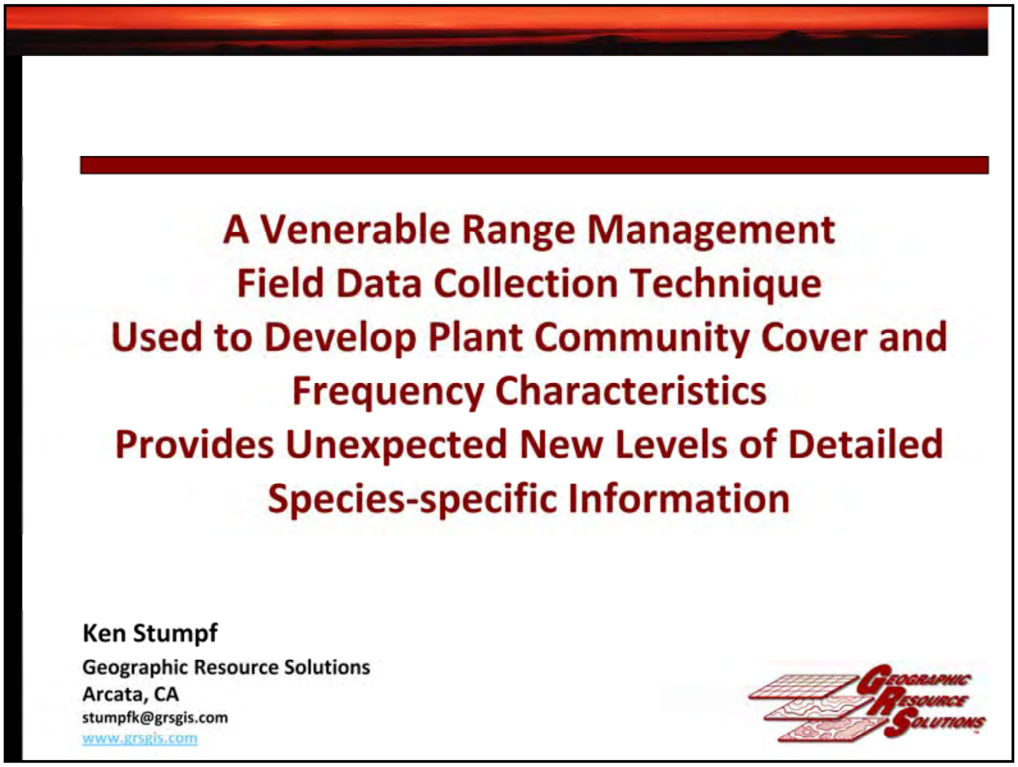
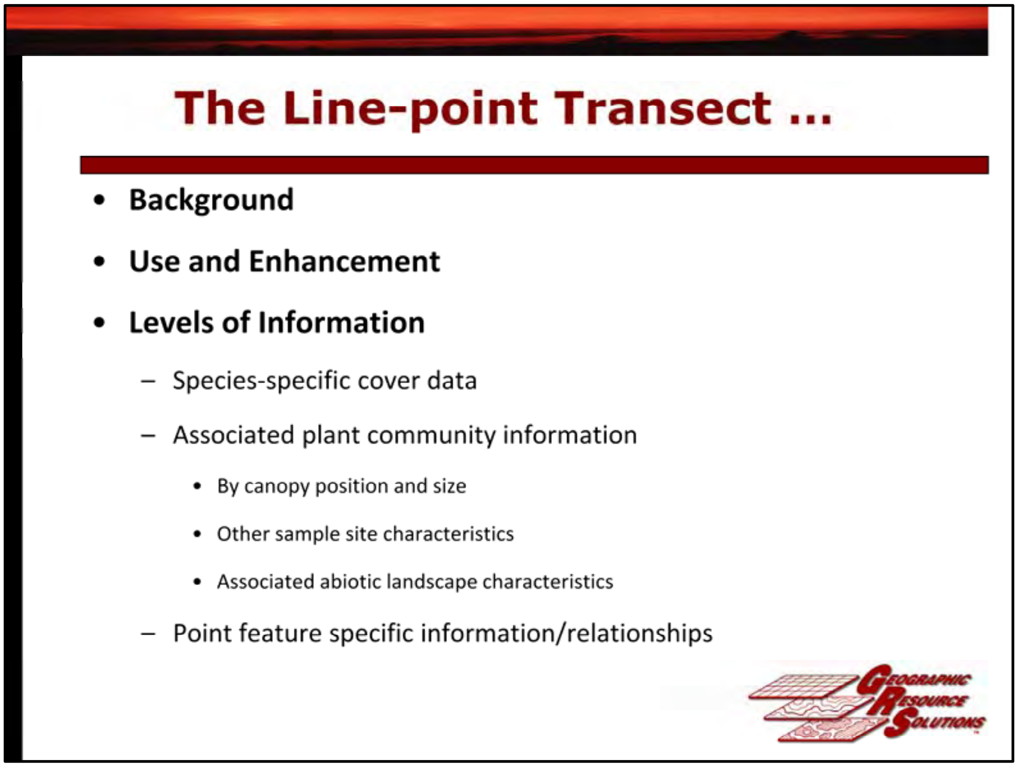


Presentation given at the Ecological Society of America in Sacramento, CA on August 13, 2014.

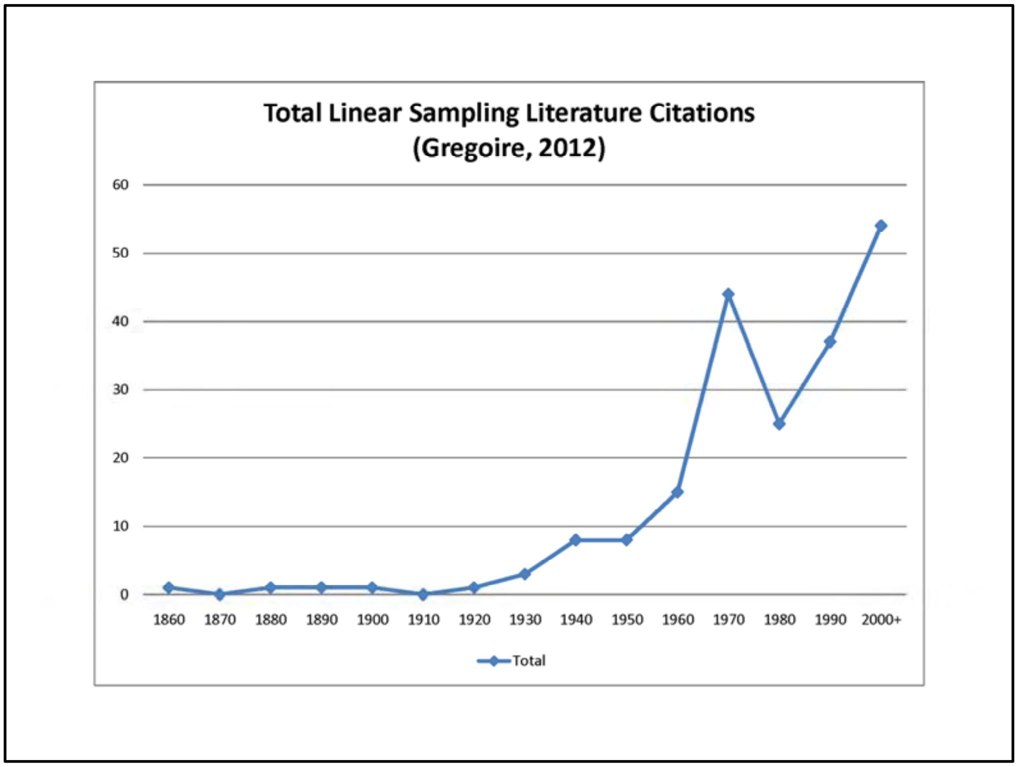
Good afternoon,

I am going to discuss a range management sampling technique, the Line-point transect, that I have used to collect and develop species-specific cover data for different types of herbaceous, shrub, and tree plant communities. A large reason for giving this presentation is that I have found that this methodology is not well understood.



I will briefly provide some background information, this method's use and our enhancement of the method to facilitate sampling shrub and forest ecosystems, and the different levels of information generated using this approach.

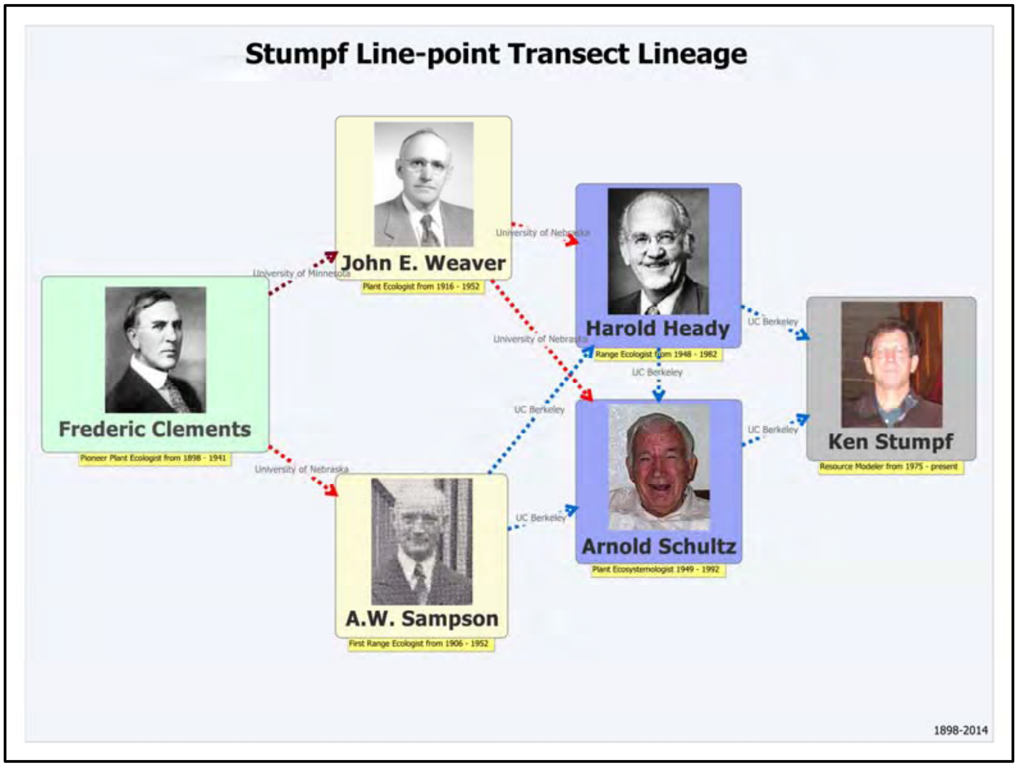
There will be lots of figures and numbers, quite small and shown quickly. If you want to see more, ask questions, or make comments please contact me (Ken Stumpf) at stumpfk@grsgis.com.



In researching this methodology I found the first citation involving linear transect sampling was from 1868.

As you can see from this graph, the number of literature citations/decade, based on a bibliography compiled by Dr. Tim Gregoire at Yale, has been increasing since the 1930's. By the way, I have only contributed one paper to this topic.

I was first exposed to this approach in 1972 while a student at Cal-Berkeley. I first recognized the need to use this methodology in 1990, when our company was hired by Calif. Dept of Forestry & Fire Protection to map 6-million acres of NW California in what was called The Timberlands Mapping Project. The project involved mapping to the California Wildlife Habitat Relationships Classification System and necessitated the development of quantitative species-specific cover estimates. I have been using it ever since!



I recalled the Line-point sampling methodology from my classes at Cal and started to use it and enhance it to use for this project. I learned a lot about the lineage of this methodology preparing for this presentation.

I learned about this method from two of my professors, Dr. Harold Heady and Dr. Arnold Schultz.

Dr. Heady was a range ecologist who taught at Cal from 1948-1982. He was very well known in California and a key individual working on much of his research at the Hopland Field Station.

Dr. Schultz was an ecologist who was at Cal for over 40 year. He claimed to be the first “Ecosystemologist” and invented the “Artificial Population Sampler.” Interestingly, both of these professors had similar influences during their education and early years at Cal.

Both Heady and Schultz got PhDs under Dr. John E. Weaver at the University of Nebraska in the late 1940’s. Both then worked in their early careers with Arthur W. Sampson at Cal.

Dr. Weaver was a professor at the University of Nebraska from 1916-1952. He got his PhD from University of Minnesota in 1916 under Dr. Frederic Clements. He is known as one of the first American Plant Ecologists and he had several major publications and co-authored the first American Plant Ecology text book.

Dr. Arthur Sampson was a professor at Cal from 1922-1952. He was a student at University of Nebraska when F. Clements taught there in the mid 1900’s. He was known as the “Father of Range Management” and was the “First Range Ecologist.” He too published

many research papers and published the first American Range Management text book. Sampson was at the University of Nebraska while Clements was teaching there in the mid-1900's.

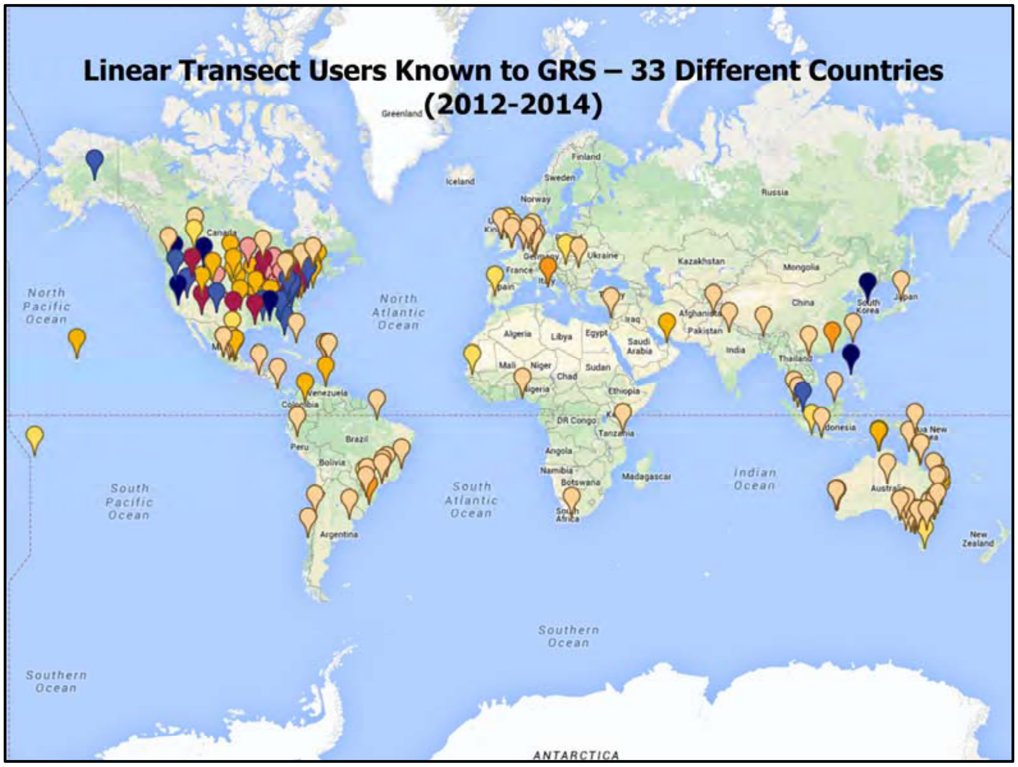
Dr. Frederic Clements has been referred to as the "Pioneer American Plant Ecologist" and is most well known for his theories of plant success and climax plant communities.

All three of these early ecologists wrote about the Line-point transect in their books and used it in their research.

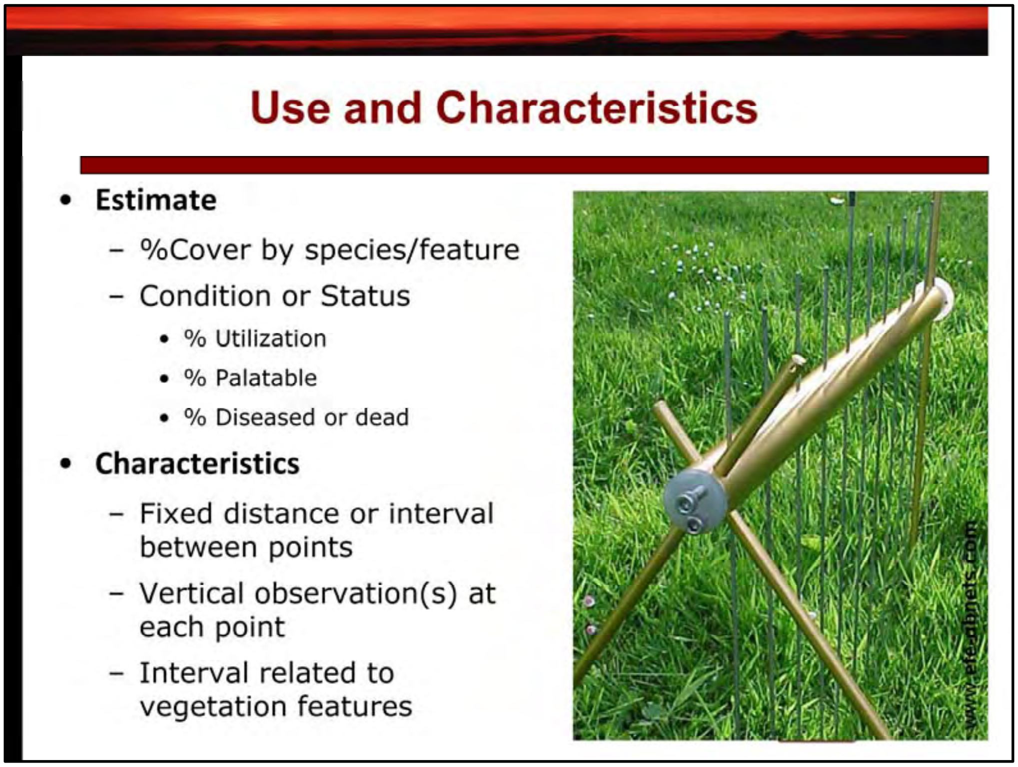
All three of them just happen to be part of the original 307 Charter Members of this Society when it formed nearly 100 years ago.

A.W. Sampson received the 5th Eminent Ecologist Award from this Society in 1958.

I find my work rather humbling in light of what these ecologists have accomplished.



If we come back to the present, I know that since 2012 some form of this methodology is now being used throughout the US and in at least 32 other countries. These are the locations of people who have purchased a vertical sighting device used with linear transect sampling during the past 3 years.



So what does this methodology involve ?

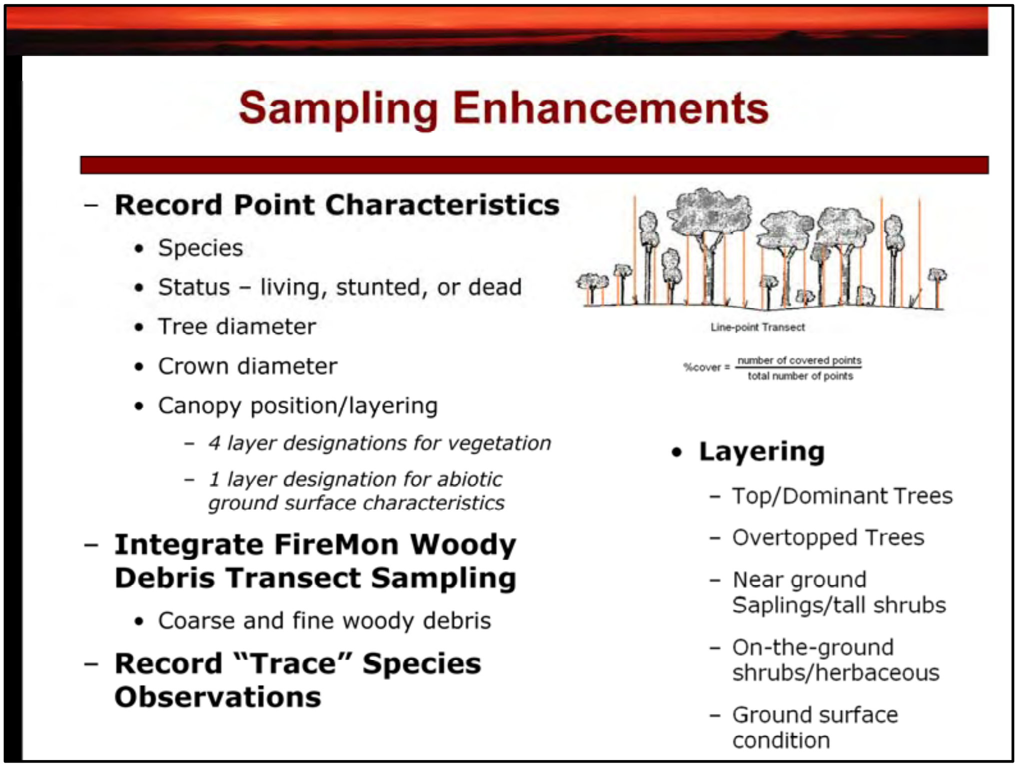
It is used to develop cover-based estimates of different plant community characteristics.

I saw it used to estimate vegetation cover, but also to estimate other characteristics, such as the % utilization or palatability. It was used extensively in “Dust Bowl” period restoration efforts to characterize different areas and estimate the degree of damage to different land in need of stabilization and restoration.

The sample design is based on implementing a linear transect with evenly spaced points at which we make an observation of what features are present or cover each point.

The distance between the points is typically relative to the lifeform of the features being sampled.

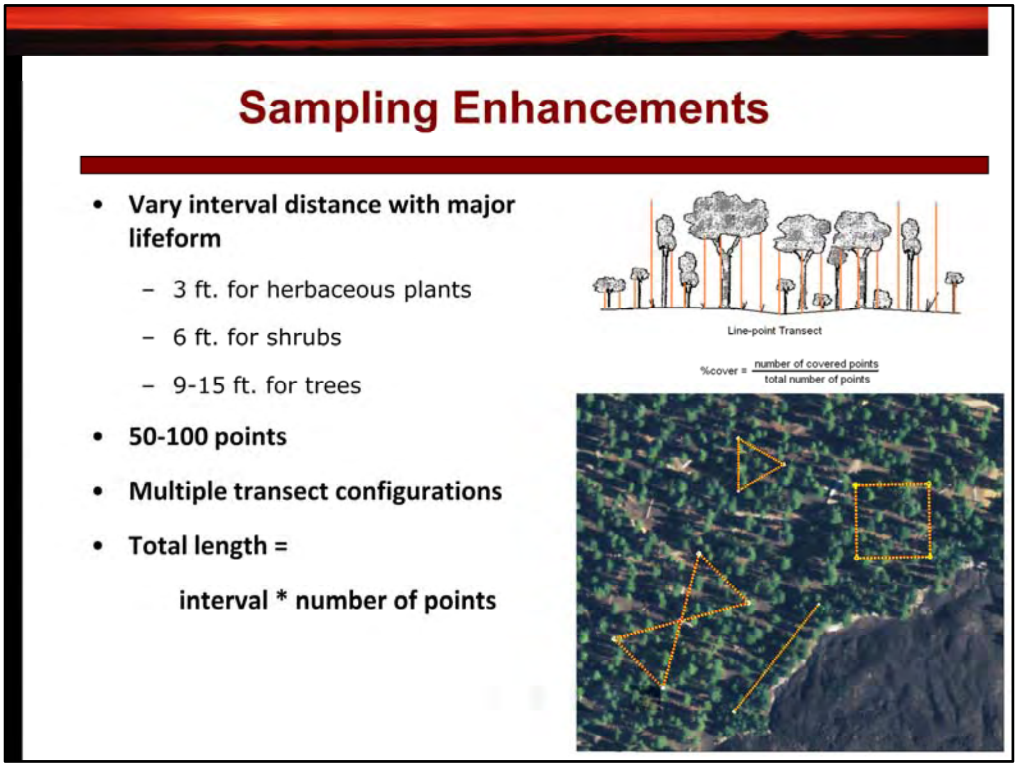
Shown here is a 10-point sampling frame used in grassland plant communities.



I have enhanced the process to include more than just observations of species and status.

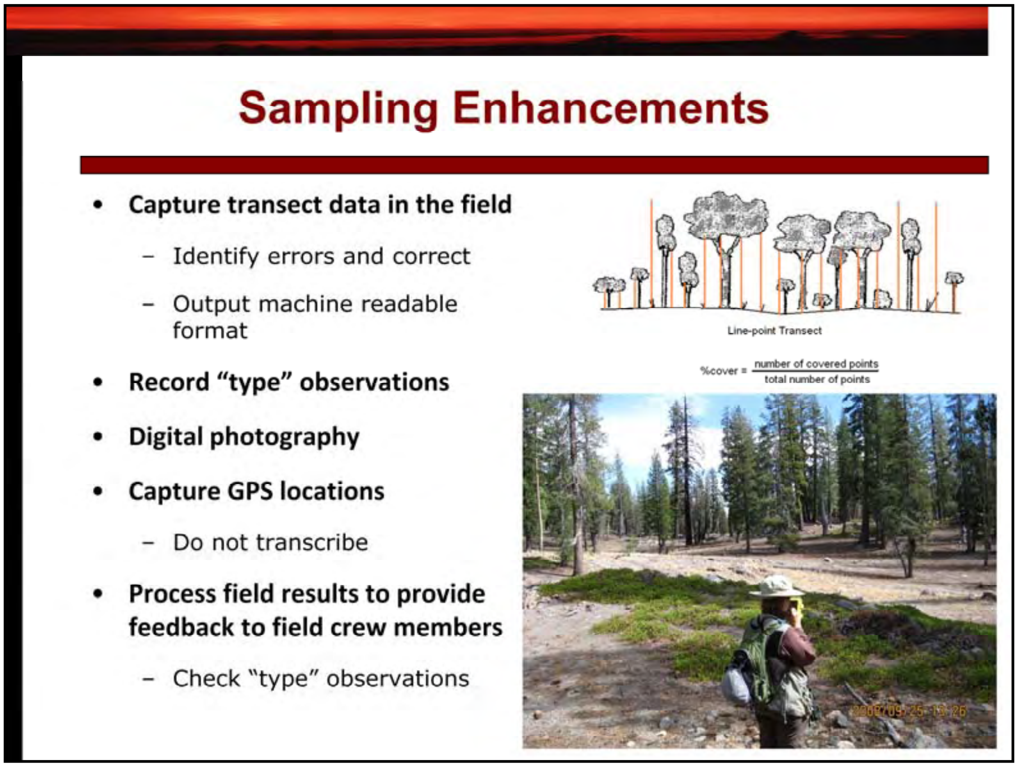
I have also included the observation of tree diameter, crown diameter, and the canopy layer in which the feature was found. In some sampling efforts I have included height estimation for each feature.

I have also integrated the Federal Fire Monitoring Woody Sampling protocols for sampling coarse and fine woody debris, as well as the observation of "Trace" species, which are species present at the sample site but were not observed at any point location.



Other enhancements have involved variable spacing for different lifeforms, samples of differing sizes (number of points), and multiple transect configurations that could handle sampling areas of different shapes.

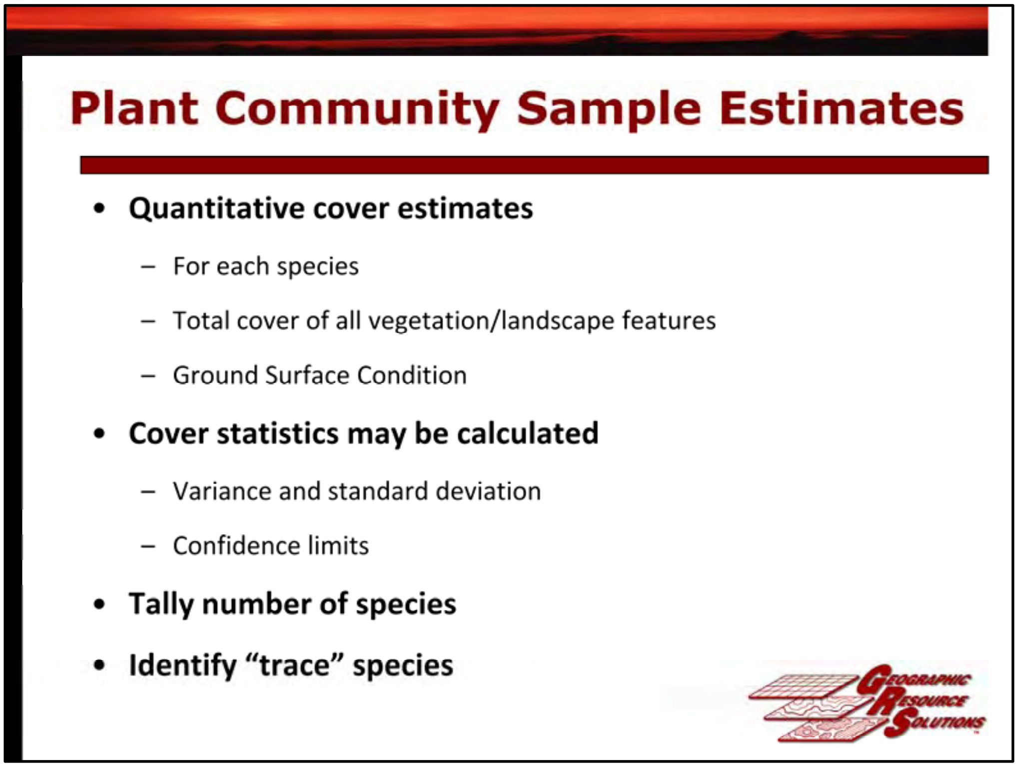
I have always liked using closed shapes as they will always provide samples neutral to changes in topography. However, points at/near the corners are not included as sample points to eliminate the possibility of distorting the sample by changing the angle under/within a possible sample feature, such as a large tree crown.



Further adaptations involved using field data collection software to speed up the collection of data, identify and eliminate errors, and output machine readable formatted data that could be quickly processed to provide feedback to the field crew.

We do have crews make type, cover, and size observations, both before and after sampling, which they can later check relative to the field data summary. This enables them to better "train their eye."

We also document all sites with photography and GPS coordinates. Transcription of GPS points can only lead to errors. GPS data should be downloaded. Transcribe it as a backup, if you find the need, but do not rely on transcription as your primary data source. In addition, photos taken with a GPS enabled camera that will record the location and azimuth of the picture are recommended.



This approach is capable of generating the typical species-specific population cover estimates we need.

We can generate totals, as well as an estimate of the ground surface condition.

We can generate statistics for these estimates!!

We can tally the number of species and observe "trace" species.

Only the generation of statistics may be new compared to some other estimation procedures.

Percent Cover Summary for All Layers:
Site/Polygon Id: 92203
Number of Sites: 1

Species	Tree Cover	Non-Tree Cover	Total Cover
Red fir	27.0		27.0
Red fir Dead	1.0		1.0
Mtn hemlock	25.0		25.0
Sierra currant		3.0	3.0
Pinemat manz		18.0	18.0
ELYELY		3.0	3.0
Achnath Occ		4.0	4.0
lichen		4.0	4.0
LUPOBT		3.0	3.0
MONODO		2.0	2.0
PENNEW		2.0	2.0
BarRoc		29.0	29.0
BarSGTA		20.0	20.0
FWD		6.0	6.0
CWD		4.0	4.0
LitDuf		41.0	41.0
Totals	**53.0**	**139.0**	**192.0**

Tree Cover Composition Summary for All Layers 53.0 Cover:

Species	Pct Total
Red fir	50.9
Red fir Dead	1.9
Mtn hemlock	47.2
Totals	100.0

Percent conifer composition = 100.0
Percent hardwood composition= 0.0
Most common specie is Red fir with 50.9 percent cover composition

Geographic Resource Solutions

Here is an example of the Total Cover Summary for one of the Lassen Volcanic National Park field sites.

It includes the species-specific cover estimates, but also includes estimates of the relative percent cover composition of the tree species.

Site/Polygon Id: 92203
Number of Sites: 1

Percent Cover Summary for Top/Dominant Layer:

Species	Tree Cover	Non-Tree Cover	Total Cover
Red fir	20.0		20.0
Red fir Dead	1.0		1.0
Mtn hemlock	23.0		23.0
Totals	**44.0**	**0.0**	**44.0**

Percent Cover Summary for Over-Topped Layer:

Species	Tree Cover	Non-Tree Cover	Total Cover
Totals	**0.0**	**0.0**	**0.0**

Percent Cover Summary for Near Ground Pole/Sapling Layer:

Species	Tree Cover	Non-Tree Cover	Total Cover
Red fir	7.0		7.0
Mtn hemlock	2.0		2.0
Sierra currant		3.0	3.0
Totals	**9.0**	**3.0**	**12.0**

Percent Cover Summary for On-the-Ground Layer:

Species	Tree Cover	Non-Tree Cover	Total Cover
Pinemat manz		18.0	18.0
ELYELY		3.0	3.0
Achnath Occ		4.0	4.0
lichen		4.0	4.0
LUPOBT		3.0	3.0
MONODO		2.0	2.0
PENNEW		2.0	2.0
Totals	**0.0**	**36.0**	**36.0**

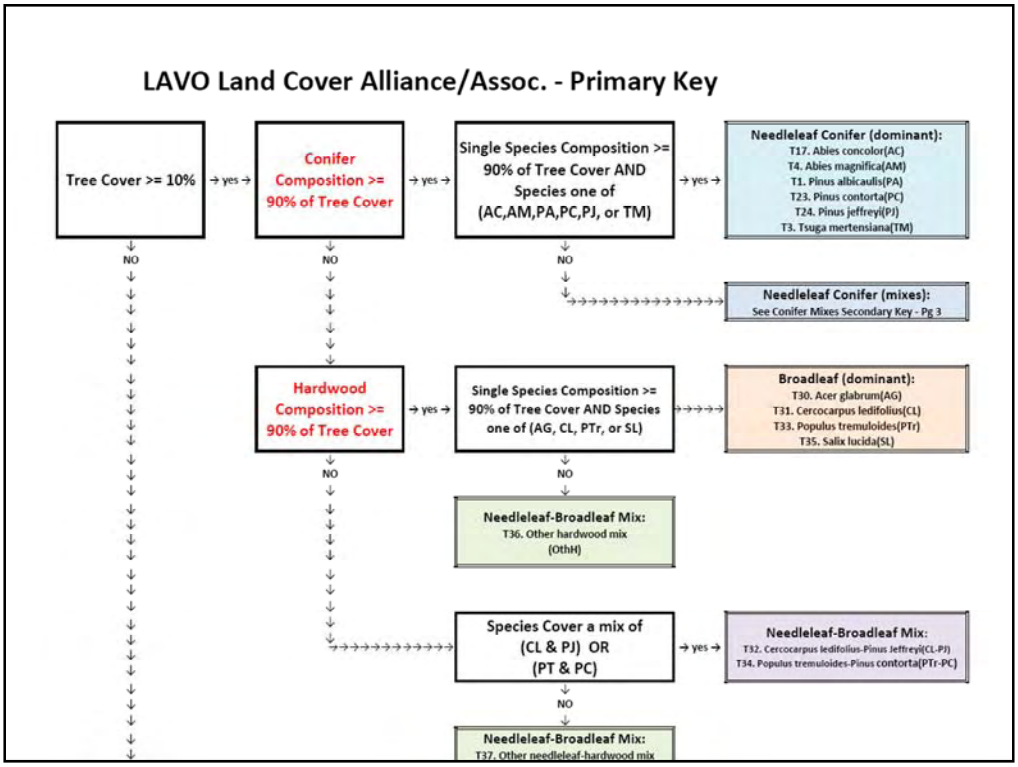
Percent Cover Summary for Ground Surface Condition Layer:

Species	Tree Cover	Non-Tree Cover	Total Cover
BarRoc		29.0	29.0
BarSGTA		20.0	20.0
FWD		6.0	6.0
CWD		4.0	4.0
LitDuf		41.0	41.0
Totals	**0.0**	**100.0**	**100.0**

Because we have recorded/observed the canopy position for every feature at every point, we are able to break out the cover by the vertical strata that were defined for this project summarizing cover by individual vertical stratum.

Cover information by canopy layer is show in these tables.

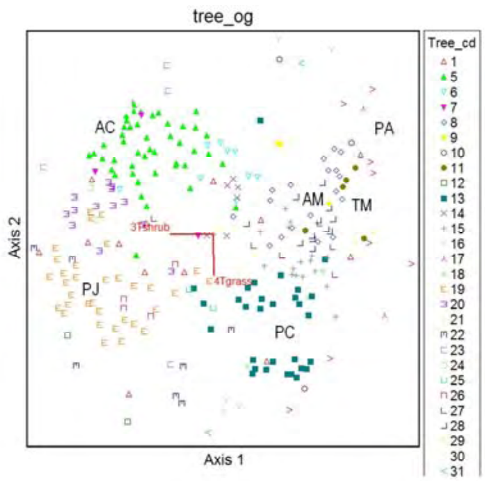
Included is a cover description of the abiotic features that comprise the ground surface condition of the sample area.



All of this detailed quantitative cover information allows the naming of standardized Associations using a type key.

Users of the Key know when estimates straddle Key thresholds and may develop “alternate calls,” as necessary, to more accurately characterize an area.

Vegetation Classification and Descriptions



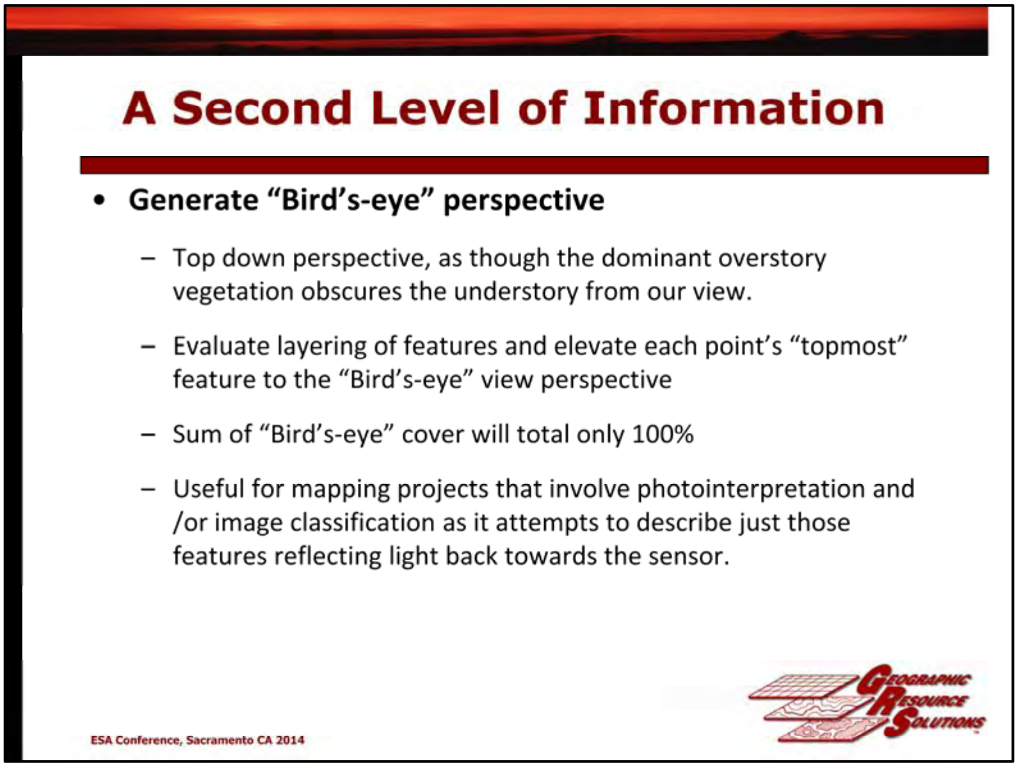
Type 538: ***Abies magnifica-(Pinus monticola)-Tsuga mertensiana/ Arctostaphylos nevadensis*** **(Sparse) Woodland**

Detailed Alliance Species	Total Frequency (%)	Total Average Cover	Total Minimum Cover	Total Maximum Cover
Tsuga mertensiana	100	11	2	25
Abies magnifica	80	16.8	2	37
Pinus monticola	40	3.6	8	10
Abies magnifica (dead)	20	0.2	1	1
Total tree		**31.6**		
Arctostaphylos nevadensis	100	26.8	4	77
Ribes nevadense	20	0.6	3	3
Holodiscus microphyllus	20	T	T	T
Ericameria bloomeri	20	T	T	T
Total shrub		**27.4**		
Lupinus obtusilobus	60	7.6	1	34
Elymus elymoides	40	0.6	3	3
Grass - other	40	0.6	3	3
Achnatherum species	20	1.2	6	6
Achnatherum occidentale	20	0.8	4	4
Rush - other	20	0.8	4	4
Carex species	20	0.4	2	2
Monardella odoratissima	20	0.4	2	2
Penstemon newberryi	20	0.4	2	2
Arabis platysperma	20	T	T	T
Total herbaceous		**12.8**		
Lichen	20	0.8	4	4
Total nonvascular		**0.8**		
Barren - litter	100	42.7	28	59
Barren - rock	100	19	3	34
Barren - duff	100	11.8	4	20
Barren - fine woody debris	100	8.5	4	14.5
Barren - fine gravelly soil	80	8	2	22
Barren - coarse woody debris	80	3.2	2	6
Barren - gravel	20	2	10	10
Barren - sand	20	2	10	10
Barren - bare soil	20	0.8	4	4
Barren - silty soil	20	0.2	1	1
Total other		**98.2**		
Totals		**170.8**		

These quantitative species-specific cover data also support Vegetation Classification efforts.

These sample area data may also be grouped by Association to yield species-specific cover data for Vegetation Descriptions.

Here I show estimated cover means, minima ,and maxima by species and lifeform, as well as frequency of occurrence.



But it turns out there is much more data that can be generated using this approach.

We can generate what is called a "Bird's-eye" view, which is a top down perspective of the dominant vegetation at the sample sites.

Our software uses the canopy position data to elevate each point's "topmost" feature to the "Bird's-eye" view to generate a "Bird's-eye" cover summary. This is especially useful for Keys that want to deal with "dominant" vegetation or for mapping projects that involve photointerpretation and/or image classification.

Site/Polygon Id: 92203
Number of Sites: 1

Percent Cover Summary for Top/Dominant Layer:

Species	Tree Cover	Non-Tree Cover	Total Cover
Red fir	20.0		20.0
Red fir Dead	1.0		1.0
Mtn hemlock	23.0		23.0
Totals	**44.0**	**0.0**	**44.0**

Percent Cover Summary for Over-Topped Layer:

Species	Tree Cover	Non-Tree Cover	Total Cover
Totals	**0.0**	**0.0**	**0.0**

Percent Cover Summary for Near Ground Pole/Sapling Layer:

Species	Tree Cover	Non-Tree Cover	Total Cover
Red fir	7.0		7.0
Mtn hemlock	2.0		2.0
Sierra currant		3.0	3.0
Totals	**9.0**	**3.0**	**12.0**

Percent Cover Summary for On-the-Ground Layer:

Species	Tree Cover	Non-Tree Cover	Total Cover
Pinemat manz		18.0	18.0
ELYELY		3.0	3.0
Achnath Occ		4.0	4.0
lichen		4.0	4.0
LUPOBT		3.0	3.0
MONODO		2.0	2.0
PENNEW		2.0	2.0
Totals	**0.0**	**36.0**	**36.0**

Percent Cover Summary for Ground Surface Condition Layer:

Species	Tree Cover	Non-Tree Cover	Total Cover
BarRoc		29.0	29.0
BarSGTA		20.0	20.0
FWD		6.0	6.0
CWD		4.0	4.0
LitDuf		41.0	41.0
Totals	**0.0**	**100.0**	**100.0**

Percent Cover Summary for Bird's-eye View:

Species	Tree Cover	Non-Tree Cover	Total Cover
Red fir	26.0		26.0
Red fir Dead	1.0		1.0
Mtn hemlock	23.0		23.0
Pinemat manz		10.0	10.0
ELYELY		3.0	3.0
Achnath Occ		4.0	4.0
lichen		4.0	4.0
LUPOBT		3.0	3.0
MONODO		2.0	2.0
BarRoc		10.0	10.0
BarSGTA		8.0	8.0
FWD		2.0	2.0
LitDuf		4.0	4.0
Totals	**50.0**	**50.0**	**100.0**

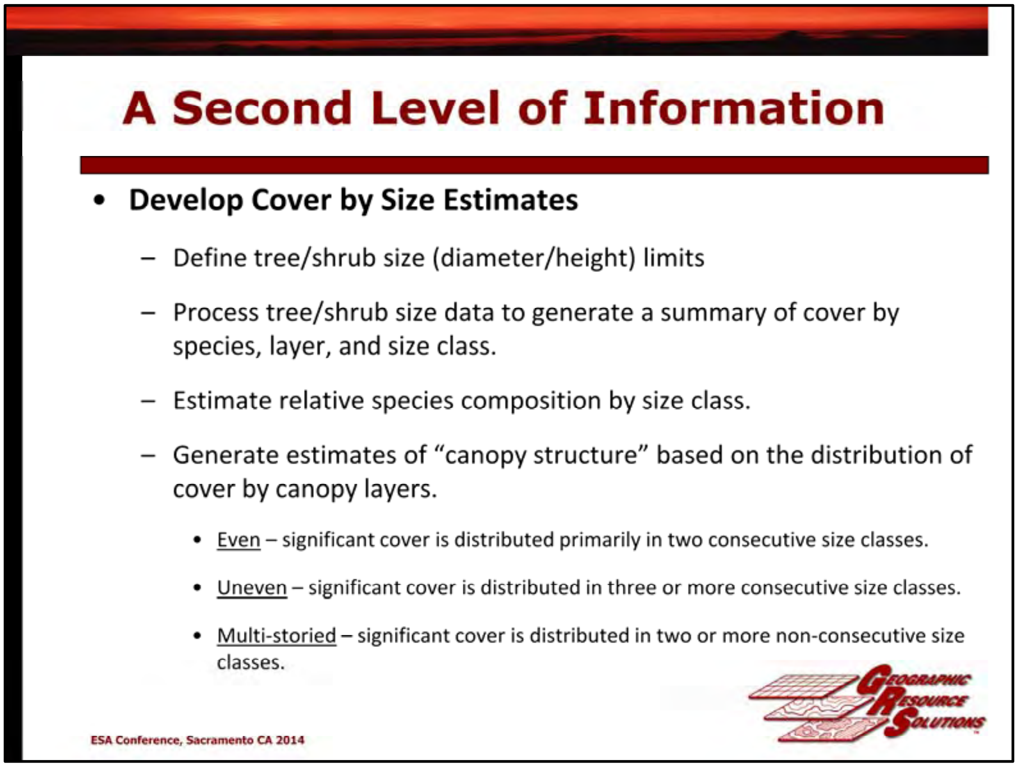
Here is the cover summary for “Bird’s-eye” view of this same sample site.

Type 538: *Abies magnifica-(Pinus monticola)-Tsuga mertensiana/Arctostaphylos nevadensis* (Sparse) Woodland

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	9.8	2	23	100	11	2	25
Abies magnifica	80	14.2	2	31	80	16.8	2	37
Pinus monticola	40	3.6	8	10	40	3.6	8	10
Abies magnifica (dead)	20	0.2	1	1	20	0.2	1	1
Total tree		**27.8**				**31.6**		
Arctostaphylos nevadensis	100	22.4	4	66	100	26.8	4	77
Ribes nevadense	P	P	P	P	20	0.6	3	3
Holodiscus microphyllus	T	T	T	T	20	T	T	T
Ericameria bloomeri	T	T	T	T	20	T	T	T
Total shrub		**22.4**				**27.4**		
Lupinus obtusilobus	60	7.2	1	32	60	7.6	1	34
Elymus elymoides	20	0.6	3	3	40	0.6	3	3
Grass - other	T	T	T	T	40	0.6	3	3
Achnatherum species	20	1.2	6	6	20	1.2	6	6
Achnatherum occidentale	20	0.8	4	4	20	0.8	4	4
Rush - other	20	0.4	2	2	20	0.8	4	4
Carex species	20	0.4	2	2	20	0.4	2	2
Monardella odoratissima	20	0.4	2	2	20	0.4	2	2
Penstemon newberryi	P	P	P	P	20	0.4	2	2
Arabis platysperma	T	T	T	T	20	T	T	T
Total herbaceous		**11**				**12.8**		
Lichen	20	0.8	4	4	20	0.8	4	4
Total nonvascular		**0.8**				**0.8**		
Barren - litter	100	11.4	2	29	100	42.7	28	59
Barren - rock	80	9.2	2	20	100	19	3	34
Barren - duff	80	7.2	2	16	100	11.8	4	20
Barren - fine woody debris	80	2.6	2	5	100	8.5	4	14.5
Barren - fine gravelly soil	80	4	2	12	80	8	2	22
Barren - coarse woody debris	40	1.6	2	6	80	3.2	2	6
Barren - gravel	20	1.2	6	6	20	2	10	10
Barren - sand	20	0.8	4	4	20	2	10	10
Barren - bare soil	P	P	P	P	20	0.8	4	4
Barren - silty soil	P	P	P	P	20	0.2	1	1
Total other		**38**				**98.2**		
Totals		**100**				**170.8**		

Using all of this information we can generate comparable means, minima, and maxima for the "Bird's-eye" view and add these information to our Vegetation Descriptions.

In this case there are slight differences of between 2-5% less cover by lifeform in the "Bird'e-eye" view relative to the Total Cover indicating less cover is present after removing the understory vegetation from consideration.



In addition, we can develop cover by size estimates.

If we develop and implement size class limits, we can process the cover data with respect to those size limits.

Such estimates can be useful in identifying canopy structure in different plant communities by evaluating how the cover is distributed through the different size classes and vertical layers.

Percent Cover Summary for All Layers:
Site/Polygon Id: 92203
Number of Sites: 1

Dbh Size Class: / Species	<= 5.95"	> 5.95" <=11.95"	>11.95" <=17.95"	>17.95" <=29.95"	>29.95"	Tree Cover	Non-Tree Cover	Total Cover
Red fir	15.0	4.0	4.0	4.0	0.0	27.0		27.0
Red fir Dead	0.0	0.0	0.0	1.0	0.0	1.0		1.0
Mtn hemlock	8.0	7.0	10.0	0.0	0.0	25.0		25.0
Sierra currant							3.0	3.0
Pinemat manz							18.0	18.0
ELYELY							3.0	3.0
Achnath Occ							4.0	4.0
lichen							4.0	4.0
LUPOBT							3.0	3.0
MONODO							2.0	2.0
PENNEW							2.0	2.0
BarRoc							29.0	29.0
BarSGTA							20.0	20.0
FWD							6.0	6.0
CWD							4.0	4.0
LitDuf							41.0	41.0
Totals	**23.0**	**11.0**	**14.0**	**5.0**	**0.0**	**53.0**	**139.0**	**192.0**

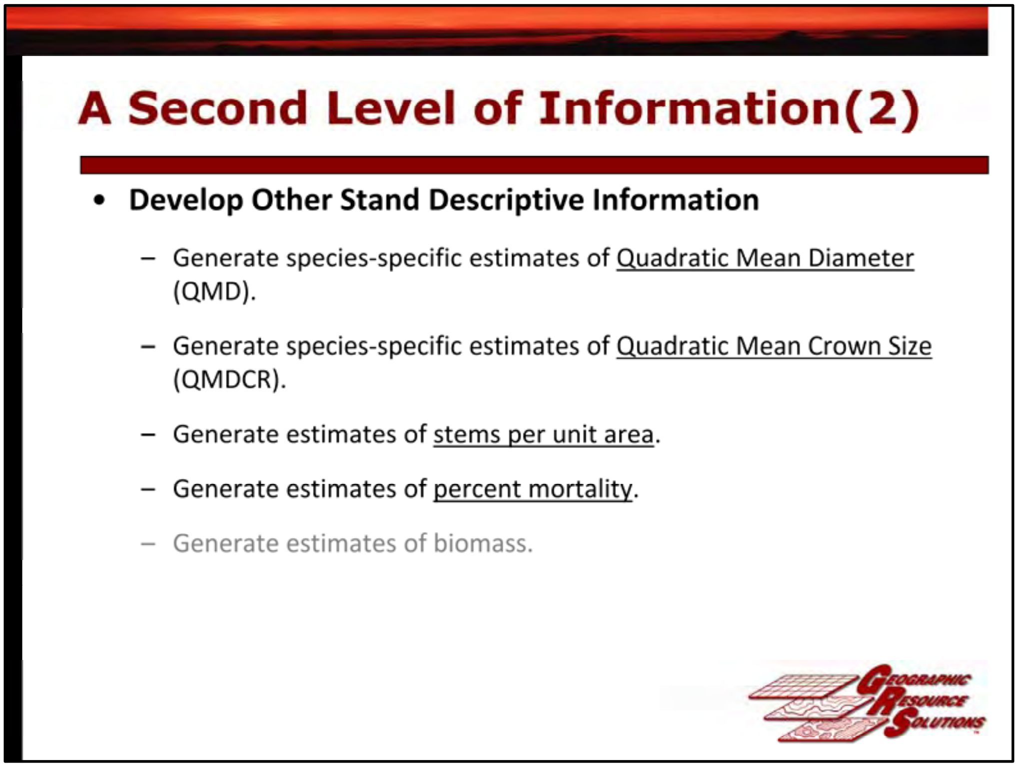
Tree Cover Composition Summary for All Layers 53.0 Cover:

Dbh Size Class: / Species	<= 5.95"	> 5.95" <=11.95"	>11.95" <=17.95"	>17.95" <=29.95"	>29.95"	All Sizes
Red fir	28.3	7.5	7.5	7.5	0.0	50.9
Red fir Dead	0.0	0.0	0.0	1.9	0.0	1.9
Mtn hemlock	15.1	13.2	18.9	0.0	0.0	47.2
Totals	**43.4**	**20.8**	**26.4**	**9.4**	**0.0**	**100.0**

Percent conifer composition= 100.0
Percent hardwood composition= 0.0
Most common specie is Red fir with 50.9 percent cover composition

Here is an example of Total Cover by Size Class.

Five size classes were defined and species-specific cover and relative cover composition values may now be generated to further refine the total cover estimates.



We can also generate other plant community characteristics.

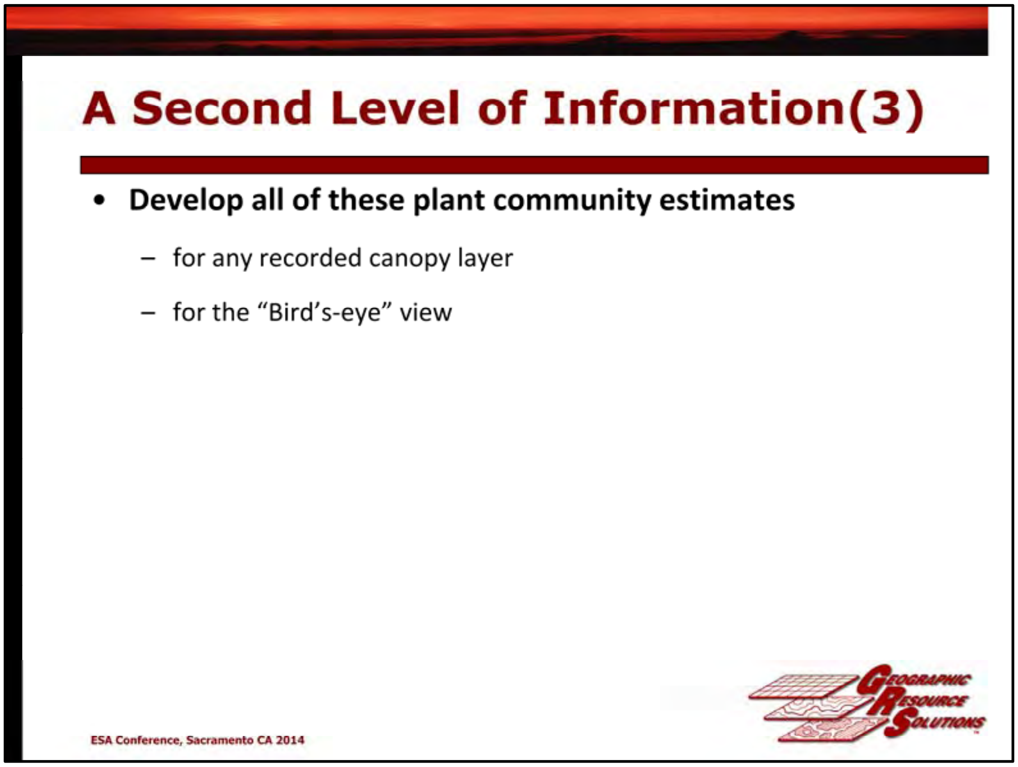
These include quadratic mean diameter(QMD), quadratic mean crown diameter(QMCR), stems/unit area, percent mortality, and even biomass, if we have included tree and shrub height measurements.

Quadratic Mean DBH and TPA Summary for All Layers:
Site/Polygon Id: 92203
Number of Sites: 1
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						
Red fir	3.2"	8.9"	15.0"	22.8"	0.0"	11.3"
cov_wt	15.0	4.0	4.0	4.0	0.0	27.0
tpa	963.9	28.4	15.7	28.2	0.0	1036.3
Red fir Dead	0.0"	0.0"	0.0"	23.0"	0.0"	23.0"
cov_wt	0.0	0.0	0.0	1.0	0.0	1.0
tpa	0.0	0.0	0.0	100.0	0.0	100.0
Mtn hemlock	4.3"	8.3"	14.4"	0.0"	0.0"	10.4"
cov_wt	8.0	7.0	10.0	0.0	0.0	25.0
tpa	106.9	61.9	81.0	0.0	0.0	249.7
	------	------	------	------	------	------
Conifer	3.6"	8.5"	14.6"	22.8"	0.0"	11.2"
cov_wt	23.0	11.0	14.0	5.0	0.0	53.0
tpa	1070.8	90.3	96.7	128.2	0.0	1386.0
	------	------	------	------	------	------
	------	------	------	------	------	------
All Species	**3.6"**	**8.5"**	**14.6"**	**22.8"**	**0.0"**	**11.2"**
cov_wt	**23.0**	**11.0**	**14.0**	**5.0**	**0.0**	**53.0**
tpa	**1070.8**	**90.3**	**96.7**	**128.2**	**0.0**	**1386.0**

Here is an example of the QMD info for by species and in total.

Included are estimates of stems per unit area. Note the high stems/unit area(**tpa**) values that are greater than 1000 for the smallest size class, as well as for the total (1386).



We can develop all of these plant community estimates for any recorded canopy layer and for the “Bird’s-eye” view.

Percent Cover Summary for Bird's-eye Layer:
Site/Polygon Id: 92203
Number of Sites: 1

Dbh Size Class: / **Species**	**<= 5.95"**	**> 5.95" <=11.95"**	**>11.95" <=17.95"**	**>17.95" <=29.95"**	**>29.95"**	**Tree Cover**	**Non-Tree Cover**	**Total Cover**
Red fir	14.0	4.0	4.0	4.0	0.0	26.0		26.0
Red fir Dead	0.0	0.0	0.0	1.0	0.0	1.0		1.0
Mtn hemlock	6.0	7.0	10.0	0.0	0.0	23.0		23.0
Pinemat manz							10.0	10.0
ELYELY							3.0	3.0
Achnath Occ							4.0	4.0
lichen							4.0	4.0
LUPOBT							3.0	3.0
MONODO							2.0	2.0
BarRoc							10.0	10.0
BarSGTA							8.0	8.0
FWD							2.0	2.0
LitDuf							4.0	4.0
Totals	20.0	11.0	14.0	5.0	0.0	50.0	50.0	100.0

Tree Cover Composition Summary for Bird's-eye Layer 50.0 Cover:

Dbh Size Class: / **Species**	**<= 5.95"**	**> 5.95" <=11.95"**	**>11.95" <=17.95"**	**>17.95" <=29.95"**	**>29.95"**	**All Sizes**
Red fir	28.0	8.0	8.0	8.0	0.0	52.0
Red fir Dead	0.0	0.0	0.0	2.0	0.0	2.0
Mtn hemlock	12.0	14.0	20.0	0.0	0.0	46.0
Totals	**40.0**	**22.0**	**28.0**	**10.0**	**0.0**	**100.0**

Percent conifer composition= 100.0
Percent hardwood composition= 0.0
Most common specie is Red fir with 52.0 percent cover composition

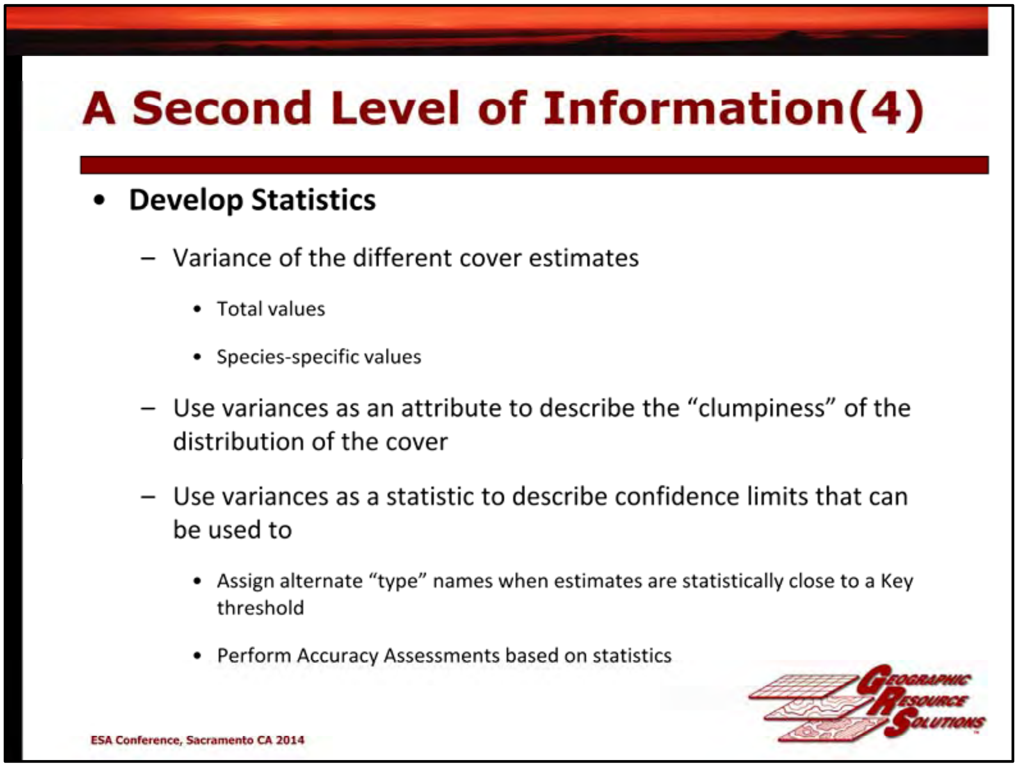
Here is an example of the "Bird's-eye" view cover summary including size classes.

Quadratic Mean DBH and TPA Summary for Bird's-eye Layer:
Site/Polygon Id: 92203
Number of Sites: 1
Weighted by Cover

Dbh Size Class: **Species**	<= 5.95"	> 5.95" <=11.95"	>11.95" <=17.95"	>17.95" <=29.95"	>29.95"	**All Sizes**
Red fir	3.3"	8.9"	15.0"	22.8"	0.0"	11.5"
cov_wt	14.0	4.0	4.0	4.0	0.0	26.0
tpa	382.4	28.4	15.7	28.2	0.0	454.7
Red fir Dead	0.0"	0.0"	0.0"	23.0"	0.0"	23.0"
cov_wt	0.0	0.0	0.0	1.0	0.0	1.0
tpa	0.0	0.0	0.0	100.0	0.0	100.0
Mtn hemlock	5.0"	8.3"	14.4"	0.0"	0.0"	10.9"
cov_wt	6.0	7.0	10.0	0.0	0.0	23.0
tpa	76.1	61.9	81.0	0.0	0.0	218.9
Conifer	3.9"	8.5"	14.6"	22.8"	0.0"	11.6"
cov_wt	20.0	11.0	14.0	5.0	0.0	50.0
tpa	458.5	90.3	96.7	128.2	0.0	773.6
All Species	**3.9"**	**8.5"**	**14.6"**	**22.8"**	**0.0"**	**11.6"**
cov_wt	**20.0**	**11.0**	**14.0**	**5.0**	**0.0**	**50.0**
tpa	**458.5**	**90.3**	**96.7**	**128.2**	**0.0**	**773.6**

Here is an example of the "Bird's-eye" view QMD and Stems/acre summary including size classes.

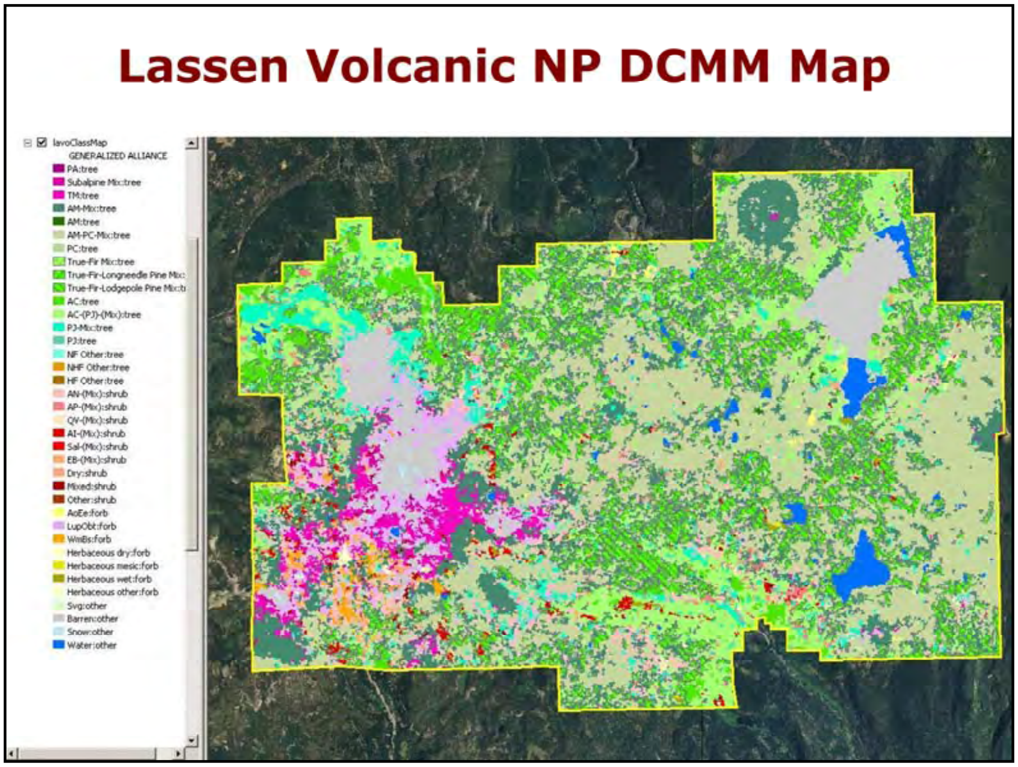
Note that nearly half the number of stems per acre(**tpa**) in the smallest size class have been removed when the understory vegetation is removed from the "Bird's-eye" view, as these are small trees observed under larger trees.



We can generate statistics by lifeform, or by individual species, or in total.

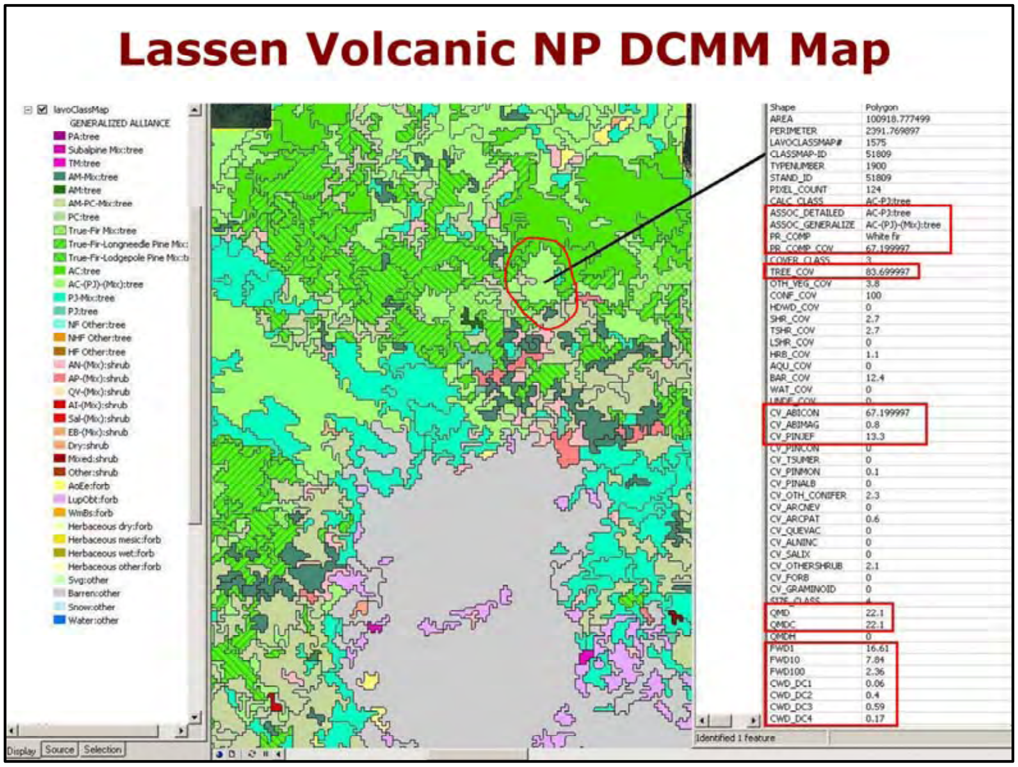
Cover variances can be stored as an attribute of a sample site as they may indicate degrees of "clumpiness."

We can use the statistics to develop "Alternate Association names" or to help perform statistically-based Accuracy Assessments.



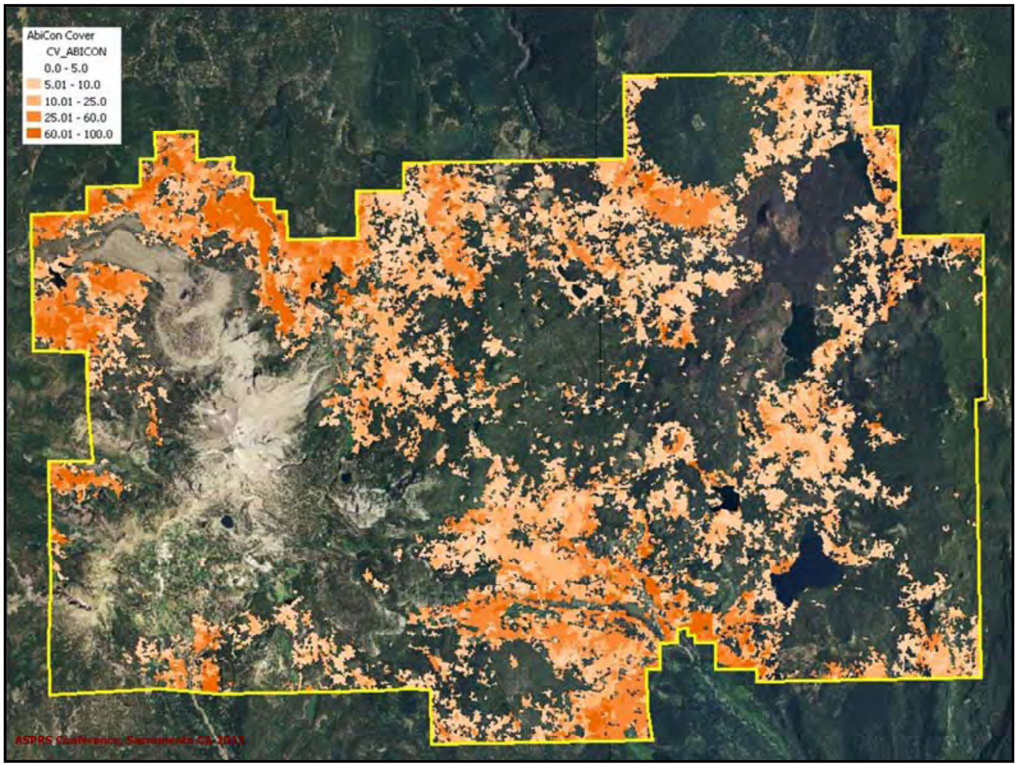
All of this quantitative information, when properly integrated with the appropriate remote sensing techniques, enables the development of detailed species-specific quantitative map data sets, like those recently developed for both Redwood National and State Parks and Lassen Volcanic National Park.

However, the resulting map data sets are far more than the standard color-coded National vegetation classification System(NVCS) type map.



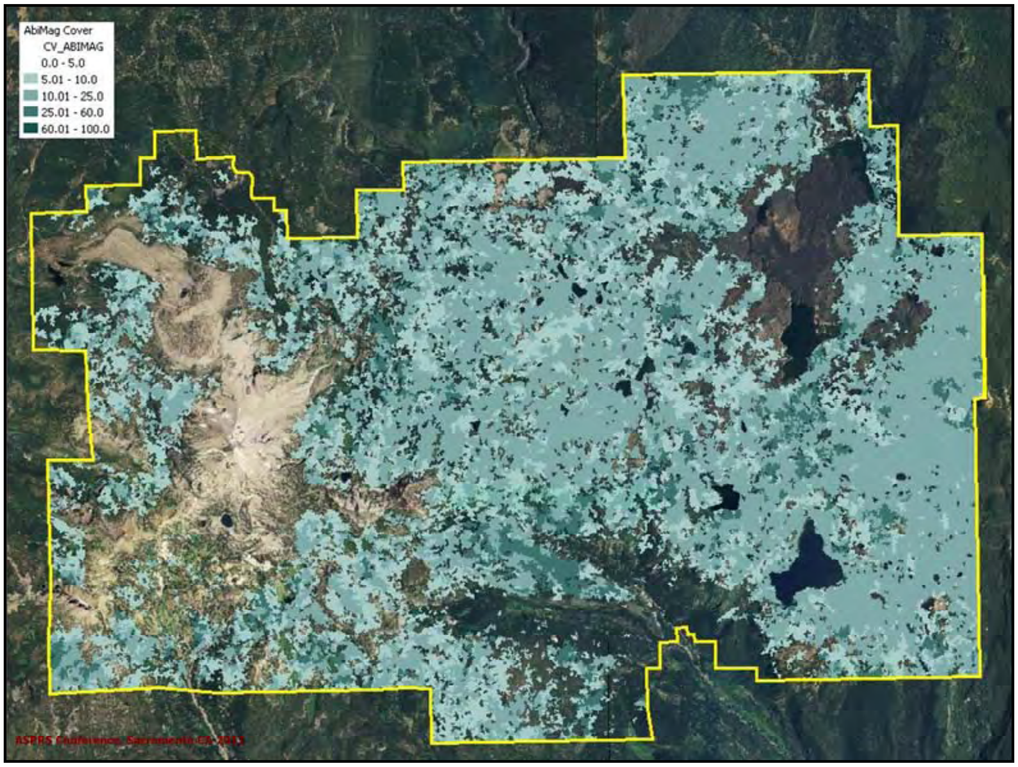
These map data sets include the required NVCS type information, but they also include all the species-specific cover estimates and many of the 2nd level plant community characteristics like dominant cover, tree size, stems/acre, and woody debris estimates.

In additional, all species/feature estimates for all canopy positions can be accessed by relating one species-cover table thereby enabling querying by any feature in any vertical strata of the map data set.



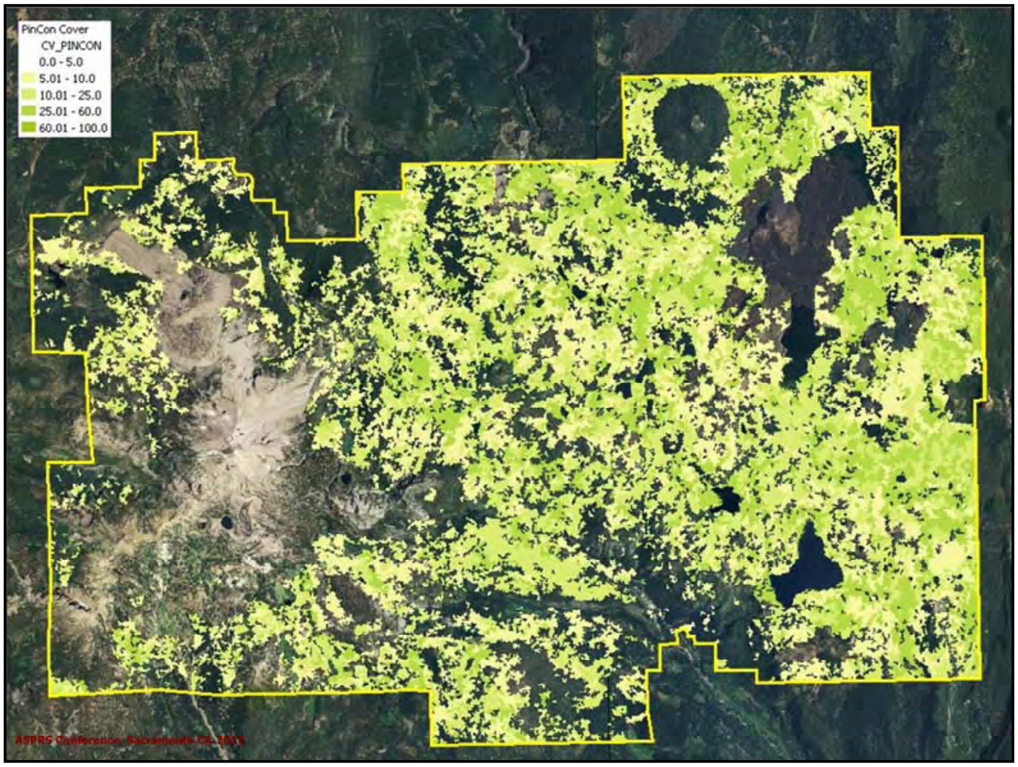
Armed with such quantitative information, the development of species cover magnitude and extent maps becomes a simple matter of generating a legend based on that particular table attribute column.

This is the cover distribution of *Abies concolor* …

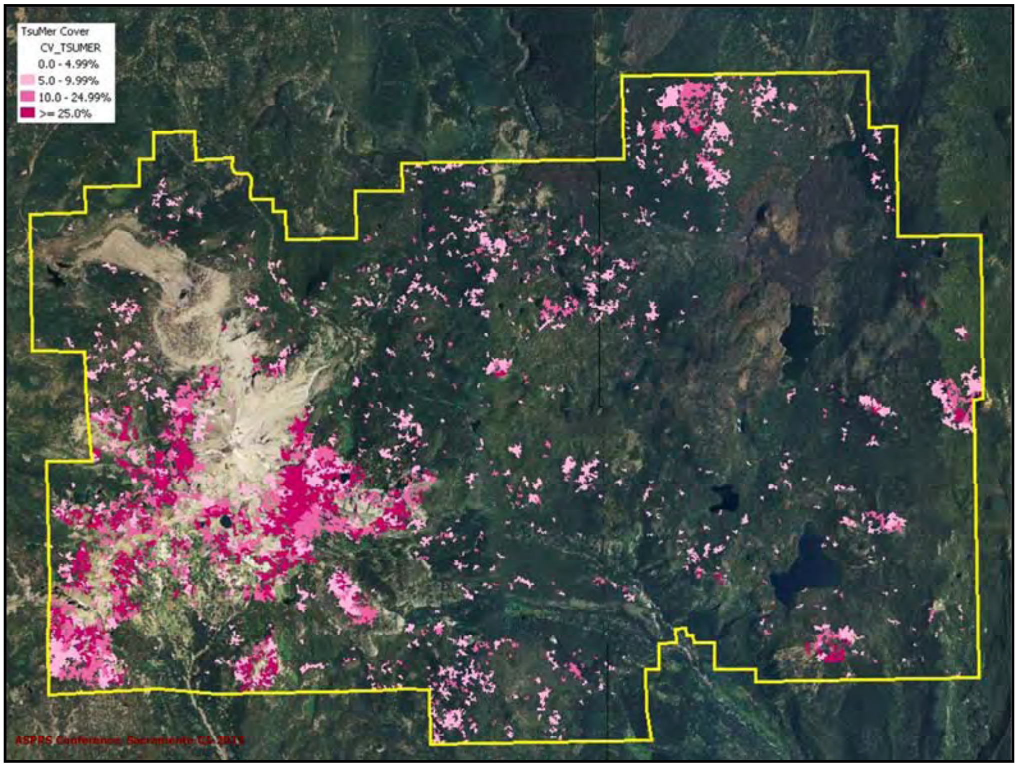


This is the cover distribution of *Abies magnifica* …

Note the different extent of these two species.

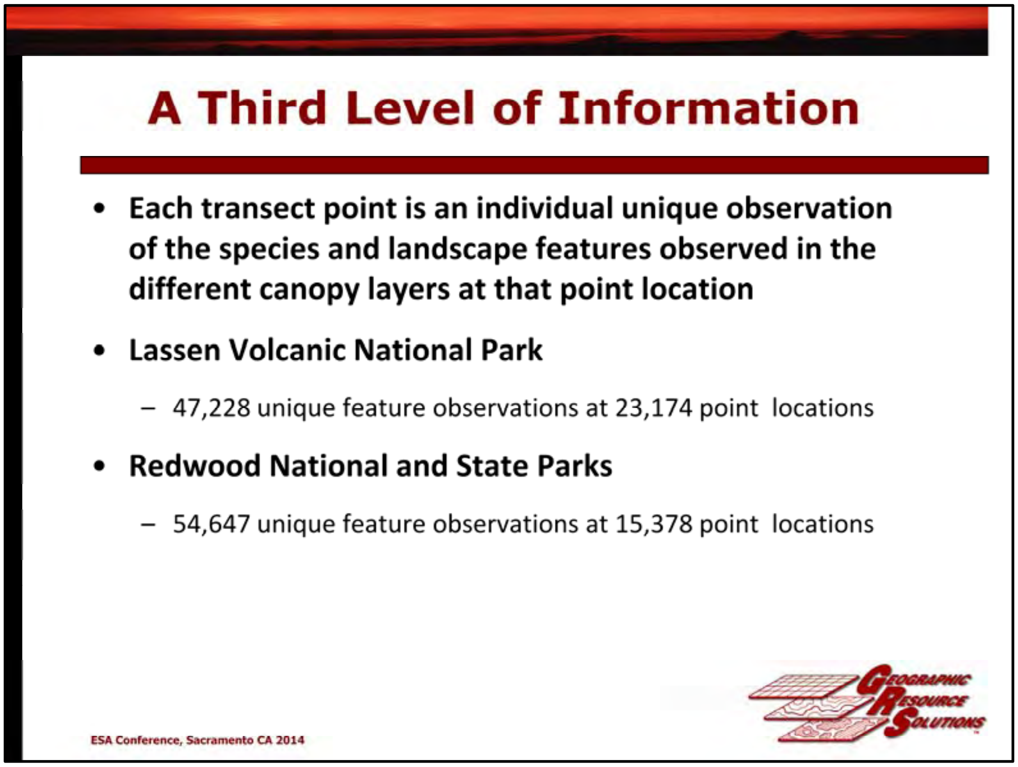


This is the cover distribution map of *Pinus contorta* …



… this is the cover distribution of *Tsuga mertensiana*, typically found at higher elevations

There is a virtually unlimited number of maps that may be developed from species-specific quantitative map data sets based on this field data collection methodology.

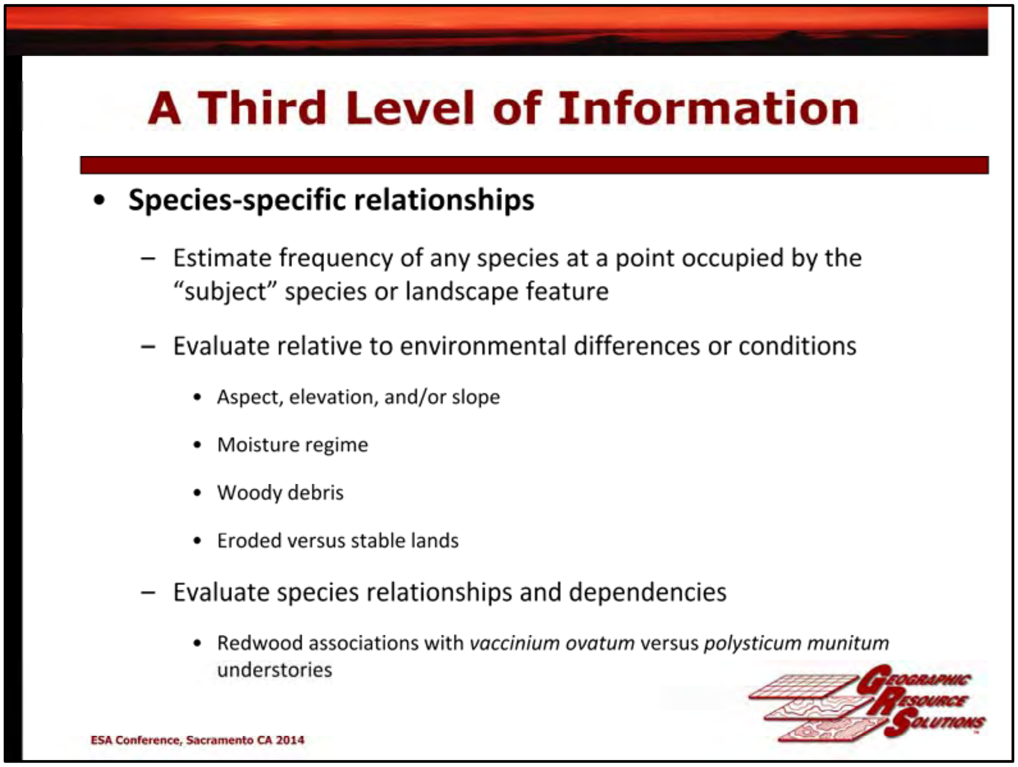


Lastly, there is a 3rd level of plant community information I stumbled upon by happenstance.

This information is developed at the individual point observation level.

In RNSP we had 47,228 unique feature observations at 23,174 point locations

while at LAVO we had 54,647 unique feature observations at 15,378 point locations



I found that I could query the transect point data to produce frequency distributions with respect to

ANY species or feature observed at a point … or by environmental characteristics of the sample area(s) in which point observations were located.

Redwood Point Frequency Distribution

Subject species: ***Sequoia sempervirens***

species_code	species_alpha	freq	%freq
1	SEQSEM	3764	100.0%
817	POLMUN	1157	30.7%
186	VACOVA	935	24.8%
42	LITDEN	690	18.3%
2	PSEMEN	631	16.8%
635	OXAORE	463	12.3%
41	ALNRUB	460	12.2%
153	RHOMAC	327	8.7%
3	TSUHET	271	7.2%
135	GAUSHA	171	4.5%
804	BLESPI	115	3.1%
4	PICSIT	94	2.5%
187	VACPAR	57	1.5%
152	RHAPUR	48	1.3%
779	VIOSEM	45	1.2%
5	ABIGRA	39	1.0%
117	BERNER	34	0.9%
22	PSEMEN(dead)	33	0.9%
514	GALTRI	27	0.7%
849	MOSS	25	0.7%
752	TRIOVA	24	0.6%
21	SEQSEM(dead)	23	0.6%
172	RUBSPE	23	0.6%
746	TRILAT	21	0.6%
371	ASACAU	19	0.5%
438	CLASIB	19	0.5%
820	PTEAQU	19	0.5%
49	UMBCAL	15	0.4%
405	CARCAL	12	0.3%

Shown here is a frequency distribution of species found at the 3,764 points occupied by redwood (SEQSEM).

Note that this is frequency at a point, rather than by an Association.

Also note the coincidence of the different species found at these points. Most frequently coincident are sword fern (POLMUN) and huckleberry (VACOVA).

Point Frequencies – Alder, Tanoak, and Madrone

Subject species: *Alnus rubra*

species_code	species_alpha	freq	%freq
41	ALNRUB	1340	100.0%
817	POLMUN	559	41.7%
1	SEQSEM	460	34.3%
172	RUBSPE	143	10.7%
4	PICSIT	121	9.0%
42	LITDEN	115	8.6%
2	PSEMEN	100	7.5%
186	VACOVA	86	6.4%
670	RANREP	73	5.4%
635	OXAORE	70	5.2%
3	TSUHET	69	5.1%
173	RUBURS	63	4.7%
153	RHOMAC	50	3.7%
135	GAUSHA	45	3.4%
117	BERNER	30	2.2%
339	OTHGRM	29	2.2%
180	SAMRAC	24	1.8%
438	CLASIB	24	1.8%
731	TOLMEN	21	1.6%
803	ATHFIL	21	1.6%
152	RHAPUR	18	1.3%
306	CAROBN	17	1.3%
230	CORJUB	16	1.2%
804	BLESPI	13	1.0%
158	RIBBRA	12	0.9%
171	RUBPAR	12	0.9%
371	ASACAU	12	0.9%
44	ACEMAC	11	0.8%
721	STAAJU	11	0.8%

Subject species: *Lithocarpus densiflorus*

species_code	species_alpha	freq	%freq
42	LITDEN	3302	100.0%
2	PSEMEN	988	29.9%
186	VACOVA	977	29.6%
1	SEQSEM	690	20.9%
153	RHOMAC	535	16.2%
817	POLMUN	374	11.3%
135	GAUSHA	212	6.4%
3	TSUHET	178	5.4%
41	ALNRUB	115	3.5%
635	OXAORE	85	2.6%
50	ARBMEN	69	2.1%
49	UMBCAL	42	1.3%
22	PSEMEN(dead)	37	1.1%
5	ABIGRA	34	1.0%
117	BERNER	33	1.0%
849	MOSS	32	1.0%
151	RHACAL	29	0.9%
11	PINATT	26	0.8%
187	VACPAR	26	0.8%
804	BLESPI	25	0.8%
746	TRILAT	24	0.7%
820	PTEAQU	24	0.7%
780	WHIMOD	23	0.7%
15	PINRXA	20	0.6%
154	RHOOCC	18	0.5%
779	VIOSEM	16	0.5%
62	LITDEN(dead)	15	0.5%
183	TOXDIV	15	0.5%
752	TRIOVA	13	0.4%
125	CORCOR	12	0.4%
781	XERTEN	12	0.4%
405	CARCAL	11	0.3%
438	CLASIB	11	0.3%

Subject species: *Arbutus menziesii*

species_code	species_alpha	freq	%freq
50	ARBMEN	111	100.0%
42	LITDEN	69	62.2%
186	VACOVA	24	21.6%
2	PSEMEN	23	20.7%
153	RHOMAC	7	6.3%
135	GAUSHA	6	5.4%

I can do this for any species … Note the lack of features found at madrone points; the stand in which madrone are often found are noted for having sparse understories, but then again, this may partially be due to a smaller sample size of madrone observations.

Point Frequencies – Woody Debris

Subject feature(s): Coarse and fine woody debris

Lassen Volcanic National Park(LAVO)

species_code	species_alpha	freq	%freq
661	CWD	593	100.0%
31	ABICON	103	17.4%
32	ABIMAG	58	9.8%
15	PINCON	44	7.4%
12	PINJEF	19	3.2%
151	CEAVEL	8	1.3%
41	ABICON(dead)	7	1.2%
160	ARCNEV	7	1.2%
22	PINJEF(dead)	6	1.0%
25	PINCON(dead)	6	1.0%
168	QUEVAC	6	1.0%
66	SALLUC	5	0.8%
119	ALNINC	5	0.8%

species_code	species_alpha	freq	%freq
660	FWD	2438	100.0%
31	ABICON	855	35.1%
32	ABIMAG	353	14.5%
15	PINCON	162	6.6%
160	ARCNEV	100	4.1%
12	PINJEF	97	4.0%
41	ABICON(dead)	67	2.7%
151	CEAVEL	45	1.8%
202	ACHOCC	35	1.4%
16	PINMON	30	1.2%
66	SALLUC	30	1.2%
194	CHRSEM	27	1.1%
42	ABIMAG(dead)	25	1.0%
49	TSUMER	25	1.0%
161	ARCPAT	25	1.0%
168	QUEVAC	22	0.9%
201	ELYELY	20	0.8%
22	PINJEF(dead)	19	0.8%
119	ALNINC	18	0.7%
25	PINCON(dead)	16	0.7%
51	CALDEC	16	0.7%
149	CEACOR	12	0.5%
230	GRA_SP	12	0.5%
13	PINLAM	10	0.4%
276	CAR SP	8	0.3%
483	MONODO	8	0.3%
175	ERIBLO	7	0.3%
469	LUPOBT	7	0.3%
495	PENGRA	7	0.3%
466	LUPANG	6	0.2%
166	PURTRI	5	0.2%

I can do this for abiotic factors noted at the points, like coarse and fine woody debris.

These figures make a lot of sense as it is the White and Red fir that grow in LAVO at such high densities and accumulate such large amounts of woody debris.

Interestingly, the first seven species listed, with minor changes in order, are the same for both the CWD and FWD frequency listings.

Point Frequencies – North and South Aspects

Alliance: *Sequoia sempervirens* (old growth) Forest Alliance

Subject feature(s):Southerly Aspects
Subject species: *Sequoia sempervirens*

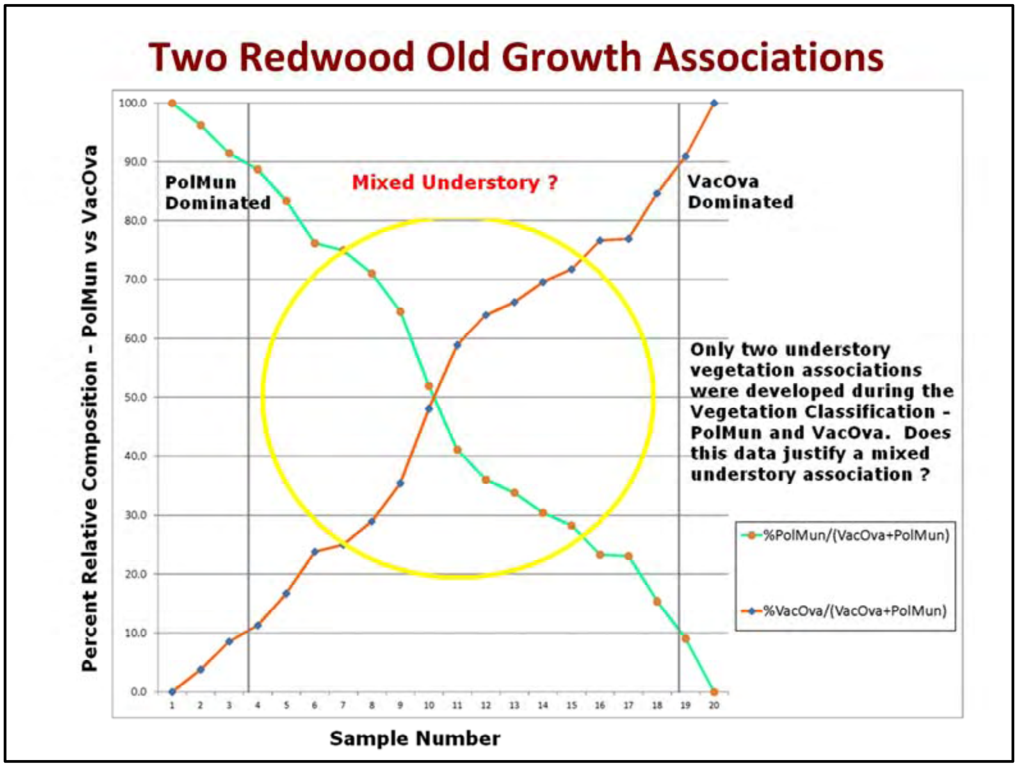
species_code	species_alpha	freq	%freq
1	SEQSEM	1867	100.0%
817	POLMUN	574	30.7%
186	VACOVA	543	29.1%
42	LITDEN	348	18.6%
2	PSEMEN	300	16.1%
635	OXAORE	230	12.3%
41	ALNRUB	217	11.6%
153	RHOMAC	157	8.4%
3	TSUHET	90	4.8%
135	GAUSHA	83	4.4%
804	BLESPI	71	3.8%
4	PICSIT	56	3.0%
187	VACPAR	30	1.6%
152	RHAPUR	23	1.2%
5	ABIGRA	22	1.2%
117	BERNER	17	0.9%
779	VIOSEM	17	0.9%
22	PSEMEN(dead)	16	0.9%
21	SEQSEM(dead)	14	0.7%
752	TRIOVA	13	0.7%
371	ASACAU	12	0.6%
746	TRILAT	11	0.6%
172	RUBSPE	8	0.4%
438	CLASIB	8	0.4%
514	GALTRI	6	0.3%
820	PTEAQU	6	0.3%
49	UMBCAL	5	0.3%
112	BACPIL	5	0.3%
849	MOSS	5	0.3%

Northerly Aspects

species_code	species_alpha	freq	%freq
1	SEQSEM	1897	100.0%
817	POLMUN	583	30.7%
186	VACOVA	392	20.7%
42	LITDEN	342	18.0%
2	PSEMEN	331	17.4%
41	ALNRUB	243	12.8%
635	OXAORE	233	12.3%
3	TSUHET	181	9.5%
153	RHOMAC	170	9.0%
135	GAUSHA	88	4.6%
804	BLESPI	44	2.3%
4	PICSIT	38	2.0%
779	VIOSEM	28	1.5%
187	VACPAR	27	1.4%
152	RHAPUR	25	1.3%
514	GALTRI	21	1.1%
849	MOSS	20	1.1%
5	ABIGRA	17	0.9%
22	PSEMEN(dead)	17	0.9%
117	BERNER	17	0.9%
172	RUBSPE	15	0.8%
820	PTEAQU	13	0.7%
438	CLASIB	11	0.6%
752	TRIOVA	11	0.6%
49	UMBCAL	10	0.5%
405	CARCAL	10	0.5%
746	TRILAT	10	0.5%
21	SEQSEM(dead)	9	0.5%
371	ASACAU	7	0.4%
43	ACECIR	6	0.3%
125	CORCOR	6	0.3%
780	WHIMOD	6	0.3%
44	ACEMAC	5	0.3%
721	STAAJU	5	0.3%

I can do this for all points in samples in the OG Redwood Alliance stands by north and south aspect.

Interestingly, we get very similar distributions with the first 11 species being the same, again with minor differences in order. We have only very minor differences in the species lists, as indicated by the species highlighted in cyan, that happen in the lowest most minor species frequencies.



The last set of slides I have concern the classification of OG Redwood Alliance stands into one of only two OG Redwood Associations, one with a dominant *Polysticum munitum* understory and the other with a dominant *Vaccinium ovatum* understory.

The 60 field sites plotted here tend to indicate that maybe there should be a third association of a mixed *polysticum-vaccinium* composition, as there are many field sites that represent the distribution of cover from pure understories to 50/50 mixes of these two species.

Vaccinium ovatum* and *Polystichum munitum

Alliance: *Sequoia sempervirens* (old growth) Forest Alliance
Observation: 1 point

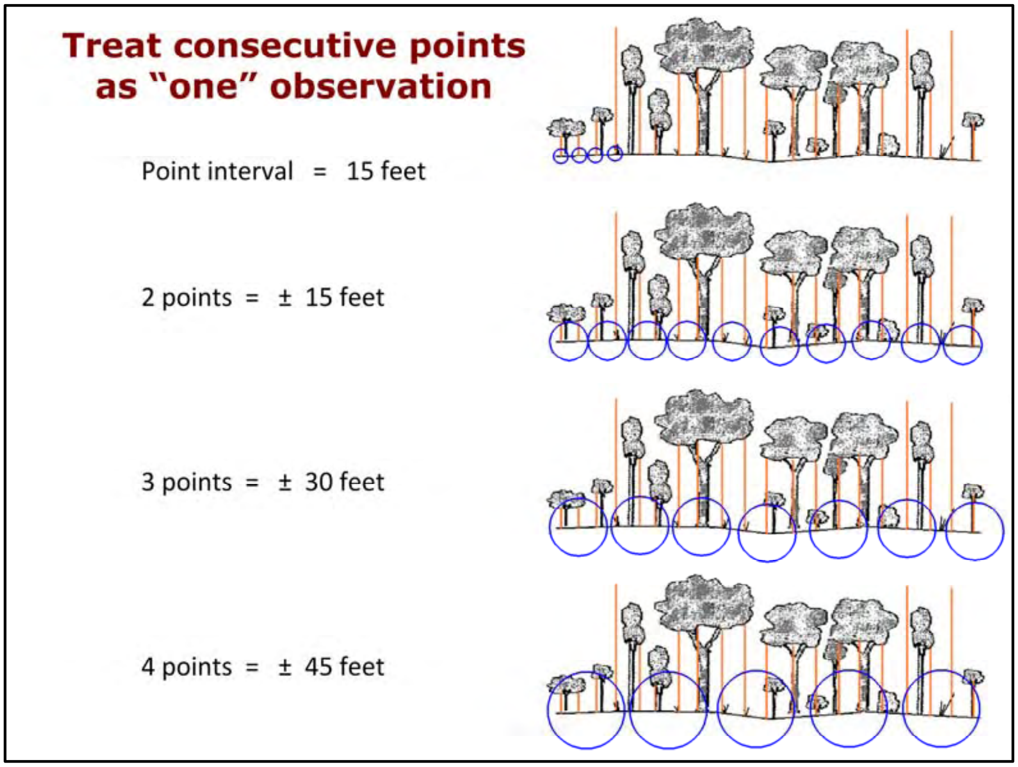
Subject Species: *Vaccinium ovatum*

species_code	species_alpha	freq	%freq
186	VACOVA	1215	100.0%
1	SEQSEM	586	48.2%
42	LITDEN	350	28.8%
2	PSEMEN	313	25.8%
817	POLMUN	268	22.1%
153	RHOMAC	229	18.8%
3	TSUHET	217	17.9%
635	OXAORE	116	9.5%
135	GAUSHA	73	6.0%
804	BLESPI	49	4.0%
187	VACPAR	28	2.3%
4	PICSIT	12	1.0%
152	RHAPUR	11	0.9%
752	TRIOVA	11	0.9%

Subject Species: *Polystichum munitum*

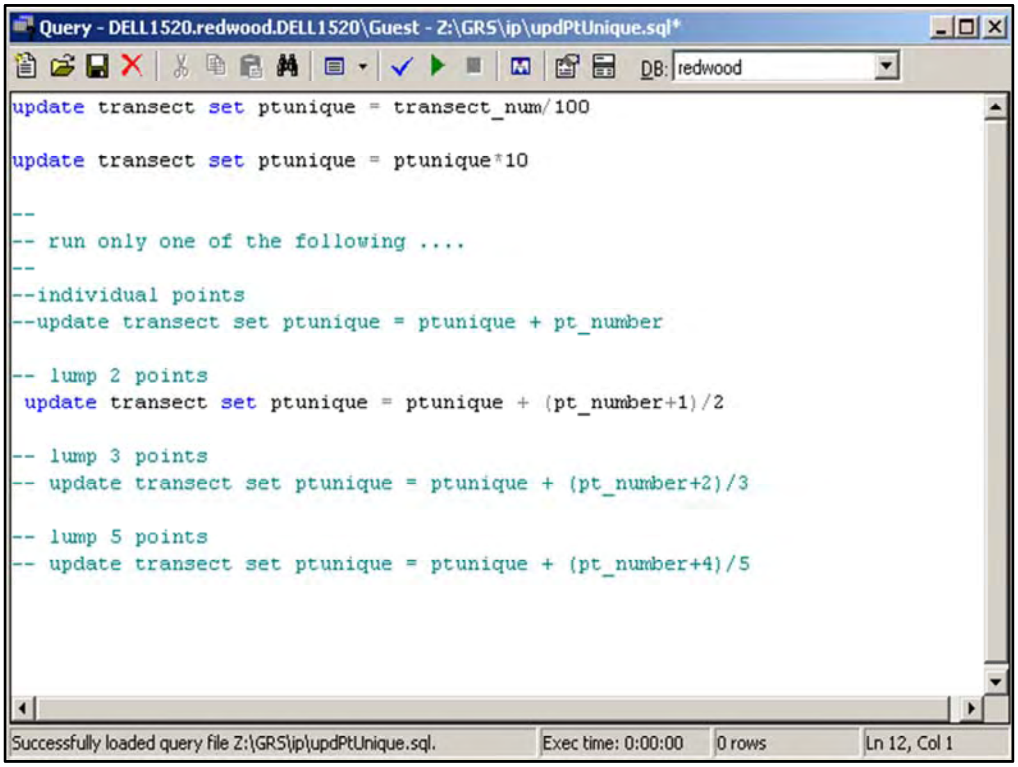
species_code	species_alpha	freq	%freq
817	POLMUN	1224	100.0%
1	SEQSEM	769	62.8%
635	OXAORE	379	31.0%
186	VACOVA	268	21.9%
3	TSUHET	205	16.7%
42	LITDEN	188	15.4%
2	PSEMEN	144	11.8%
804	BLESPI	109	8.9%
153	RHOMAC	104	8.5%
135	GAUSHA	47	3.8%
187	VACPAR	41	3.3%
152	RHAPUR	23	1.9%
41	ALNRUB	19	1.6%
125	CORCOR	19	1.6%
4	PICSIT	16	1.3%
172	RUBSPE	13	1.1%
371	ASACAU	11	0.9%
752	TRIOVA	11	0.9%
779	VIOSEM	11	0.9%

If we look at the individual point frequency listing for points in these two OG Redwood associations, we find there are nearly 1200 point observations for each of these species and the two species are **found coincident with each other about 22% of the time**.



Again, one day by happenstance I realized there was more I could do with these point data.

Since the linear transect are comprised of sequentially numbered points, I found I could cluster consecutive points, pool their features, and treat them as one observation representative of the clustered points.



This was accomplished in the database using sql statements like this.

Vaccinium ovatum **and** ***Polystichum munitum***

Alliance: *Sequoia sempervirens* (old growth) Forest Alliance

Observation: 2 consecutive points

Subject Species: ***Vaccinium ovatum***

species_code	species_alpha	freq	%freq
186	**VACOVA**	**826**	**100.0%**
1	SEQSEM	514	62.2%
817	**POLMUN**	**351**	**42.5%**
42	LITDEN	313	37.9%
2	PSEMEN	265	32.1%
153	RHOMAC	241	29.2%
3	TSUHET	182	22.0%
635	OXAORE	164	19.9%
135	GAUSHA	98	11.9%
804	BLESPI	72	8.7%
187	VACPAR	49	5.9%
152	RHAPUR	17	2.1%
752	TRIOVA	15	1.8%
4	PICSIT	13	1.6%
779	VIOSEM	13	1.6%

Polystichum munitum

species_code	species_alpha	freq	%freq
817	**POLMUN**	**851**	**100.0%**
1	SEQSEM	618	72.6%
635	OXAORE	364	42.8%
186	**VACOVA**	**351**	**41.2%**
3	TSUHET	213	25.0%
42	LITDEN	189	22.2%
2	PSEMEN	150	17.6%
804	BLESPI	133	15.6%
153	RHOMAC	123	14.5%
135	GAUSHA	75	8.8%
187	VACPAR	56	6.6%
152	RHAPUR	30	3.5%
779	VIOSEM	20	2.4%
752	TRIOVA	19	2.2%
4	PICSIT	17	2.0%
125	CORCOR	17	2.0%
41	ALNRUB	14	1.6%
746	TRILAT	13	1.5%
371	ASACAU	12	1.4%
514	GALTRI	11	1.3%

When considering 2 consecutive points as one observation the percent coincidence of these two species nearly doubles to about **42%**.

Vaccinium ovatum and *Polystichum munitum*

Alliance: *Sequoia sempervirens* (old growth) Forest Alliance
Observation: 3 consecutive points

Subject Species: *Vaccinium ovatum*

species_code	species_alpha	freq	%freq
186	VACOVA	633	100.0%
1	SEQSEM	450	71.1%
817	POLMUN	333	52.6%
42	LITDEN	283	44.7%
2	PSEMEN	236	37.3%
153	RHOMAC	227	35.9%
3	TSUHET	170	26.9%
635	OXAORE	162	25.6%
135	GAUSHA	101	16.0%
804	BLESPI	76	12.0%
187	VACPAR	54	8.5%
752	TRIOVA	19	3.0%
152	RHAPUR	18	2.8%
779	VIOSEM	15	2.4%
4	PICSIT	12	1.9%
514	GALTRI	11	1.7%

Subject Species: *Polystichum munitum*

species_code	species_alpha	freq	%freq
817	POLMUN	660	100.0%
1	SEQSEM	528	80.0%
186	VACOVA	333	50.5%
635	OXAORE	317	48.0%
3	TSUHET	200	30.3%
42	LITDEN	181	27.4%
2	PSEMEN	147	22.3%
804	BLESPI	131	19.8%
153	RHOMAC	117	17.7%
135	GAUSHA	75	11.4%
187	VACPAR	63	9.5%
152	RHAPUR	30	4.5%
752	TRIOVA	23	3.5%
779	VIOSEM	23	3.5%
514	GALTRI	18	2.7%
4	PICSIT	17	2.6%
125	CORCOR	17	2.6%
746	TRILAT	15	2.3%
371	ASACAU	12	1.8%
405	CARCAL	11	1.7%
849	MOSS	11	1.7%

When considering 3 consecutive points as one observation the percent coincidence of these two species is now over **50%**

Vaccinium ovatum and *Polystichum munitum*

Alliance: *Sequoia sempervirens* (old growth) Forest Alliance
Observation: 4 consecutive points

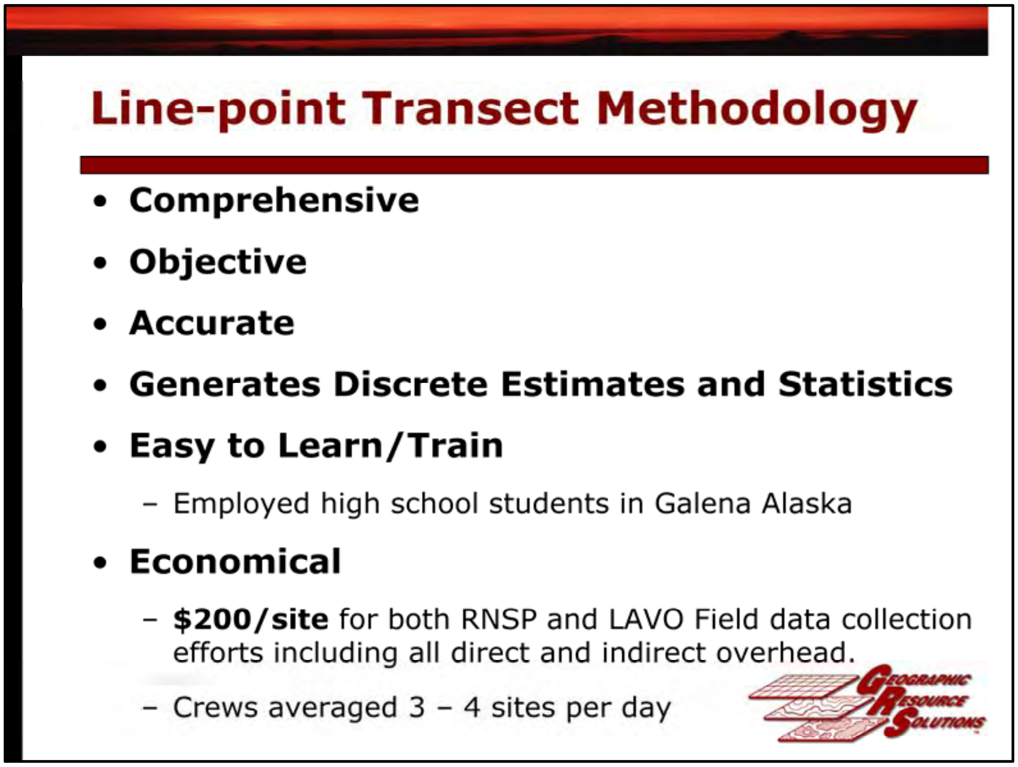
Subject Species: *Vaccinium ovatum* — *Polystichum munitum*

species_code	species_alpha	freq	%freq	species_code	species_alpha	freq	%freq
186	**VACOVA**	**528**	**100.0%**	**817**	**POLMUN**	**535**	**100.0%**
1	SEQSEM	408	77.3%	1	SEQSEM	449	83.9%
817	**POLMUN**	**310**	**58.7%**	**186**	**VACOVA**	**310**	**57.9%**
42	LITDEN	253	47.9%	635	OXAORE	287	53.6%
2	PSEMEN	222	42.0%	3	TSUHET	189	35.3%
153	RHOMAC	204	38.6%	42	LITDEN	169	31.6%
635	OXAORE	170	32.2%	2	PSEMEN	153	28.6%
3	TSUHET	160	30.3%	804	BLESPI	121	22.6%
135	GAUSHA	106	20.1%	153	RHOMAC	112	20.9%
804	BLESPI	78	14.8%	135	GAUSHA	82	15.3%
187	VACPAR	56	10.6%	187	VACPAR	64	12.0%
752	TRIOVA	23	4.4%	152	RHAPUR	28	5.2%
152	RHAPUR	21	4.0%	779	VIOSEM	24	4.5%
779	VIOSEM	20	3.8%	752	TRIOVA	23	4.3%
4	PICSIT	13	2.5%	4	PICSIT	17	3.2%
117	BERNER	12	2.3%	514	GALTRI	17	3.2%
514	GALTRI	12	2.3%	125	CORCOR	15	2.8%
				746	TRILAT	15	2.8%
				117	BERNER	12	2.2%
				371	ASACAU	12	2.2%
				849	MOSS	12	2.2%
				41	ALNRUB	11	2.1%
				405	CARCAL	11	2.1%

And when considering 4 consecutive points as one observation the percent coincidence of these two species more than doubles to about 58%.

This project had a minimum mapping size limit of 0.5 hectares or about 1.2 acres. The spacing of 4 consecutive points is about 45 feet, a distance well within the MMU limit. It appears to me, that maybe there should have been a "mixed *Polysticum munitum-Vaccinium ovatum*" understory association to better represent the levels of coincidence of these two species indicated in the sample data.

Information like this and analyses of this nature may be instrumental in examining how plant communities may vary relative to our scale of mapping, as well as the scale of our field data collection efforts.



In summary, the Line-point transect methodology has much to offer as a plant community sampling tool.

In addition, it is … see slide.

Accuracy Citations

Alaska Interagency Fire Effects Task Group (FETG). “Fire Effects Monitoring Protocol (Version 1.0).” April 2007: 44pp.

Fiala, Anne C.S., Garman, Steven L., Gray, Andrew N. “Comparison of Five Canopy Cover Estimation Techniques in the Western Oregon Cascades.” *Forest Ecology and Management* 232, 2006:188-197.

Huynh, M.L. “Assessment of Various Methods of Canopy Cover Estimation That Yield Accurate Results With Field Repeatability.” MSc. Thesis, Northern Airzona University, Flagstaff, AZ., 2005.

Jennings, S.B., Brown, N.D. and Sheil, D. “Assessing Forest Canopies and Understory Illumination: Canopy Closure, Canopy Cover and Other Measures.” *Forestry* 72(1), 1999:59-73.

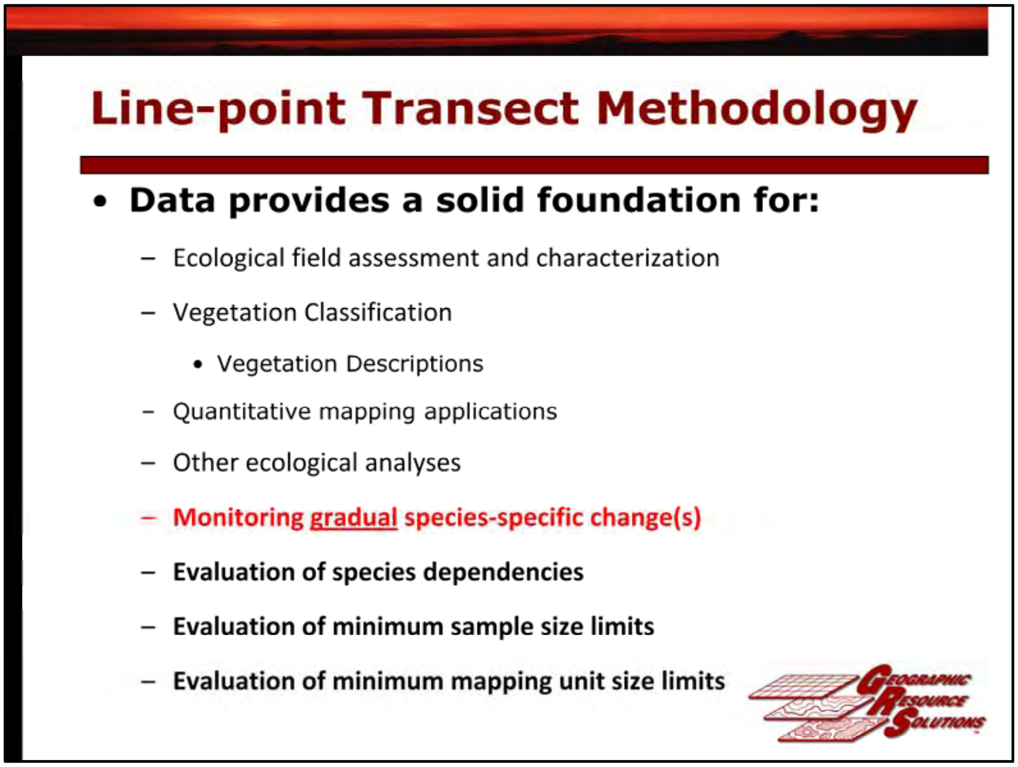
Korhonen, Lauri, Korhonen, Kari T., Rautiainen, Miina and Stenberg, Pauline. “Estimation of Forest Canopy Cover: a Comparison of Field Measurement Techniques.” *Silva Fennica* 40(4) 2006: 577-588.

Paletto, Alessandro, Tosi, Vittorio. “Forest Canopy Cover and Canopy Closure: Comparison of Assessment Techniques.” *European Journal of Forest Research* 128 2009: 265-272

Robards T.A., Berbach, M. W., Cafferata, P.H. and Valentine, B.E. “A Comparison of Techniques for Measuring Canopy in Watercourse and Lake Protection Zones.” *California Forestry Note* No. 115, June 2000:1-15

I mentioned Accuracy. Here is a listing of citations of papers that review different cover estimation techniques.

All of them find the Line-point transect with vertical sampling to be one of the most accurate, if not the most accurate cover sampling tools.



The type of plant community information I have shown you has many uses.

One of the most important uses I want to emphasize is for **monitoring change**.

Our current Alliance/Association based methods are better suited for monitoring catastrophic changes due to fire, volcanic eruption, hurricane, flood, or other devastating event. In order to monitor some of the gradual species-specific changes that may be occurring as we move forward in time, we need quantitative based estimates that are sensitive to the smaller gradual changes we may experience.

I think the Line-point transect methodology has a lot of potential!

Thank-you.