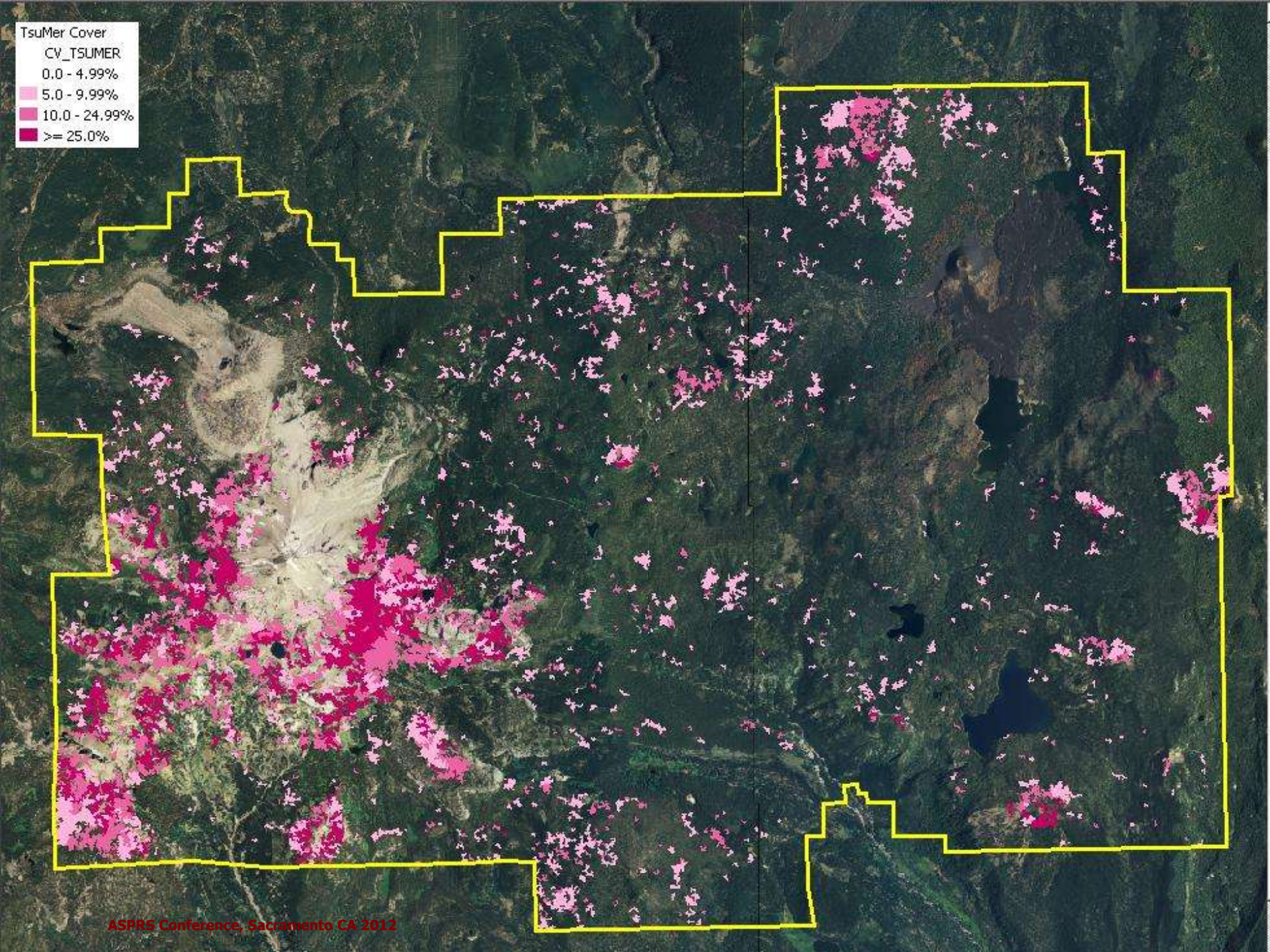
This is the cover distribution of Abies magnifica …

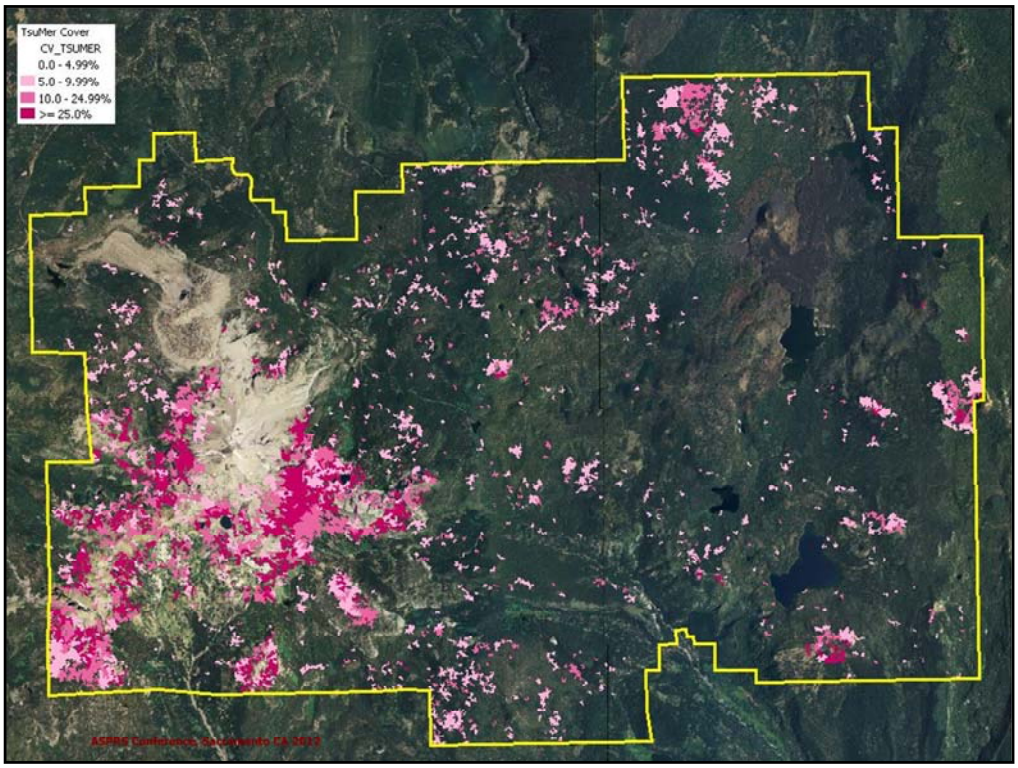
Note the different extent


PinCon Cover
CV_PINCON
0.0 - 5.0
5.01 - 10.0
10.01 - 25.0
25.01 - 60.0
60.01 - 100.0
ASPRS Conference, Sacramento CA 2012

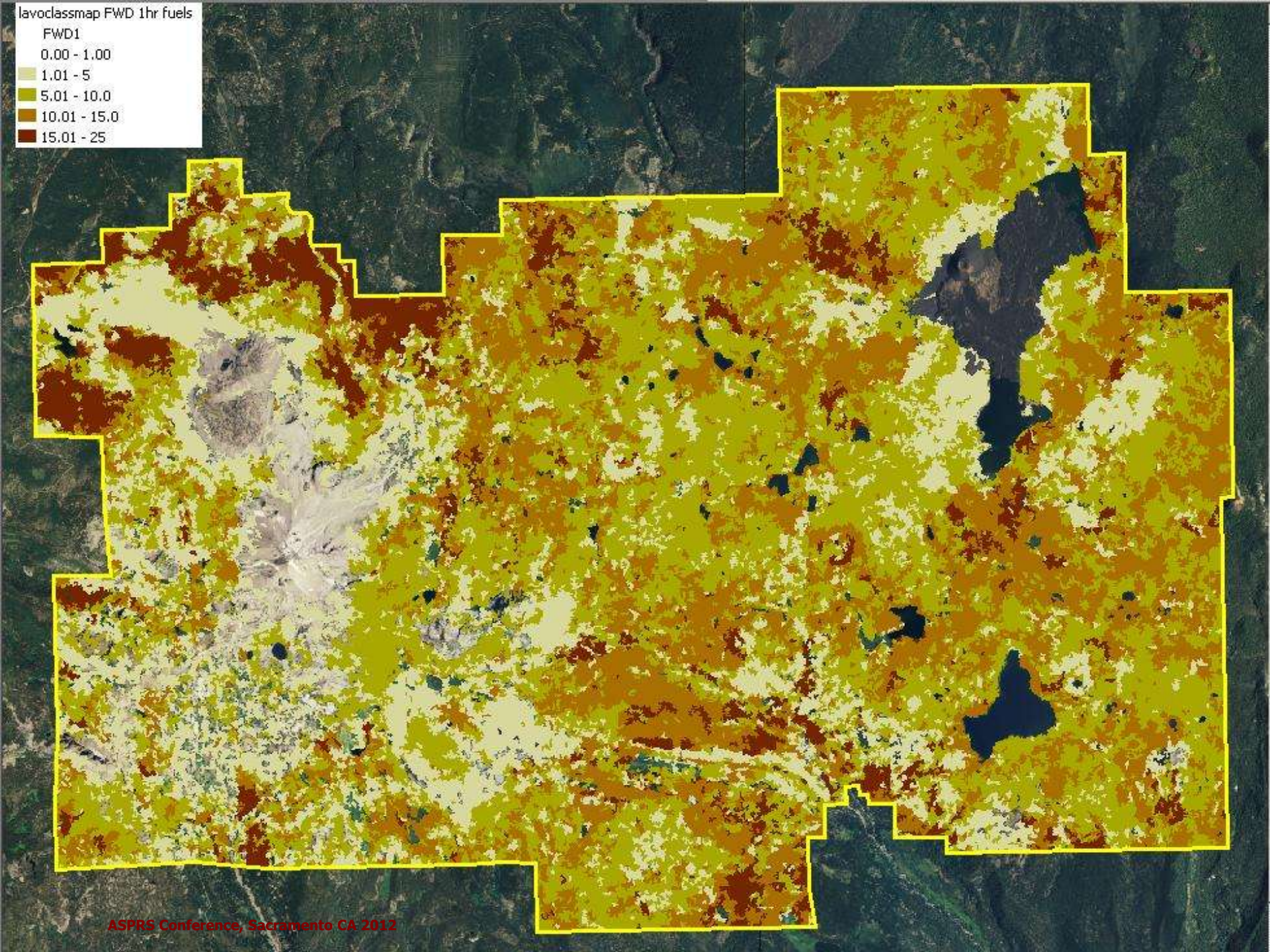


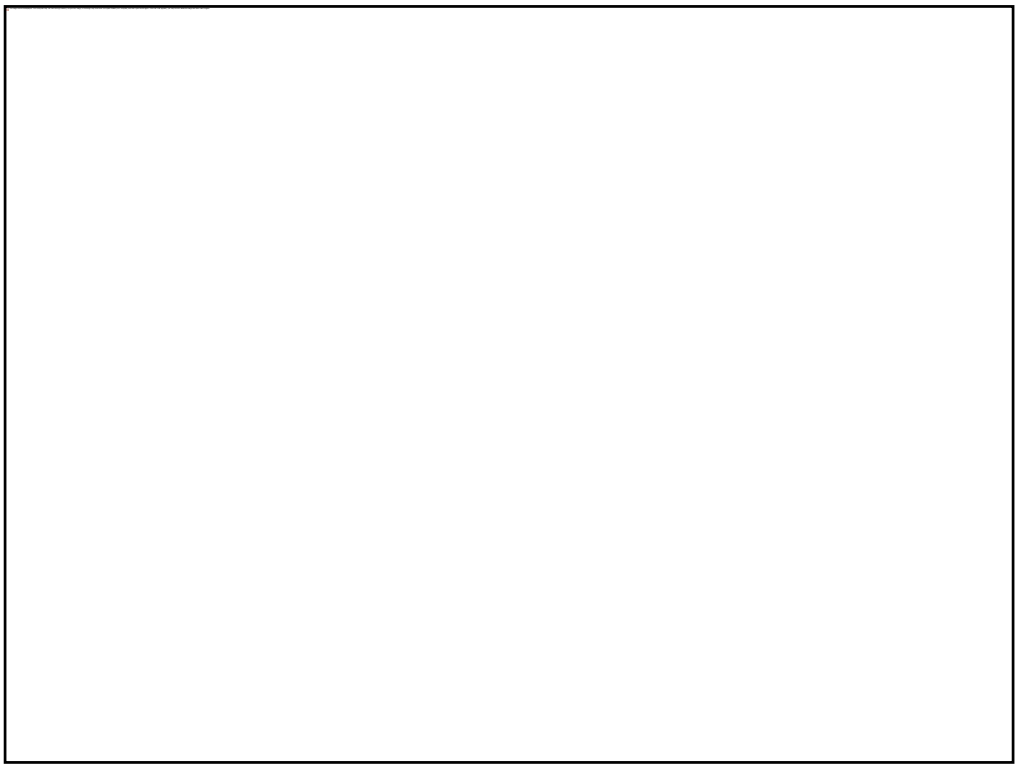
This is the cover distribution of Pinus contorta


TsuMer Cover
CV_TSUMER
0.0 - 4.99%
5.0 - 9.99%
10.0 - 24.99%
>= 25.0%
ASPRS Conference, Sacramento CA 2012



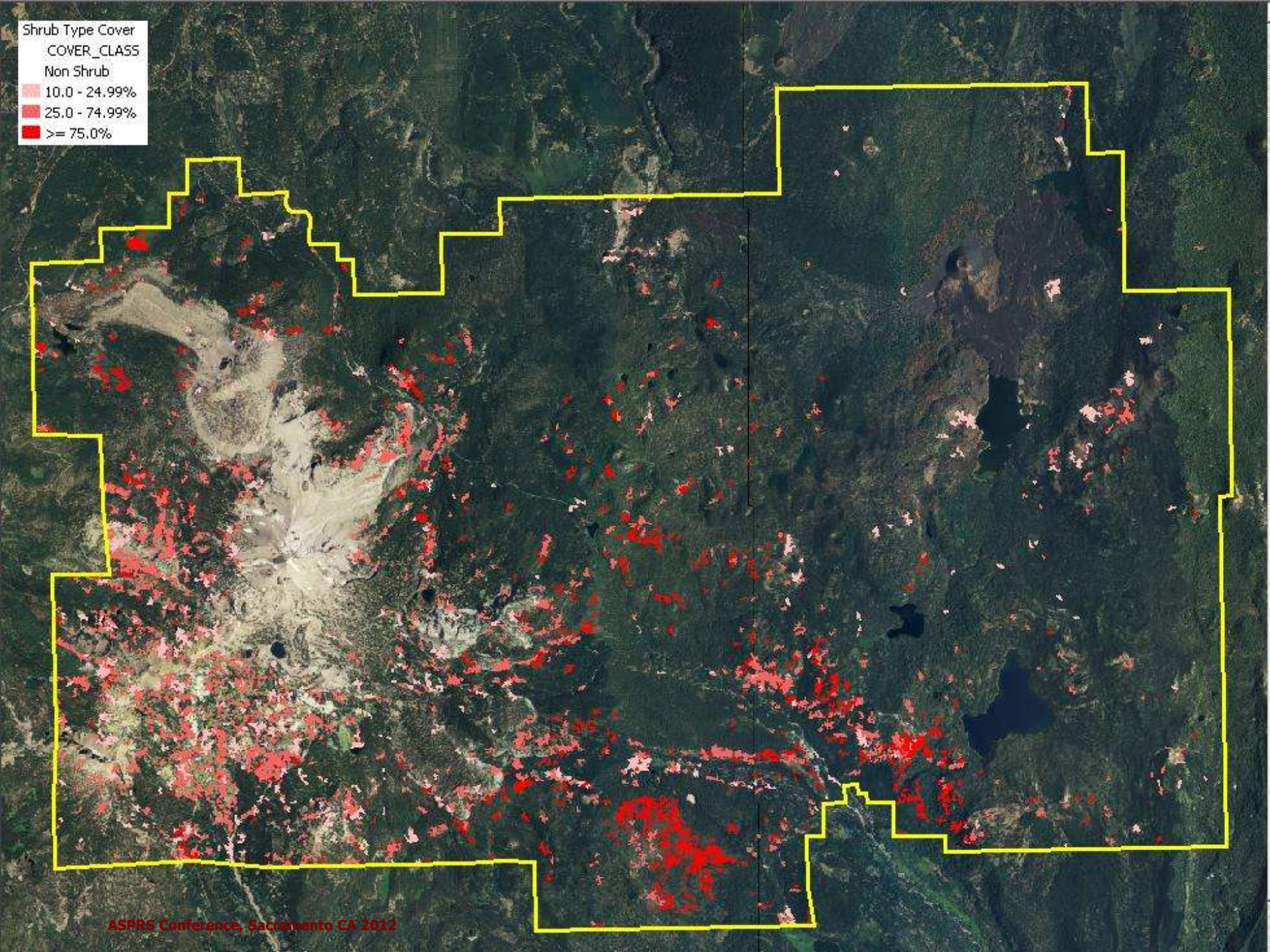
This is the cover distribution of Tsuga mertensiana

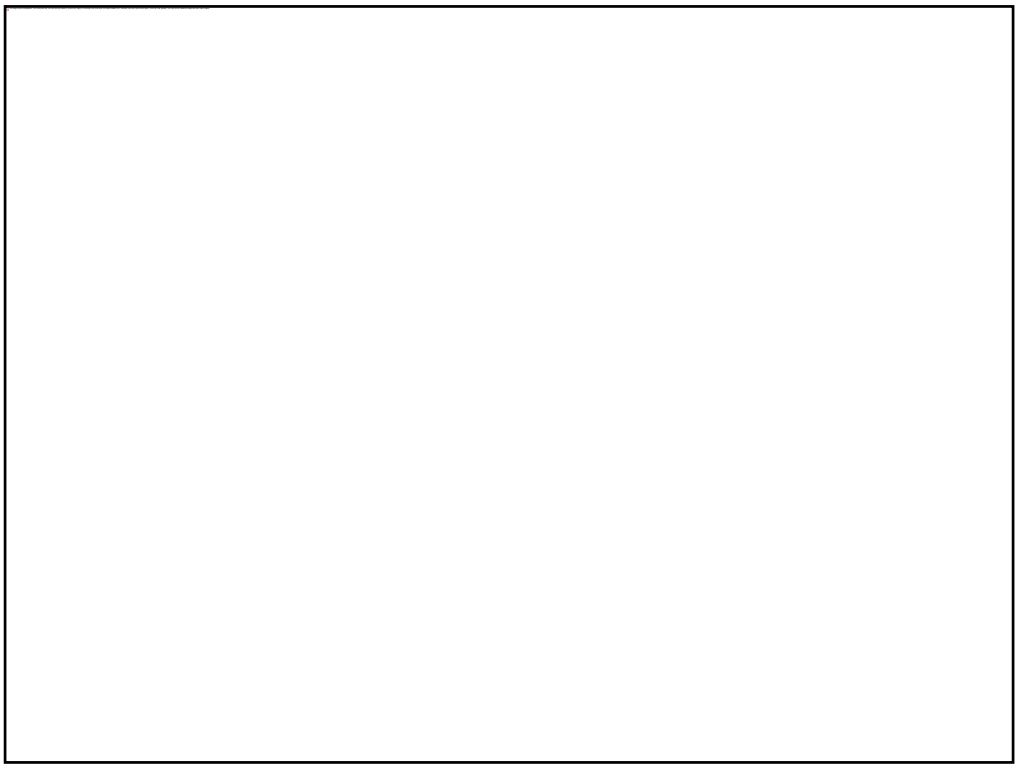

lavoclassmap FWD 1hr fuels
FWD1
0.00 - 1.00
1.01 - 5
5.01 - 10.0
10.01 - 15.0
15.01 - 25
ASPRS Conference, Sacramento CA 2012



But what else can we do ?

Estimate of Firemon transect FWD 1 hour fuel counts … mapped average count/transect for FWD 1-hr fuels

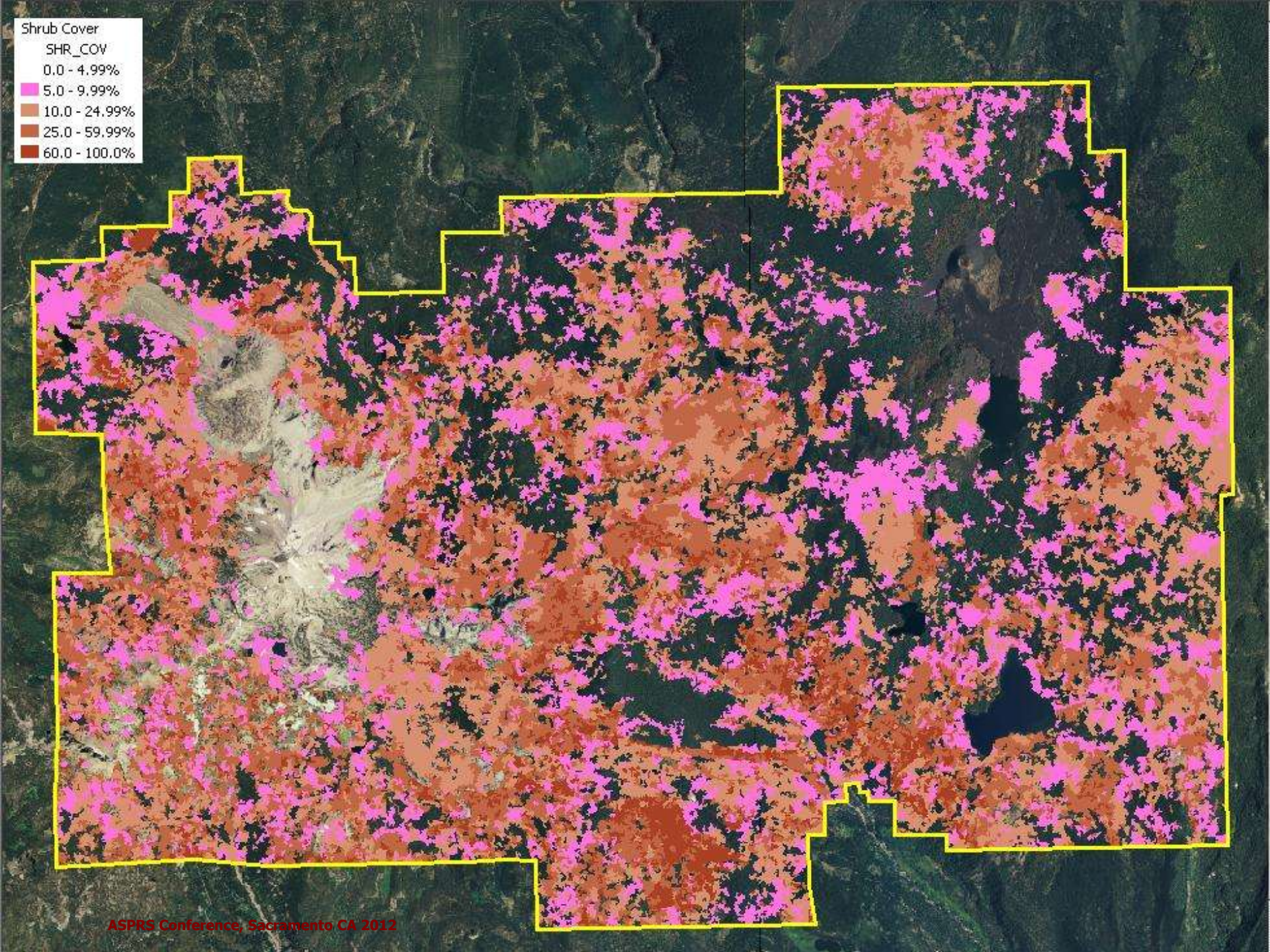

Shrub Type Cover
COVER_CLASS
Non Shrub
10.0 - 24.99%
25.0 - 74.99%
>= 75.0%
ASPRS Conference, Sacramento CA 2012

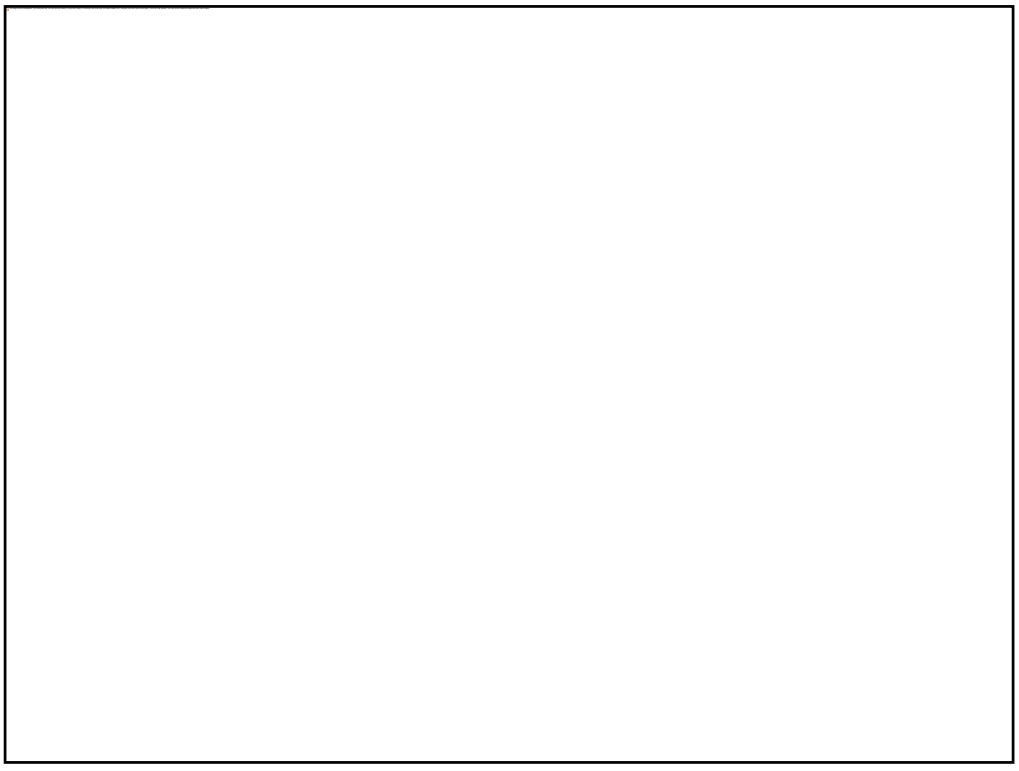


How about evaluating critical habitat ?

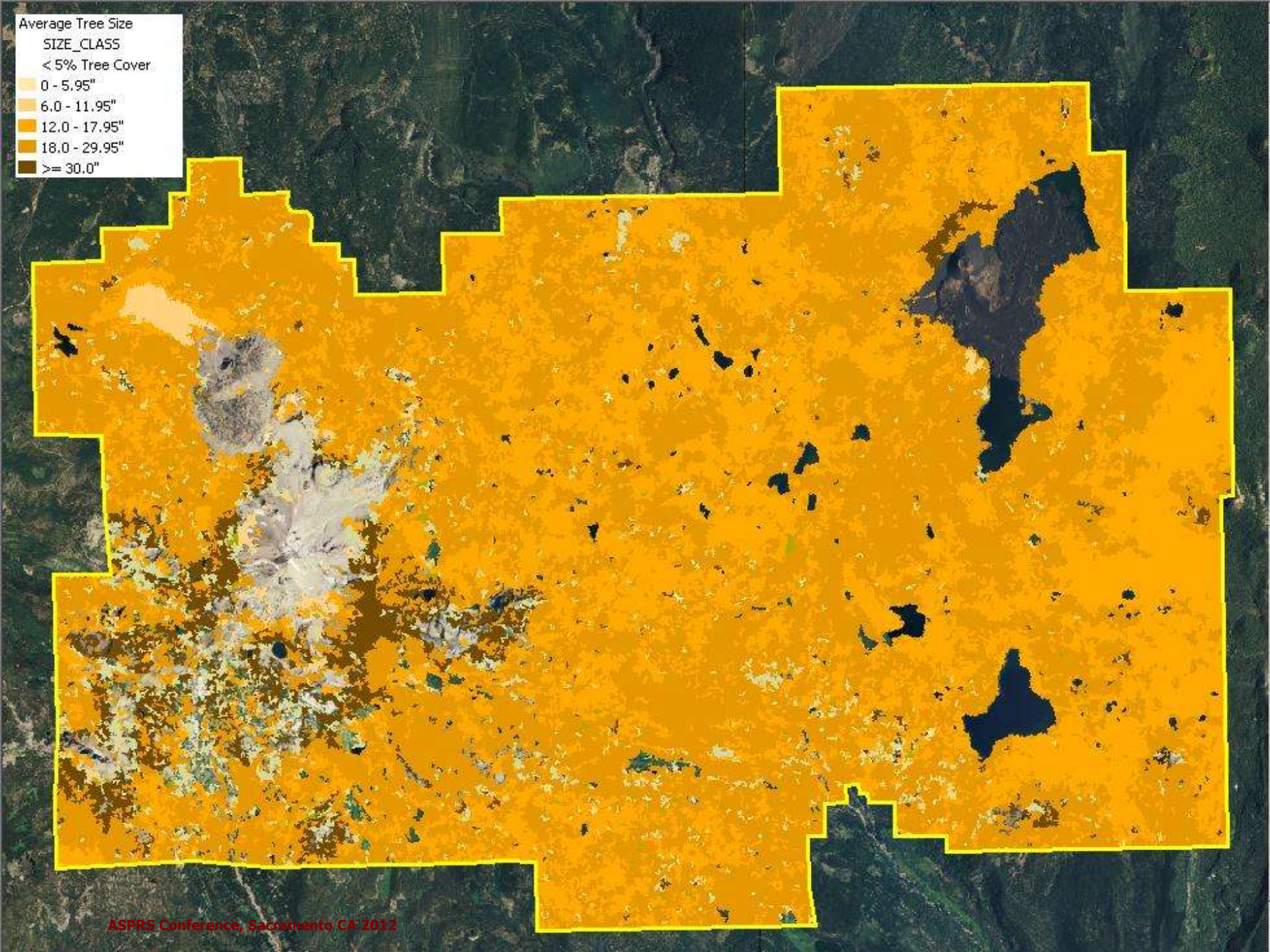
Let say we have some wildlife critter dependent on shrub cover …

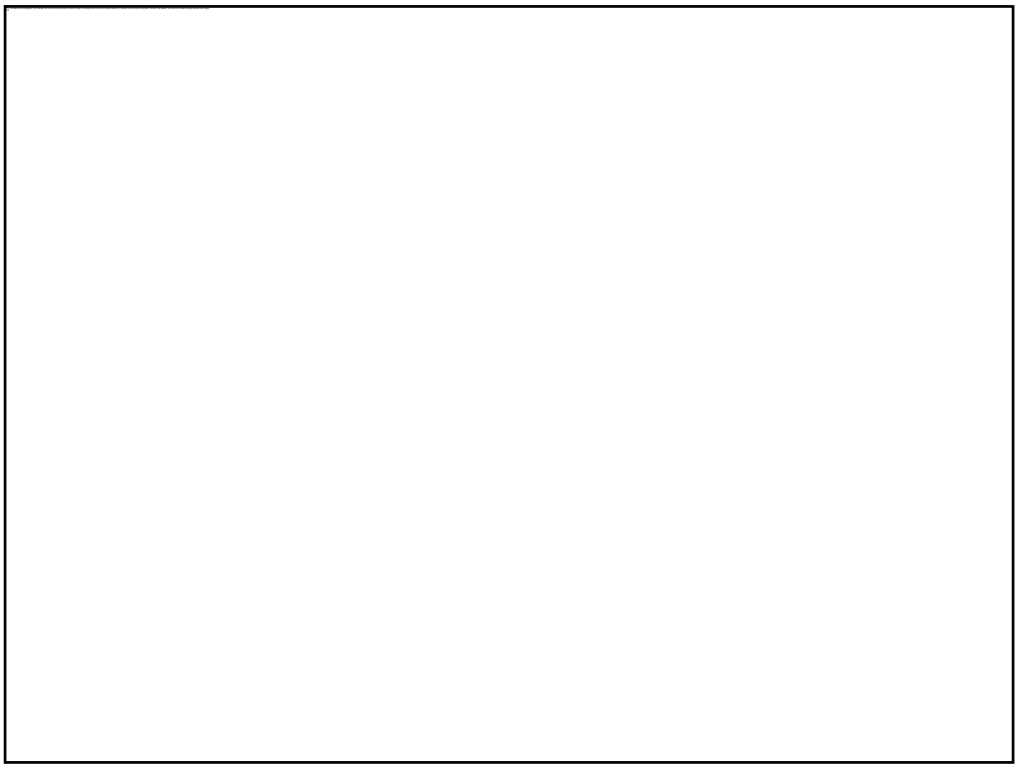
Map Shrub types …. Show this much cover. It is quite fragmented.


Shrub Cover
SHR_COV
0.0 - 4.99%
5.0 - 9.99%
10.0 - 24.99%
25.0 - 59.99%
60.0 - 100.0%
ASPRS Conference, Sacramento CA 2012



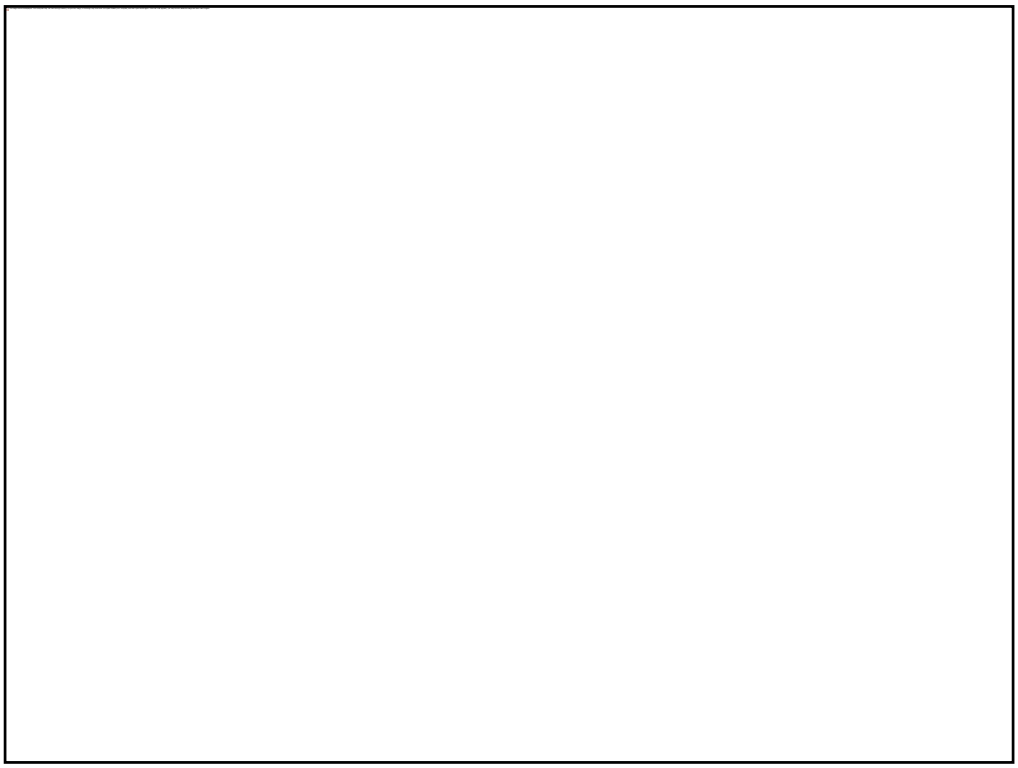
But let's look at the shrub cover including non-shrub types. It is much more prevalent and hardly as fragmented. We might reach a different management decision using this map rather than the prior map.


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"

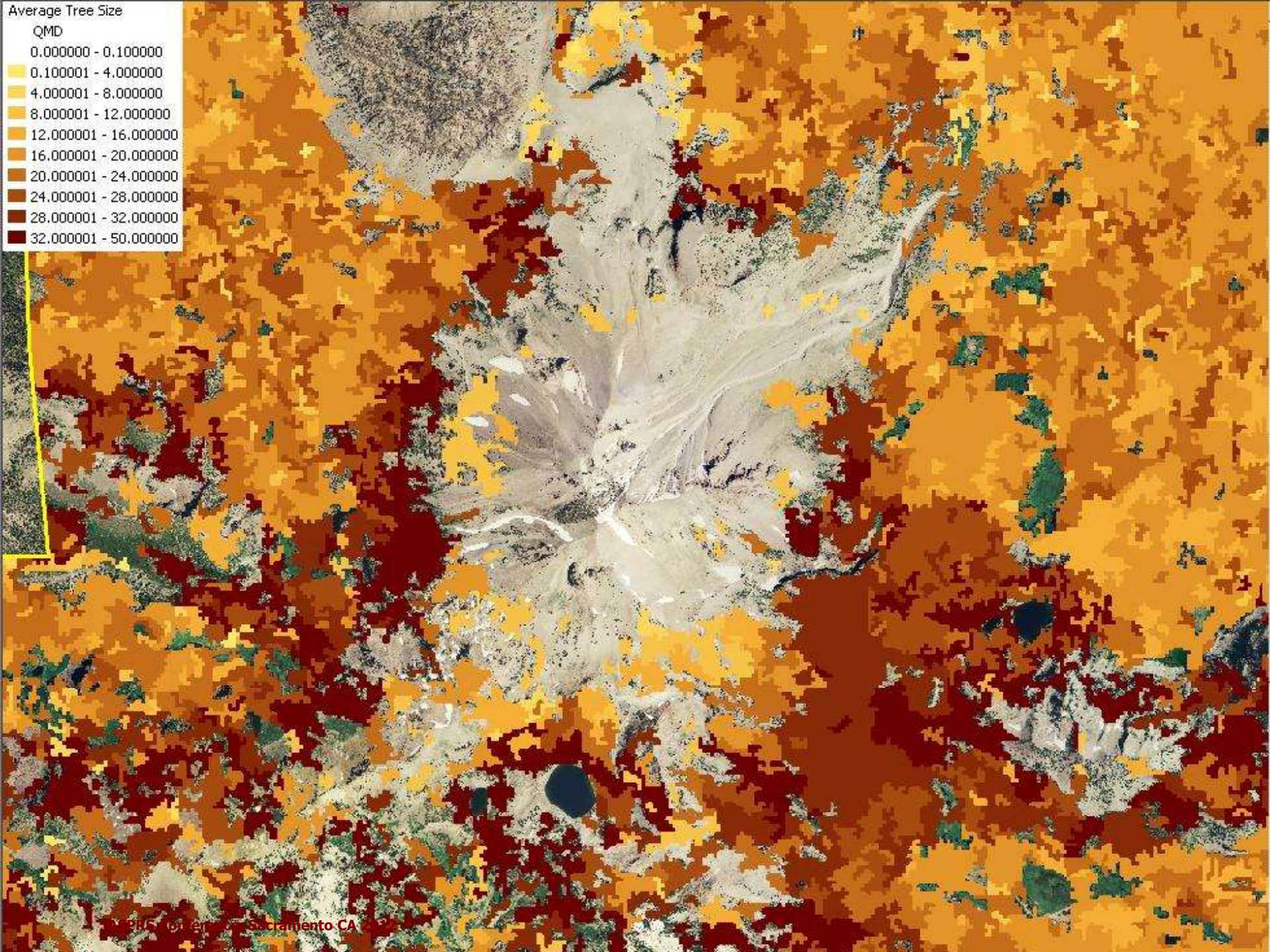


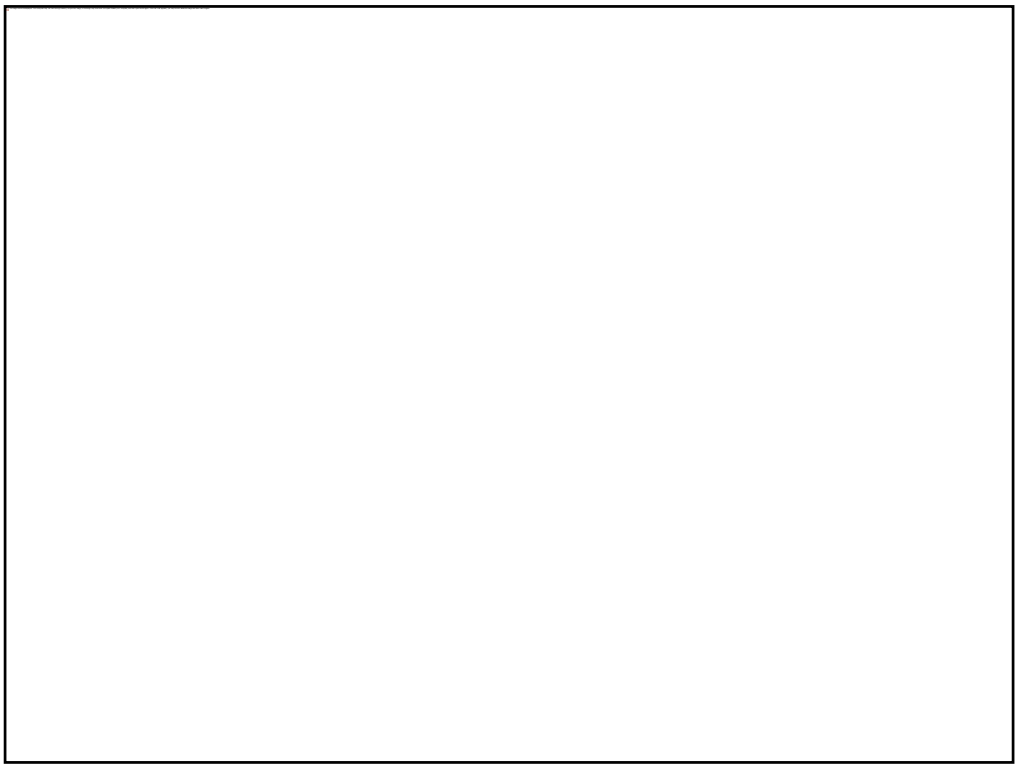
How about mapping tree size classes ? Here we have 5 classes based on the average tree size variable.


Average Tree Size
QMD
< 5% Tree Cover
0 - 5.95"
6.0 - 11.95"
12.0 - 17.95"
18.0 - 29.95"
>= 30.0"
ASPRS Conference, Sacramento CA 2012

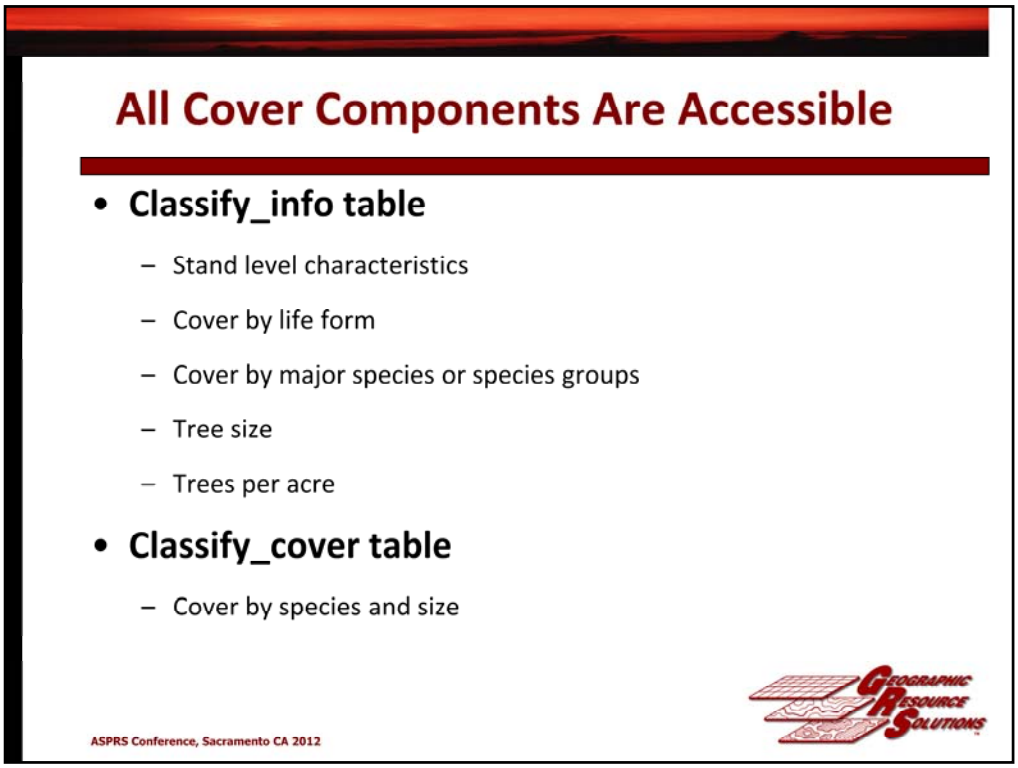


We see this when we zoom in. Let now make a new legend with 10 classes based on the value of the QMD …


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

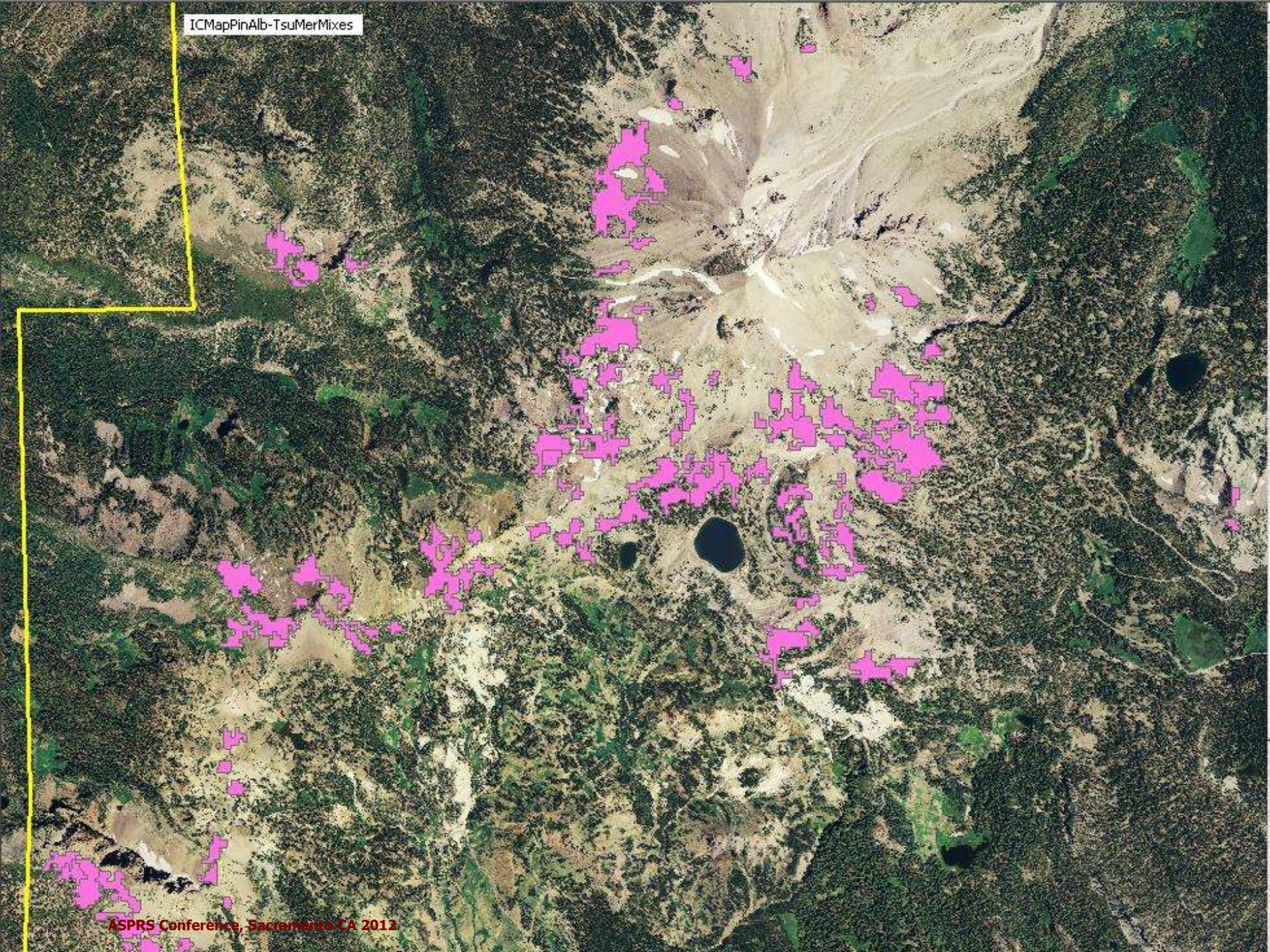


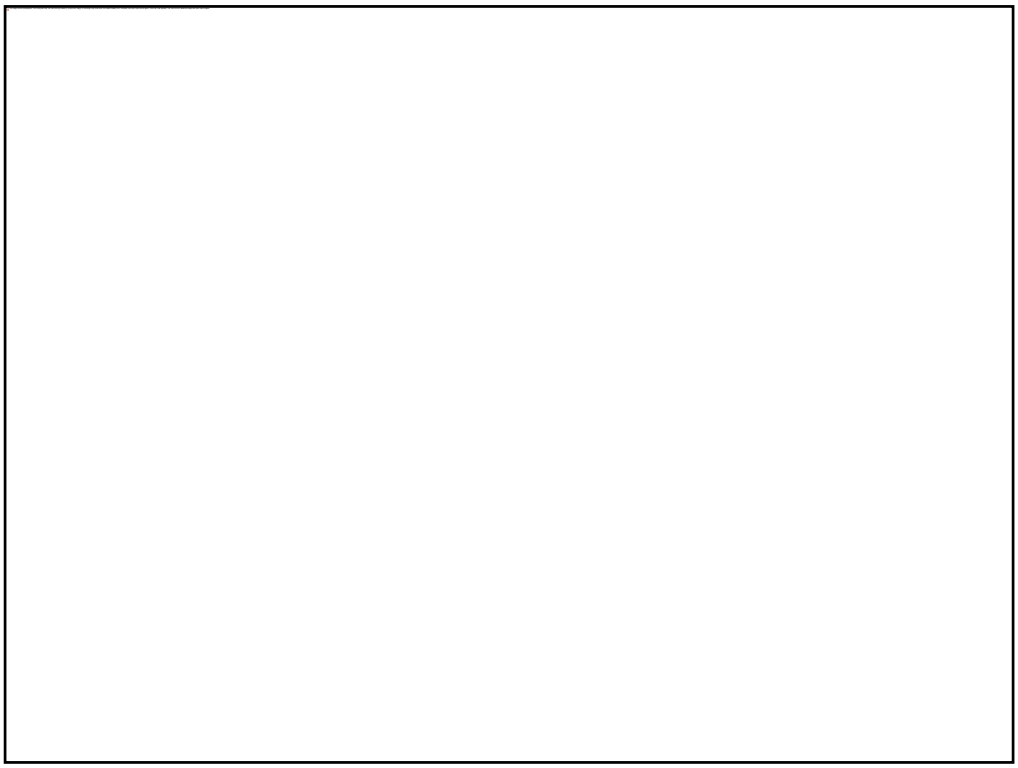
We produce a new map – based on different class rules, which are simply reflected by another legend.



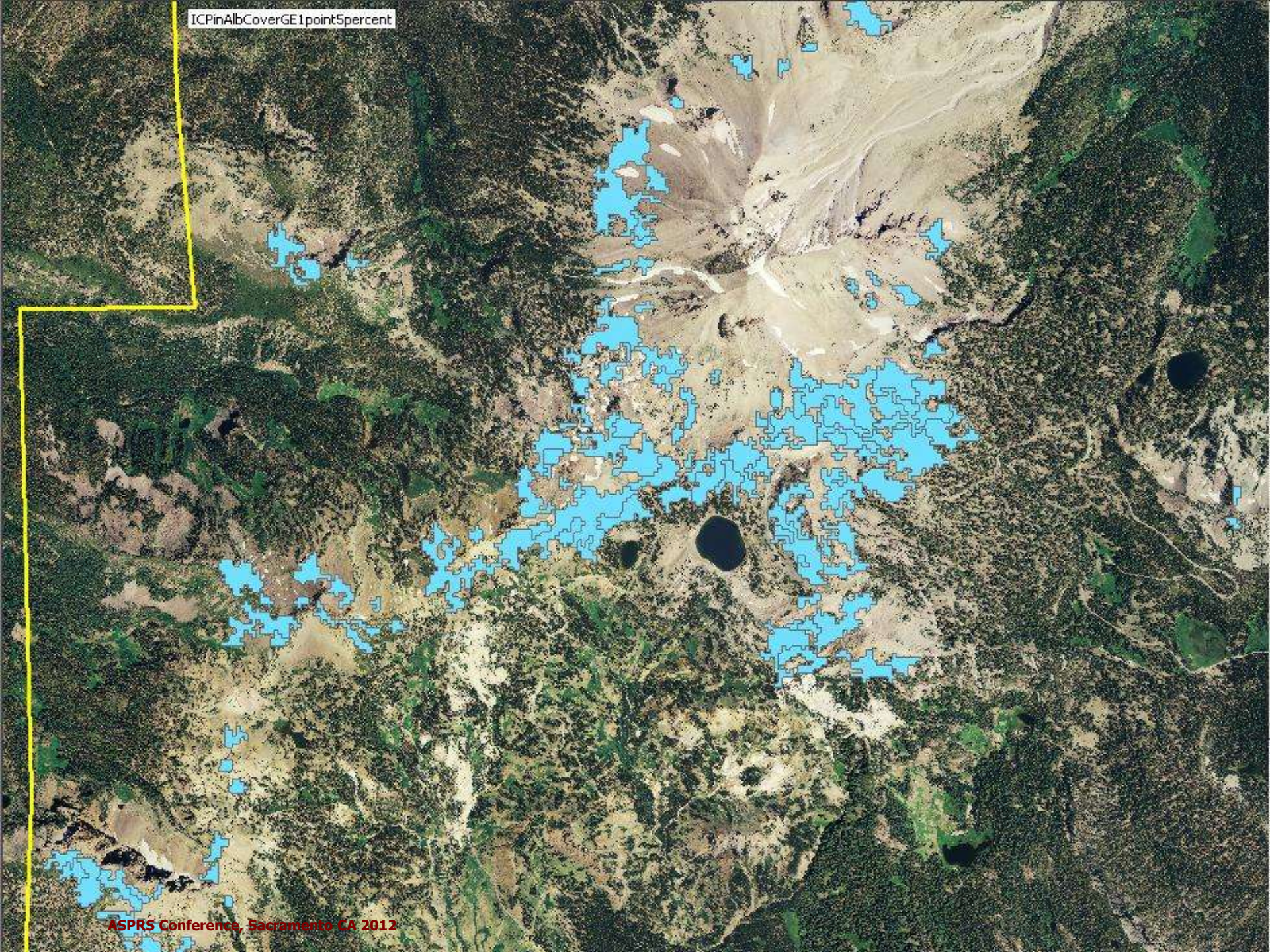
We store all the cover data in another table and can relate it to our maps and use it for queries

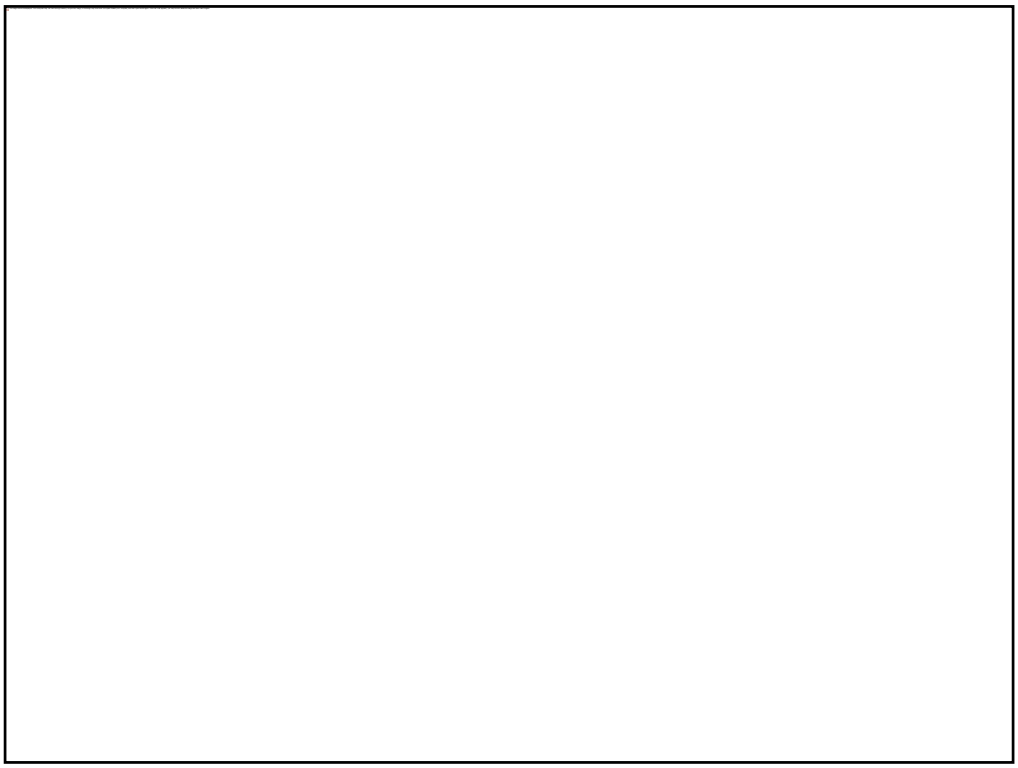
In the next example, someone within the NPS Network requested a map that represented where we would find Western White Pine.


ICMapPinAlb-TsuMerMixes
ASPRS Conference, Sacramento CA 2012

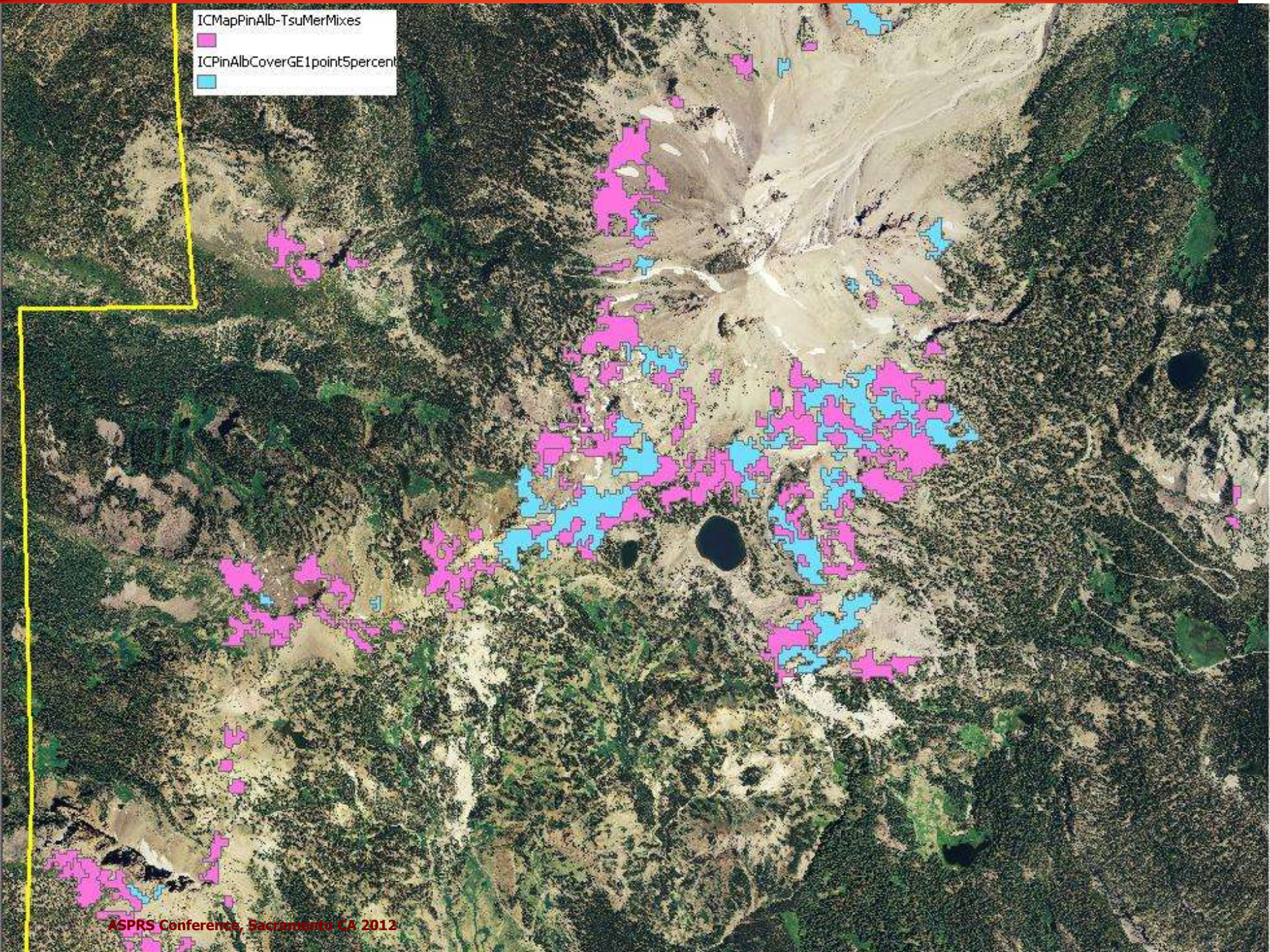


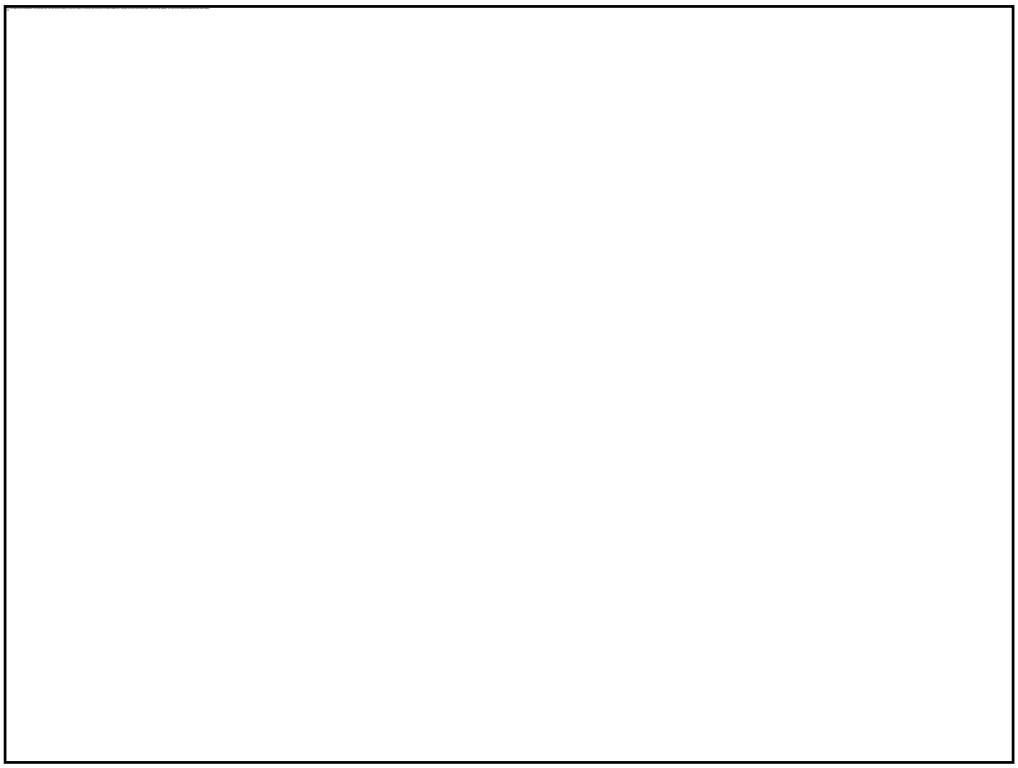
Base on NVCS types that included Pinus albicaulis in the type name we develop this map…


ICPinAlbCoverGE1point5percent



Based on a query where Pinus albicaulis cover > 1.5% we develop this map …

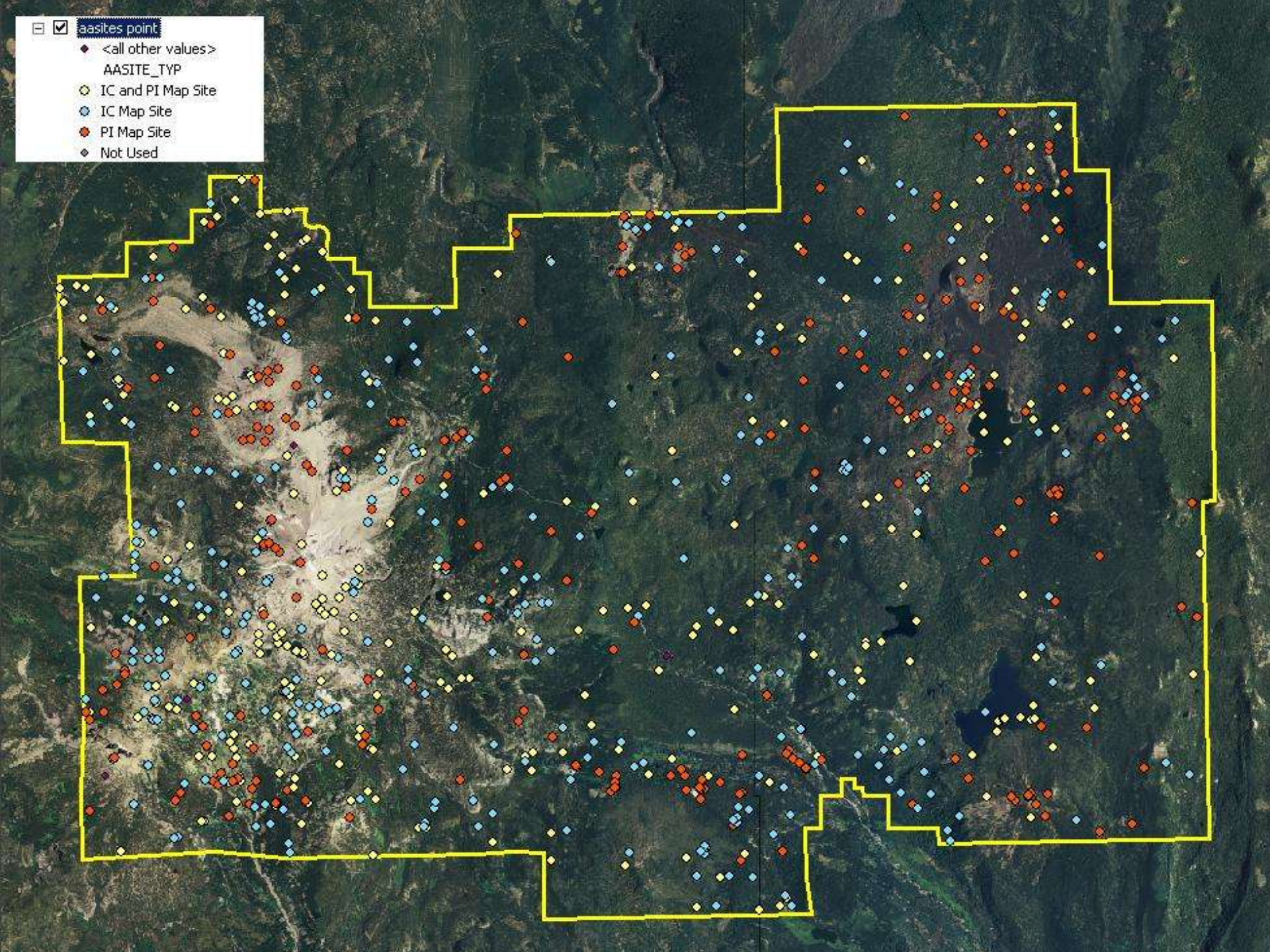

ICMapPinAlb-TsuMerMixes
ICPinAlbCoverGE1point5percent

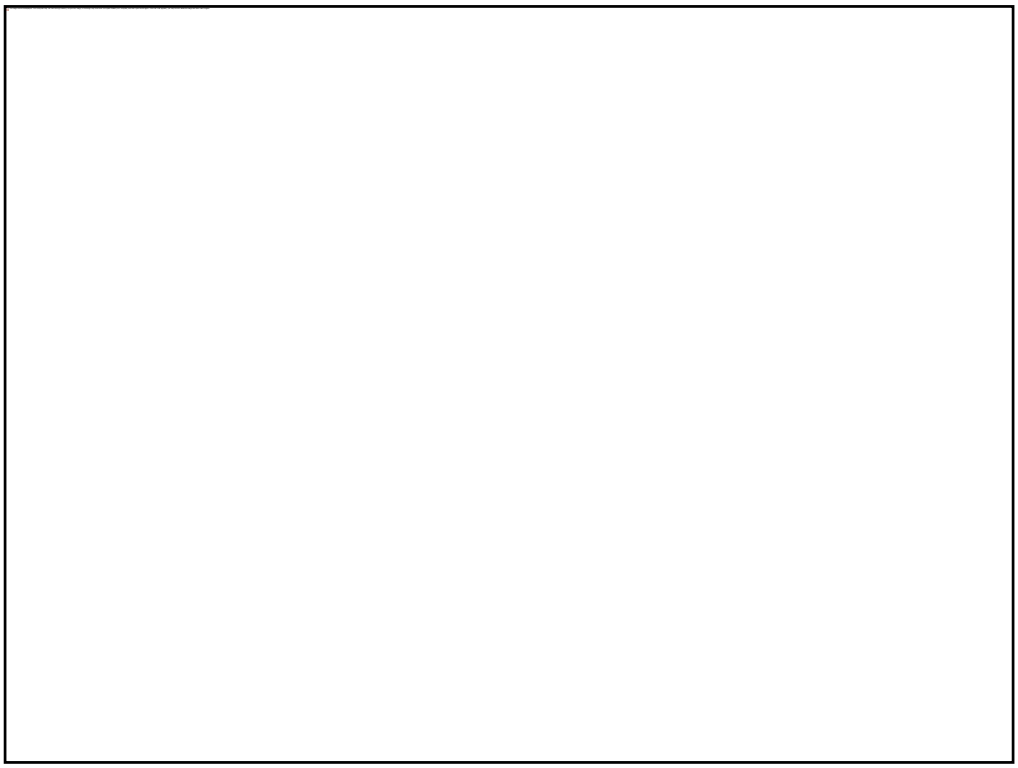


The difference in the maps is based on a type query versus a cover query … we can see areas added by querying cover estimates rather than just type names.

Accuracy Assessment – Preliminary

- Stratified random sample based upon Generalized Classes (Alliances)
- The two maps were tested independently of each other
- Over 1000 field sample sites visited and assessed
- Some sites tested one map, some the other map, and some both maps


aasites point
<all other values>
AASITE_TYP
IC and PI Map Site
IC Map Site
PI Map Site
Not Used



AA Sites … A random stratified sample typically results in a clumped distribution ! It is NOT systematically distributed !

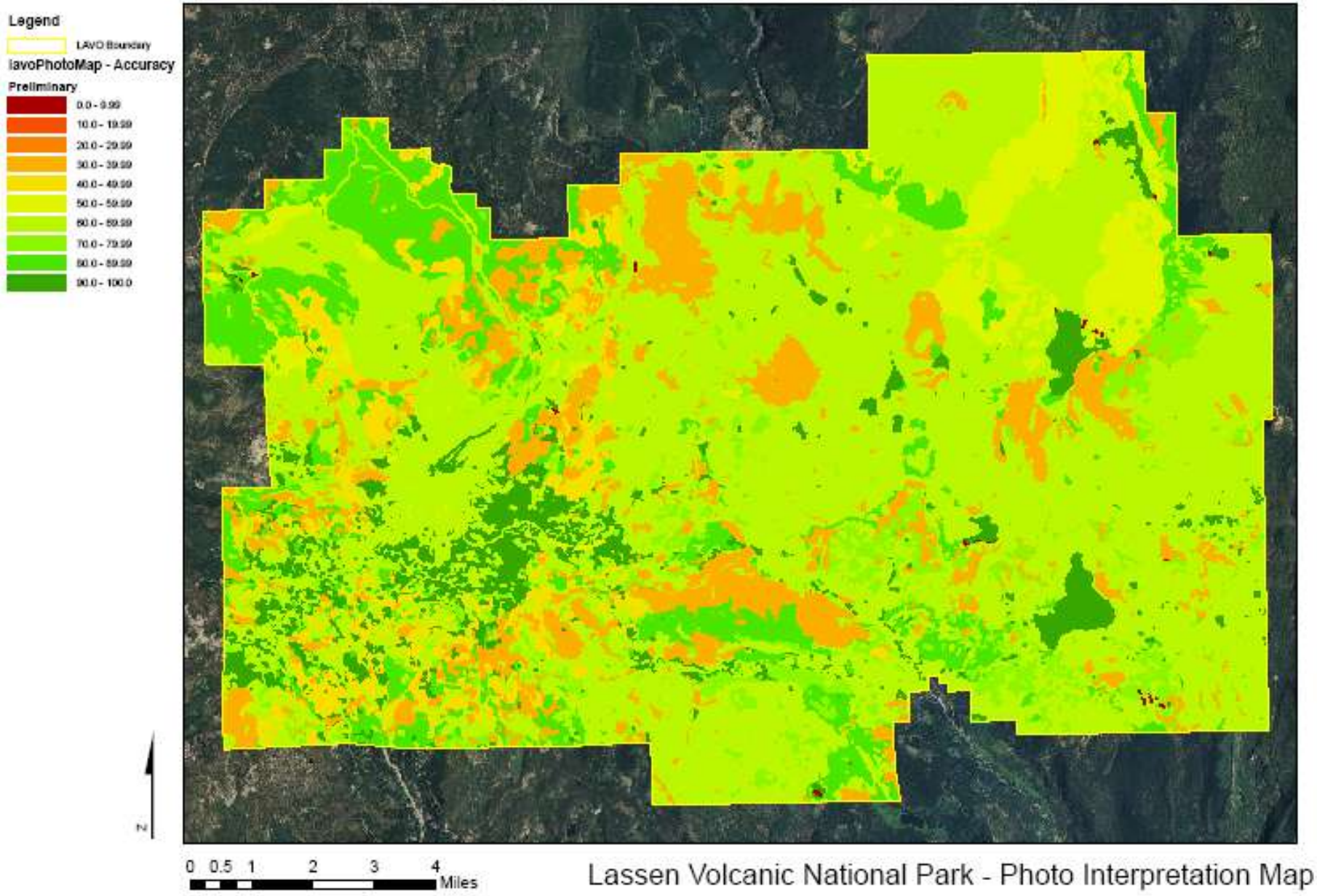
View Preliminary Accuracy Results …

- **Represented by incorporating Map Accuracy into the Map data Set attributes**
  - Photo Interpreted Map
  - Image Classification Map

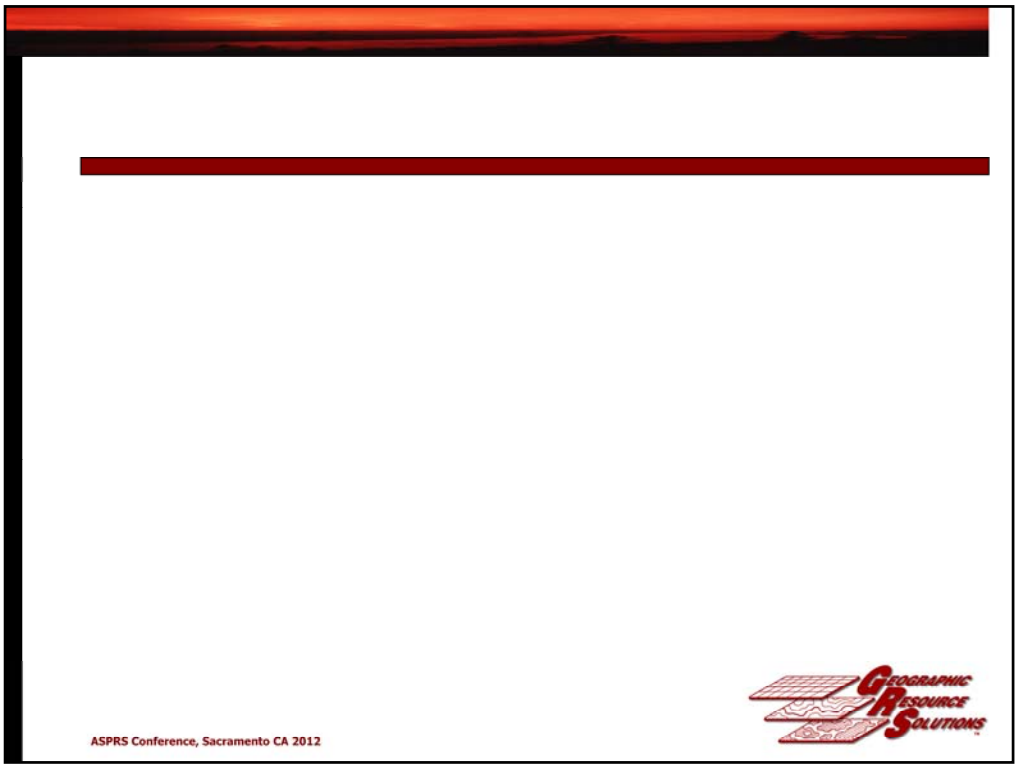
Field	Value
FID	6581
Shape	Polygon
AREA	9725301.11445
PERIMETER	170690.404784
UNIT_ID	7260
TYPE_ID	13
ACREAGE	2403.1599
DENSITY_MO	> 60%
DENSITY_CL	9
ASSOCIATION_GENERALIZED	LupObt:forb
ALLIANCE_GENERALIZED	LupObt:forb
ASSOCVEG_GENERALIZED	
ASSOCIATION_DETAILED	LoPd:forb
ALLIANCE_DETAILED	LoPd:forb
ASSOCVEG_DETAILED	
AAMAP_GENERALIZED	69
AAMAP_DETAILED	69

Let's look at the preliminary accuracy assessment results … if we add the accuracy assessments percent correct values by type …

Lassen Volcanic National Park Comparative Mapping Project

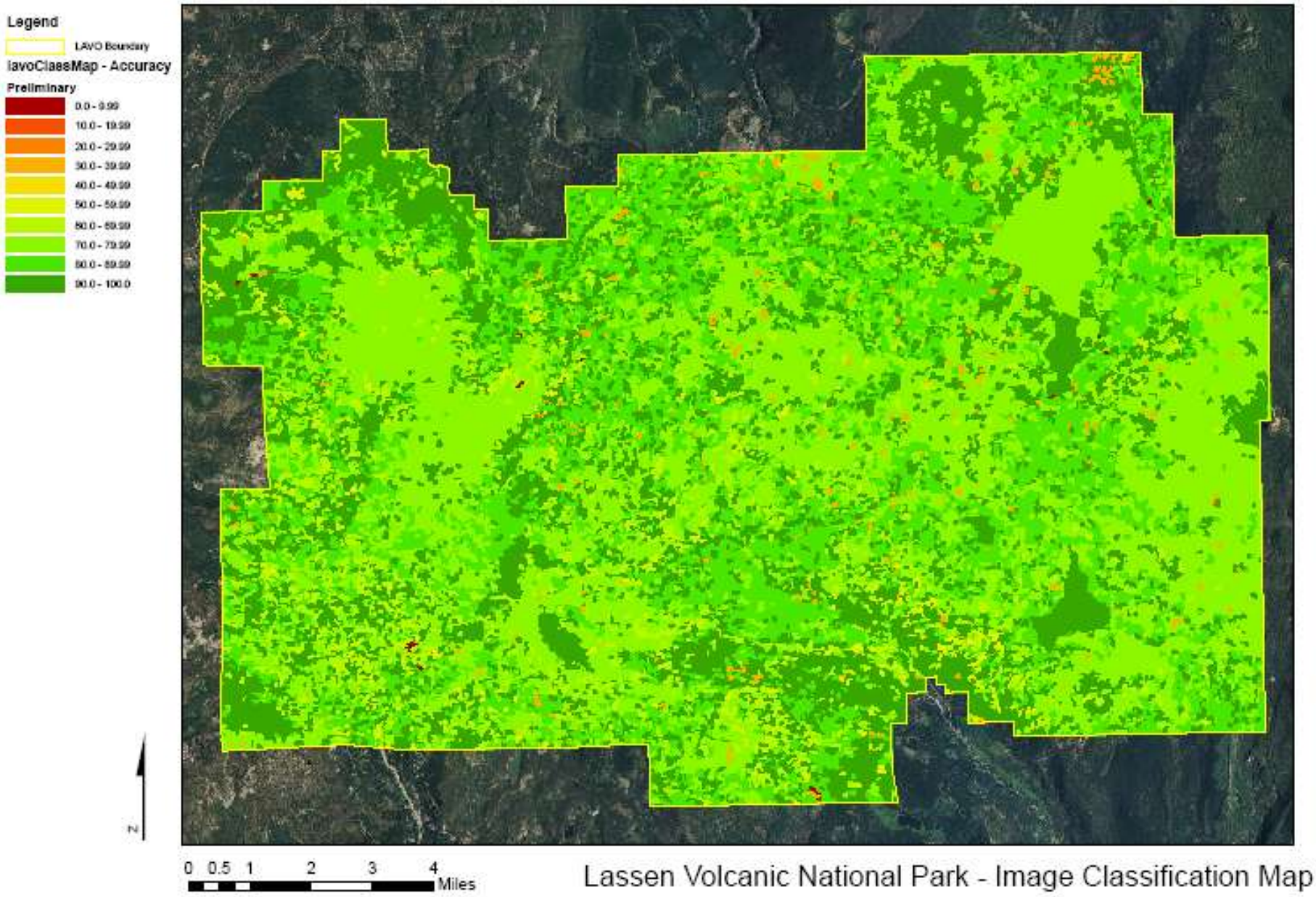


Lassen Volcanic National Park - Photo Interpretation Map

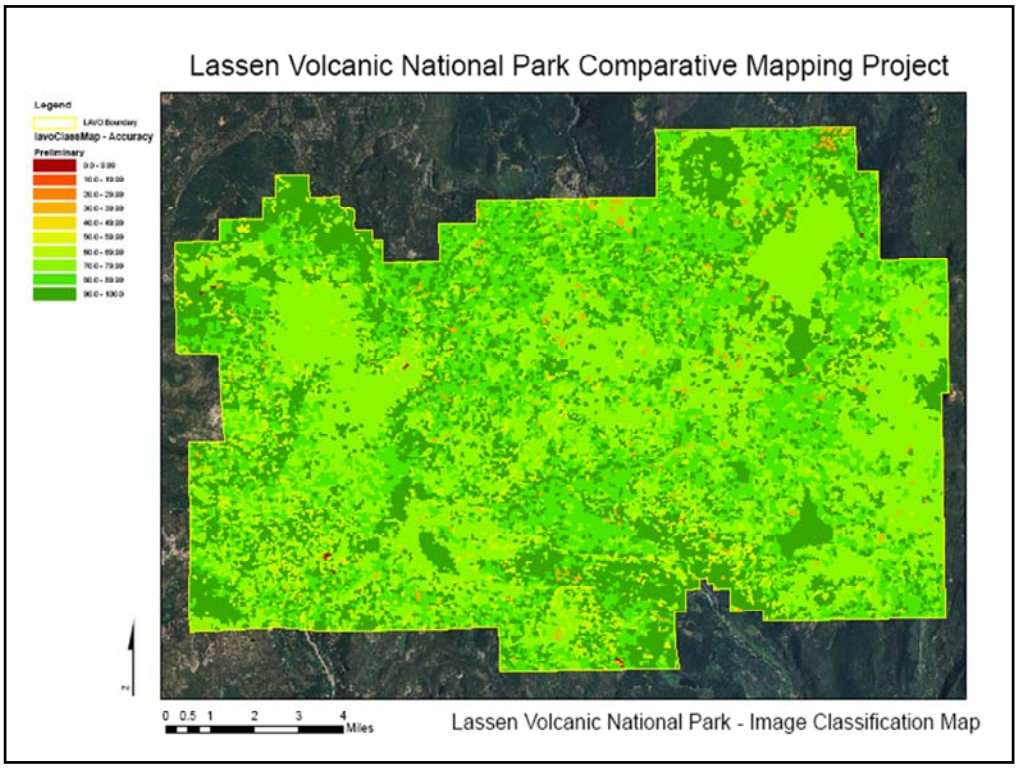


We can develop a map of the Accuracy of the Photo Interpreted Map …. Red, oranges are lowest in accuracy; darker greens are highest.

Lassen Volcanic National Park Comparative Mapping Project



Lassen Volcanic National Park - Image Classification Map



This is the accuracy of the image classification map … which one do you think is more accurate ?

Summary

- Field data provides the foundation of Discrete Classification
- Discrete Classification enables the 1:1 correspondence between field data (sites) and classes in the classmap.
- Estimating and mapping discrete species-specific estimates of the continuous variable of cover and size provide tremendous flexibility in making land cover data sets.
- Ecological rules are used to develop polygons, rather than spectral values.
- Discrete estimates provide the basis for a statistically based Accuracy Assessment without fuzzy logic.

Questions and Comments