The Development of Fire Fuel Data Using Satellite Image Classification / Land Cover Mapping Techniques

By

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What are we doing ?

- ✦ Mapping fire fuel classes
  - – Anderson fuel classes
  - – Custom fuel classes
- ✦ Detailed characteristics
- ✦ High accuracy
- ✦ Used in fire modeling applications
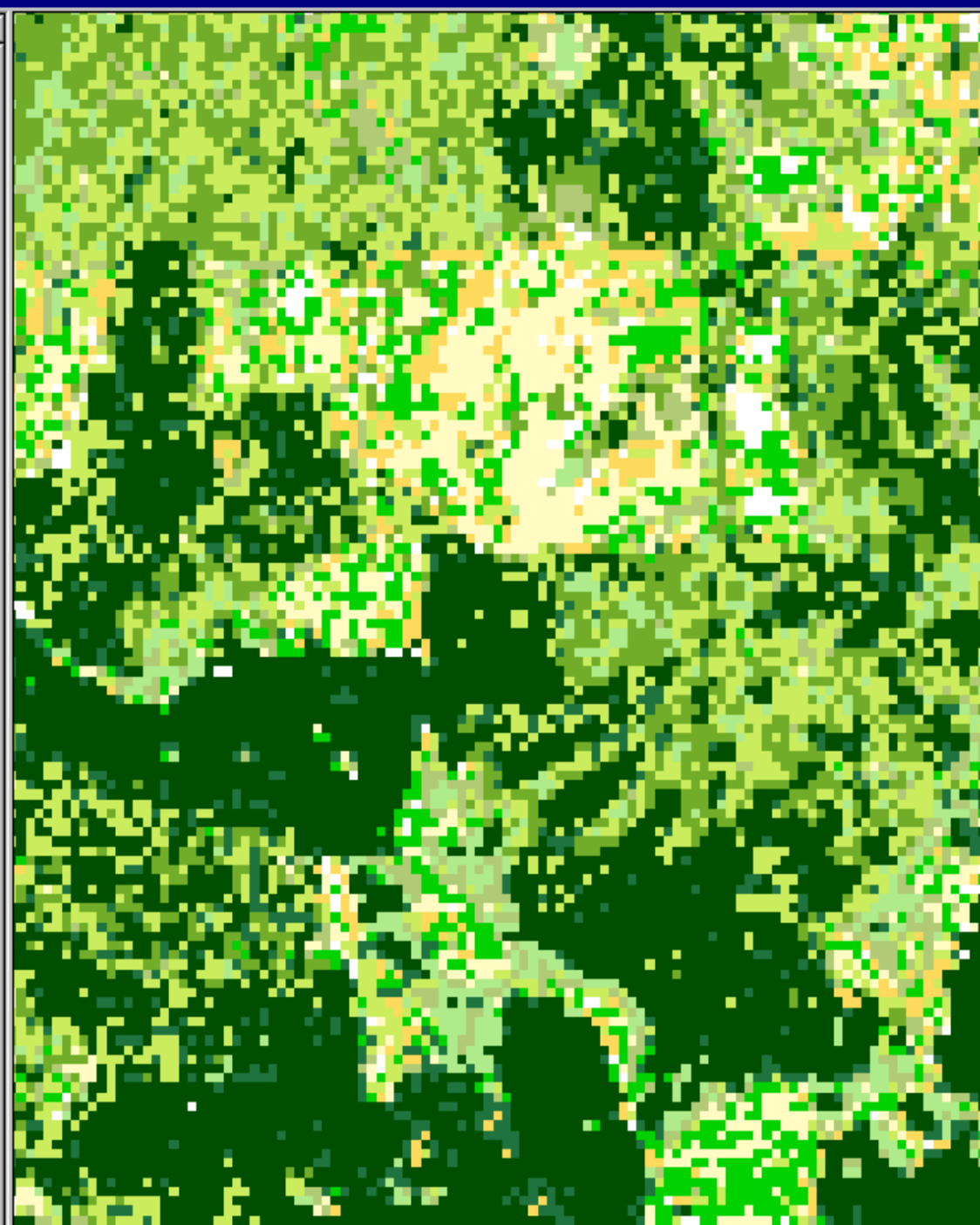
Applegate Watershed

✦ Mapped fuel classes

☑ Apple1996
- No Veg Component
- Forb Dominant
- Forb with Timber Overstory
- Shrub Dominant
- Shrub Dominant with Forb and Timber Component
- Mature Shrub Dominant
- Timber Dominant with Compact Litter
- Timber Dominant with Shrub/Forb Component
- Mature Timber Dominant with Woody Debris Component
- Open/Timber Dominant with High Woody Debris Component

Applegate Watershed

- ✦ Mapped fuel classes
- ✦ Attributes
  - – Fuel class
 - – Land cover characteristics

Value	Count	Veg_type	Closure_class	Tree Cover	Pct_conifer	Pct_hdwood	Size_class	Qmdbh	Qmdbhcon	Qmdbhhwd	OtherVegetationCov	Anderson Fuel Class	Pt_species
0	2726			0.0000	0.0000	0.0000	0	0.0000	0.0000	0.0000	0.0000	0	
1	2434	TF	7	79.0000	100.0000	0.0000	5	20.8000	20.8000	0.0000	0.0000	10	white fir
2	1321	MC	7	76.0000	100.0000	0.0000	8	36.8000	36.8000	0.0000	6.0000	10	Douglas-fir
3	2295	MC	9	96.0000	83.3000	16.7000	7	26.3000	28.4000	10.8000	0.0000	10	Douglas-fir
4	998	MC	7	77.0000	71.4000	28.6000	5	20.3000	23.9000	3.8000	12.0000	9	Douglas-fir
5	1492	SC	0	11.0000	100.0000	0.0000	7	29.3000	29.3000	0.0000	44.0000	6	misc shrub
6	2953	TF	5	53.0000	100.0000	0.0000	6	23.3000	23.3000	0.0000	22.0000	8	white fir
7	2331	MC	7	77.0000	84.4000	15.6000	4	16.5000	17.4000	10.5000	2.0000	10	Douglas-fir
8	509	TF	2	26.0000	100.0000	0.0000	4	13.4000	13.4000	0.0000	20.0000	11	white fir
9	691	TF	8	85.0000	100.0000	0.0000	7	28.9000	28.9000	0.0000	5.0000	10	white fir
10	5485	MC	9	91.0000	78.6000	21.4000	7	26.3000	29.2000	9.9000	4.0000	10	Douglas-fir
11	728	MC	3	32.0000	96.9000	3.1000	1	2.0000	2.1000	0.0000	55.0000	11	Douglas-fir
12	908	SC	0	8.0000	0.0000	0.0000	0	0.0000	0.0000	0.0000	67.0000	5	shrub/brush
13	1447	TF	2	27.0000	100.0000	0.0000	7	28.0000	28.0000	0.0000	25.0000	11	red fir
14	1165	TF	2	24.0000	100.0000	0.0000	5	19.6000	19.6000	0.0000	24.0000	11	red fir
15	440	MC	2	26.0000	100.0000	0.0000	2	7.4000	7.4000	0.0000	56.0000	11	Jeffrey pine
16	6444	MC	8	80.0000	100.0000	0.0000	6	25.1000	25.1000	0.0000	7.0000	10	Douglas-fir
17	1031	MC	5	57.0000	94.7000	5.3000	2	8.1000	8.3000	0.0000	40.5000	11	Douglas-fir
18	6411	MC	4	46.0000	80.4000	19.6000	3	12.2000	13.2000	6.5000	38.0000	11	ponderosa pine
19	670	MC	3	33.0000	100.0000	0.0000	1	2.7000	2.7000	0.0000	54.0000	11	ponderosa pine
20	652	TF	2	23.0000	100.0000	0.0000	5	17.2000	17.2000	0.0000	29.0000	11	red fir
21	186	TF	2	24.0000	100.0000	0.0000	1	0.0000	0.0000	0.0000	29.5000	11	red fir
22	5064	TF	8	82.5000	100.0000	0.0000	5	18.2000	18.2000	0.0000	1.0000	10	red fir
23	4151	MC	7	70.0000	85.7000	14.3000	4	13.4000	11.1000	22.6000	12.0000	8	Douglas-fir
24	883	MC	2	26.0000	96.2000	3.8000	6	21.4000	21.8000	5.1000	28.0000	11	ponderosa pine
25	1715	MC	5	51.0000	86.3000	13.7000	2	5.6000	5.7000	4.8000	41.5000	11	Douglas-fir
26	1798	TF	6	69.0000	100.0000	0.0000	6	21.5000	21.5000	0.0000	3.0000	10	red fir
27	4711	MC	5	52.0000	100.0000	0.0000	4	16.8000	16.8000	0.0000	15.5000	10	ponderosa pine
28	1621	TF	2	23.0000	100.0000	0.0000	7	26.9000	26.9000	0.0000	63.5000	5	white fir
29	511	SC	0	6.0000	0.0000	0.0000	0	0.0000	0.0000	0.0000	76.5000	5	ripar shrub
30	5441	MC	9	92.0000	94.6000	5.4000	7	28.7000	29.3000	15.6000	0.0000	10	Douglas-fir
31	2044	MC	9	99.0000	92.9000	7.1000	7	30.3000	31.1000	15.9000	1.0000	10	Douglas-fir
32	250	MC	2	28.0000	100.0000	0.0000	3	12.6000	12.6000	0.0000	54.5000	11	sugar pine
33	1050	TF	3	30.0000	100.0000	0.0000	6	24.7000	24.7000	0.0000	49.0000	2	red fir
34	150	MC	2	23.0000	100.0000	0.0000	7	31.9000	31.9000	0.0000	50.5000	11	sugar pine
35	4495	TF	6	66.0000	100.0000	0.0000	6	24.2000	24.2000	0.0000	32.0000	11	white fir
36	651	MC	8	86.0000	87.2000	12.8000	3	11.0000	11.6000	5.0000	12.9000	8	ponderosa pine
37	1467	MC	3	39.0000	100.0000	0.0000	1	4.3000	4.3000	0.0000	47.5000	11	ponderosa pine
38	1221	MC	3	34.0000	100.0000	0.0000	1	4.8000	4.8000	0.0000	49.0000	2	Douglas-fir
39	6909	CH	7	75.0000	44.0000	56.0000	3	11.2000	13.1000	9.4000	1.0000	9	hardwoodC
40	1120	EH	9	97.5000	16.4000	83.6000	3	11.8000	21.9000	8.5000	0.5000	9	hardwoodC
41	9	MC	9	95.0000	70.5000	29.5000	4	12.2000	12.6000	12.2000	3.5000	9	Douglas-fir

| Anderson Fuel Class	Pr_species	Pred_sp_pct	Tpa_tot	Tpa_con	Tpa_hwd	Cv_shr	Cv_hrb	Cv_bar	Cv_oth	Cv1	Cv2	Cv3
0		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.00
10	white fir	77.0000	161.9000	161.9000	0.0000	0.0000	0.0000	21.0000	0.0000	0.0000	2.0000	1.00
10	Douglas-fir	49.0000	110.4000	110.4000	0.0000	3.0000	3.0000	18.0000	0.0000	3.0000	4.0000	2.00
10	Douglas-fir	70.0000	205.9000	160.6000	45.4000	0.0000	0.0000	4.0000	0.0000	0.0000	5.0000	6.00
9	Douglas-fir	35.0000	1648.4000	580.5000	1067.8000	7.0000	5.0000	11.0000	0.0000	43.0000	5.0000	0.00
6	misc shrub	24.0000	150.1000	150.1000	0.0000	25.0000	19.0000	45.0000	0.0000	2.0000	0.0000	0.00
8	white fir	50.0000	301.3000	301.3000	0.0000	17.0000	5.0000	25.0000	0.0000	5.0000	5.0000	4.00
10	Douglas-fir	58.0000	108.8000	72.9000	35.9000	1.0000	1.0000	21.0000	0.0000	2.0000	9.0000	13.00
11	white fir	20.0000	763.9000	763.9000	0.0000	15.0000	5.0000	54.0000	0.0000	16.0000	6.0000	1.00
10	white fir	53.0000	153.3000	153.3000	0.0000	1.0000	4.0000	10.0000	0.0000	3.0000	5.0000	5.00
10	Douglas-fir	57.5000	132.2000	70.5000	61.7000	1.0000	3.0000	5.0000	0.0000	3.0000	15.0000	11.00
11	Douglas-fir	13.0000	1601.4000	1462.7000	138.7000	37.5000	17.5000	13.0000	0.0000	31.0000	1.0000	0.00
5	shrub/brush	23.0000	246.0000	246.0000	0.0000	24.0000	43.0000	25.0000	0.0000	4.0000	2.0000	1.00
11	red fir	15.0000	813.2000	813.2000	0.0000	7.0000	18.0000	48.0000	0.0000	9.0000	0.0000	0.00
11	red fir	20.0000	1580.6000	1580.6000	0.0000	19.0000	5.0000	52.0000	0.0000	13.0000	0.0000	0.00
11	Jeffrey pine	20.0000	731.6000	731.6000	0.0000	45.0000	11.0000	18.0000	0.0000	8.0000	12.0000	4.00
10	Douglas-fir	55.0000	55.5000	55.5000	0.0000	4.0000	3.0000	13.0000	0.0000	0.0000	1.0000	2.00
11	Douglas-fir	50.0000	422.8000	187.9000	234.9000	39.0000	1.5000	2.5000	0.0000	6.0000	29.0000	20.00
11	ponderosa pine	32.0000	395.3000	132.8000	262.5000	5.0000	33.0000	16.0000	0.0000	8.0000	8.0000	12.00
11	ponderosa pine	21.0000	858.1000	858.1000	0.0000	52.0000	2.0000	13.0000	0.0000	32.0000	1.0000	0.00
11	red fir	19.0000	1689.1000	1689.1000	0.0000	15.0000	14.0000	48.0000	0.0000	14.0000	0.0000	0.00
11	red fir	20.0000	2001.9000	2001.9000	0.0000	14.5000	15.0000	46.5000	0.0000	24.0000	0.0000	0.00
10	red fir	70.5000	155.9000	155.9000	0.0000	0.0000	1.0000	16.5000	0.0000	3.0000	8.0000	14.50
8	Douglas-fir	26.0000	408.7000	380.1000	28.6000	7.0000	5.0000	18.0000	0.0000	12.0000	25.0000	0.00
11	ponderosa pine	22.0000	517.7000	514.4000	3.3000	14.0000	14.0000	46.0000	0.0000	6.0000	2.0000	1.00
11	Douglas-fir	41.0000	634.8000	242.4000	392.4000	34.5000	7.0000	7.5000	0.0000	13.0000	38.0000	0.00
10	red fir	68.0000	228.5000	228.5000	0.0000	1.0000	2.0000	28.0000	0.0000	3.0000	14.0000	10.00
10	ponderosa pine	31.0000	180.9000	180.9000	0.0000	12.5000	3.0000	32.5000	0.0000	10.0000	14.0000	5.00
5	white fir	15.0000	708.6000	708.6000	0.0000	34.5000	29.0000	13.5000	0.0000	8.0000	0.0000	0.00
5	ripar shrub	29.0000	470.9000	470.9000	0.0000	38.5000	38.0000	17.5000	0.0000	5.0000	1.0000	0.00
10	Douglas-fir	42.0000	156.3000	150.7000	5.6000	0.0000	0.0000	8.0000	0.0000	2.5000	20.0000	19.00
10	Douglas-fir	77.0000	141.5000	129.1000	12.3000	0.0000	1.0000	0.0000	0.0000	6.0000	15.0000	10.00
11	sugar pine	14.0000	485.6000	485.6000	0.0000	54.5000	0.0000	17.5000	0.0000	6.0000	5.0000	4.00
2	red fir	16.0000	405.8000	405.8000	0.0000	9.5000	39.5000	21.0000	0.0000	7.0000	1.0000	2.00
11	sugar pine	16.0000	153.3000	153.3000	0.0000	48.0000	2.5000	26.5000	0.0000	1.0000	0.0000	1.00
11	white fir	46.5000	195.3000	195.3000	0.0000	31.0000	1.0000	2.0000	0.0000	9.0000	6.0000	4.50
8	ponderosa pine	46.0000	292.8000	161.1000	131.7000	11.4000	1.5000	1.0000	0.0000	10.0000	14.0000	36.00
11	ponderosa pine	28.0000	565.1000	565.1000	0.0000	0.5000	47.0000	13.5000	0.0000	24.0000	15.0000	0.00
2	Douglas-fir	24.0000	426.2000	426.2000	0.0000	2.5000	46.5000	17.0000	0.0000	19.0000	14.0000	1.00
9	hardwoodC	32.0000	396.4000	103.5000	292.9000	1.0000	0.0000	24.0000	0.0000	12.0000	25.0000	18.00
9	hardwoodC	68.5000	536.8000	8.1000	528.7000	0.0000	0.5000	2.0000	0.0000	21.0000	39.5000	14.00
9	Douglas-fir	56.0000	247.7000	213.7000	134.0000	2.5000	0.0000	1.5000	0.0000	27.0000		

It's that easy !!
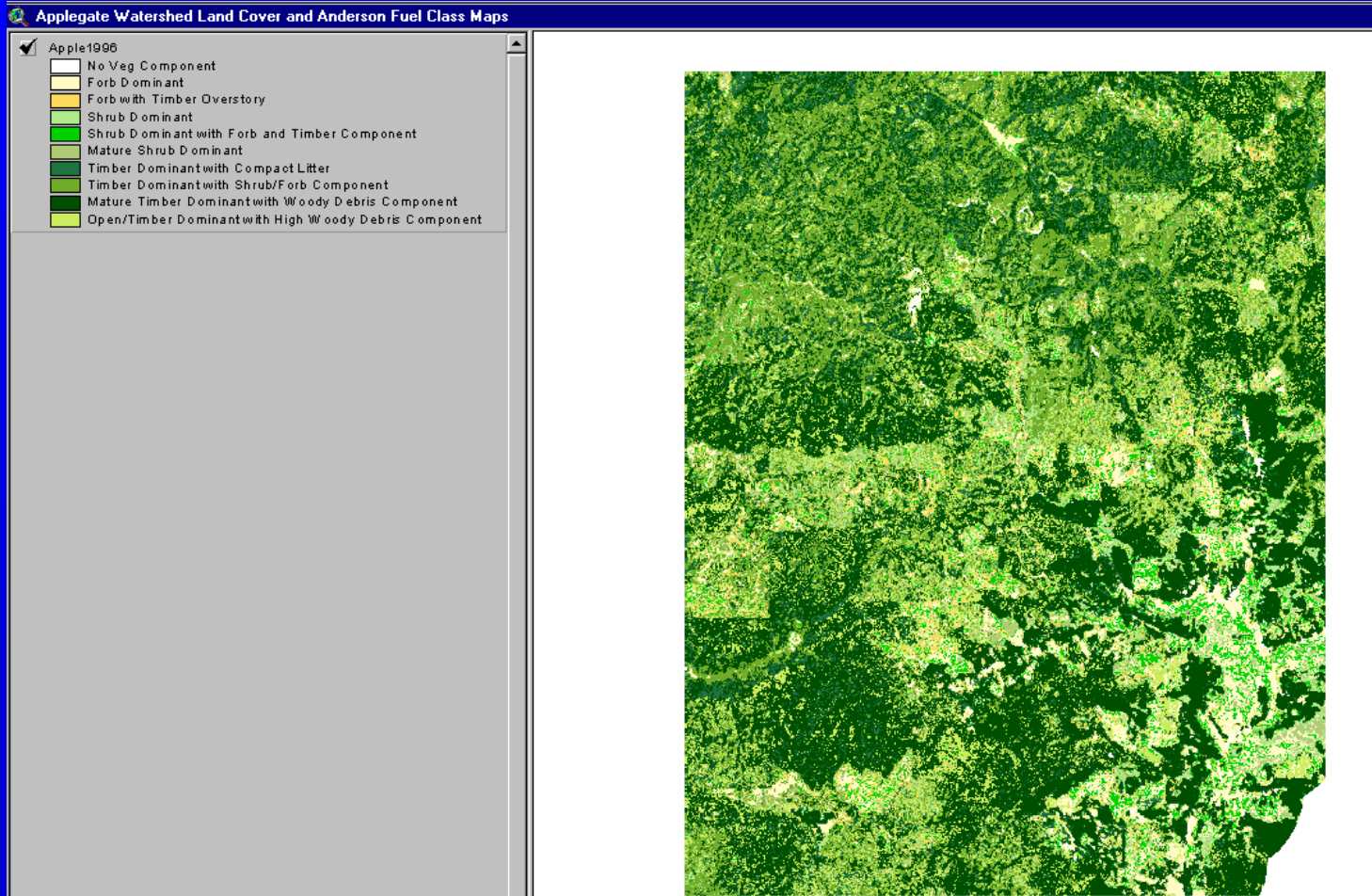
Should You be Skeptical ?

- ✦ Yes !

- ✦ Why ?
  - – Can't "see" the individual elements like trees ...
  - – Can't "see the understory …
  - – Can't "see" the forest floor or down woody debris

- ✦ How can you map detail that you cannot "see" ?
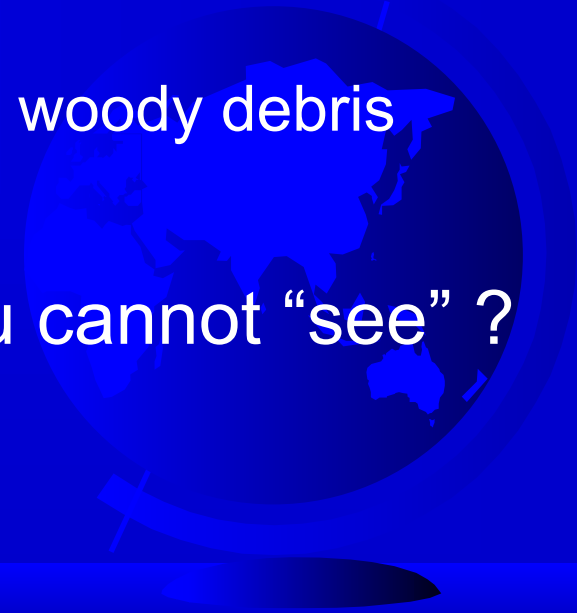
GRS Land Cover Data Are Based on ….

A Different Methodology

What's Different ??

✦ <u>Retain detail throughout the process</u> - Splitter not a lumper - we don't rely on categorical map data, although the results may be shown that way.

✦ <u>Output</u> - Develop variety of quantitative map data that support reclassification and modeling efforts.

GRS Map Data Are Based on ....

- ✦ Field data collection techniques that thoroughly describe the different land cover attributes in terms of vertical and horizontal diversity.

- ✦ Image classification techniques the develop and retain uniqueness of signatures, detail, and accuracy rather than generalization.

- ✦ SQL commands that assign fuel class names/values based on consideration of land cover characteristics.

- ✦ History of activities

The Problem with Most Classification Efforts …

– general cover-type description
  - ◆ Forb, Barren, Shrub, Conifer, Hardwood, …
– general density class values
  - ◆ Sparse, Poor, Moderate, Dense ….
– general size class values
  - ◆ Sapling, Pole, Small, Medium, Large, …

Categorical Map Data – Cover-Type
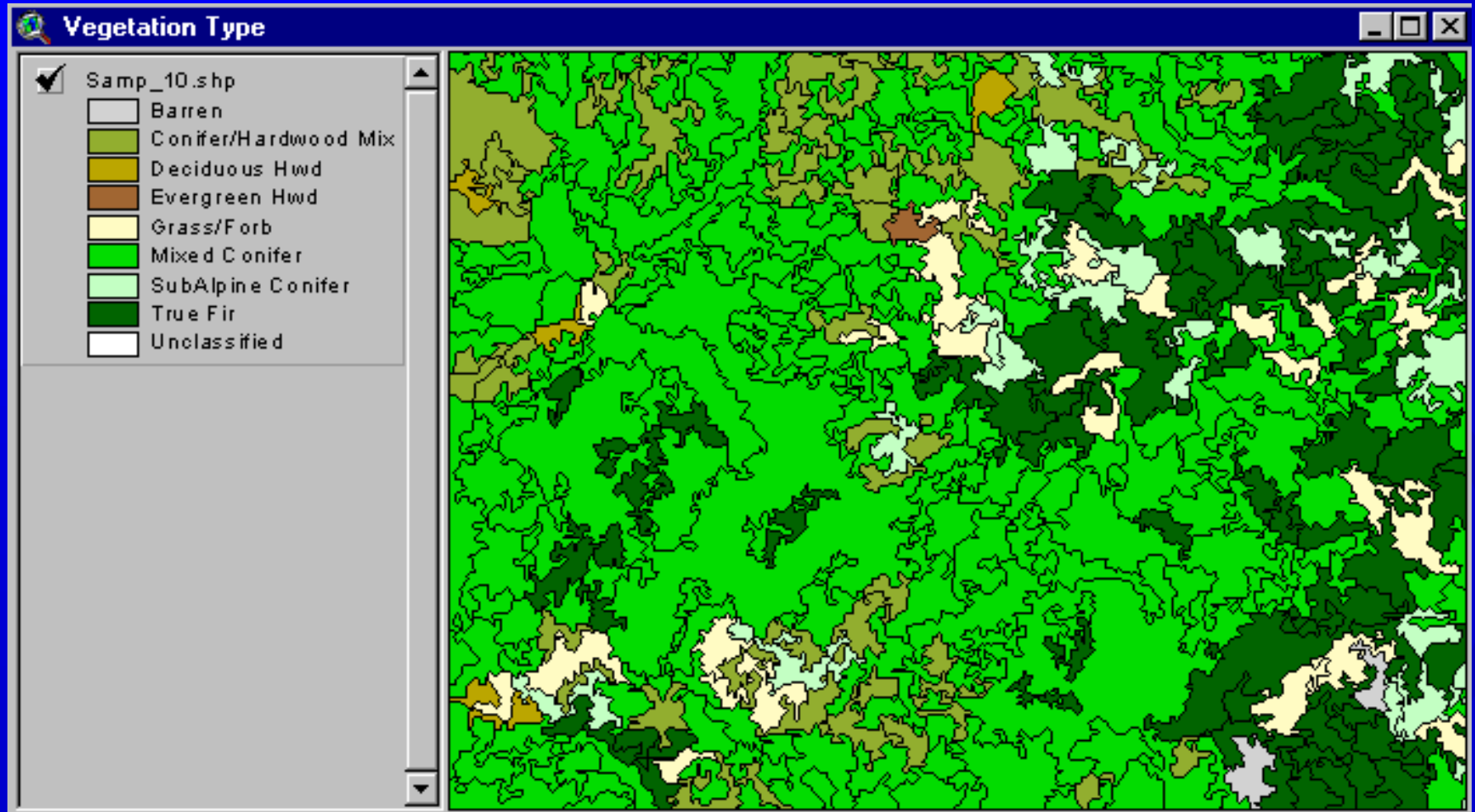
Categorical Map Data - Density
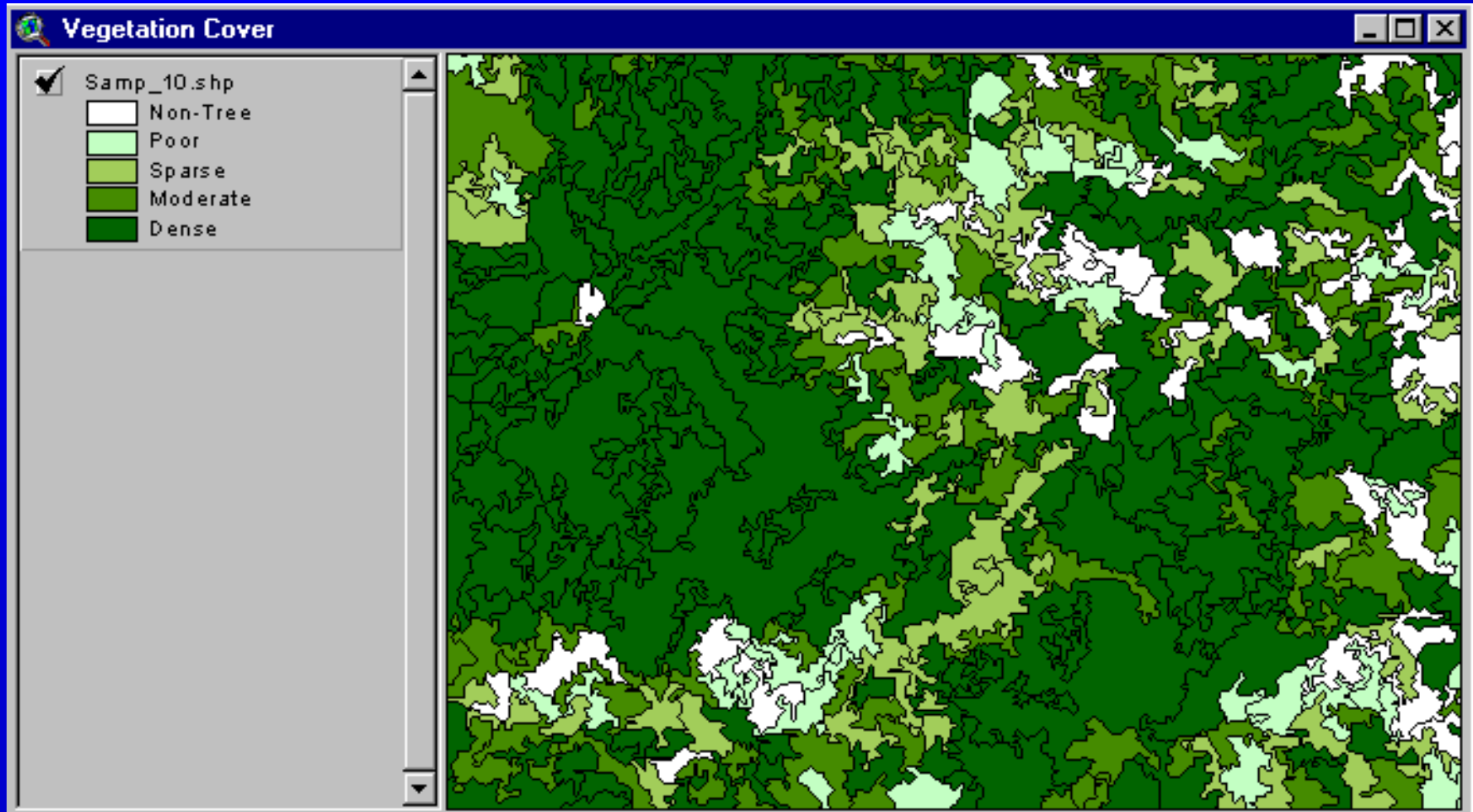
Categorical Map Data – Tree Size
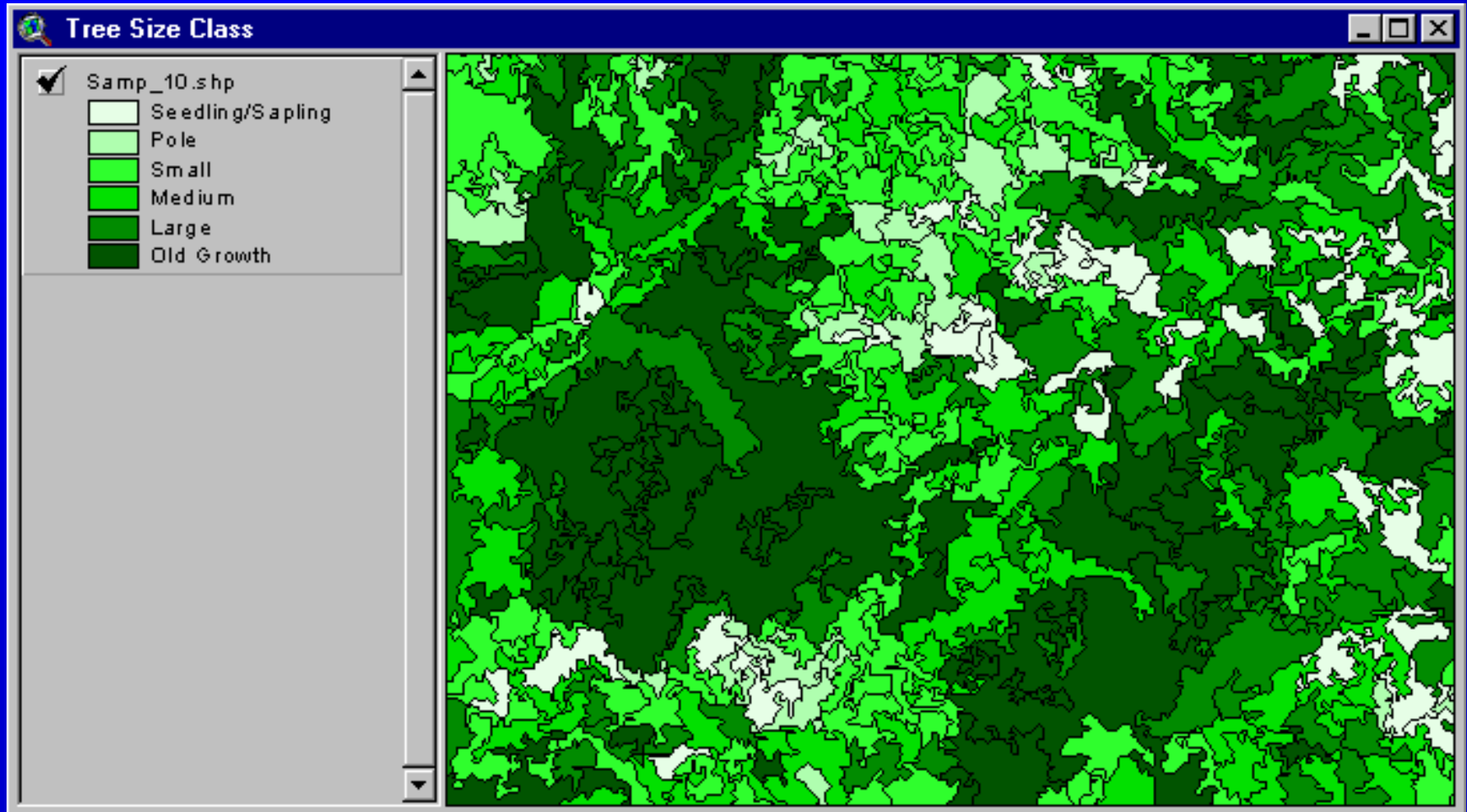
Unfortunately …

- ✦ too general to be of much value
- ✦ low accuracy
- ✦ better than nothing, but not worth spending much time, effort, or (considerable) expense

Rather …

- Need detailed and accurate data that can be processed to yield fire fuel class map data

- Land cover data should reflect the aggregation of features being mapped

Data Descriptions

✦ Field data collection techniques that thoroughly describe the different land cover attributes as land cover associations

- Density and species composition
- Tree size
- Should include:
  - ◆ non-tree/non-vegetative components
  - ◆ understory components
  - ◆ forest floor conditions

Classification Techniques

- **Illumination Normalization**
  - Reduce field data collection efforts and eliminate errors
- **Training Site Selection**
  - Represent the range of possible types and conditions
- **Training Set Development**
  - Retain uniqueness of training classes - no lumping of sites that causes higher spectral variances
- **Hybrid Classification**
  - Supervised and unsupervised techniques cover the entire range of spectral signatures
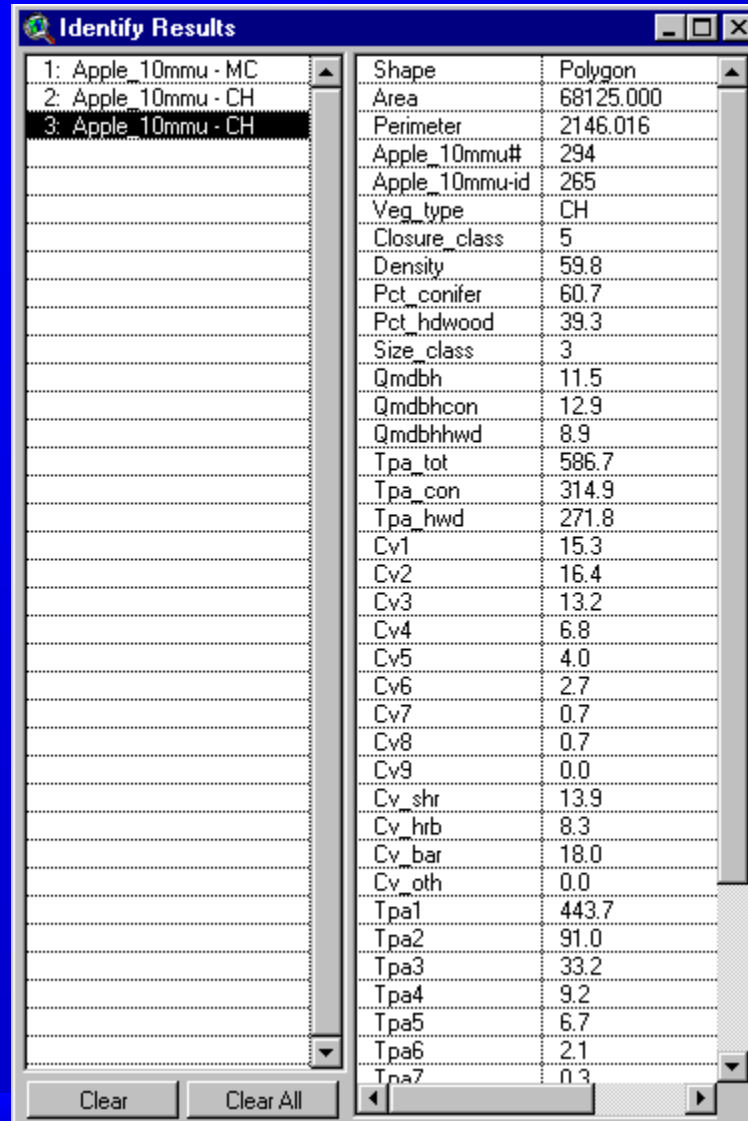
The Result is the Detailed Land Cover Data Set

- "Bird's-eye" cover components by specie/condition
  - ◆ 29 % cover redwood, 8% Doug-fir, 35 % cover alder, 4% salal, 6 % fern, and 18% litter and duff
- Average tree size
  - ◆ Conifer = 23.8" qmd
  - ◆ Hardwood = 10.8" qmd
- Specific types
  - ◆ Mixed Conifer/Douglas-fir
  - ◆ Alder-willow: low shrub: open
- Other components …
- Understory components …
- Surface Condition …

Quantitative Map Data

Quantitative Map Data

Quantitative Map Data

Develop Fuel Class Information

✦ SQL commands are applied to the land cover data to develop fuel classes.

✦ Can implement an existing system, such as Anderson fuel classes, or custom classes, or both.

SQL Classification

- /* Behavior Class 8 - Closed forest, some shrub/forb, and some litter */

  update classify set reclass_value = 8 where density >= 35 and pct_conifer >= 75 and cv_hrb < 20 and cv_shr < 20

- /* Behavior Class 9 - Hardwood/Conifer forest with litter */

  update classify set reclass_value = 9 where density >= 20 and pct_conifer < 75

- /* Behavior Class 10 - Timber with litter & dead/down material */

  update classify set reclass_value = 10 where density >= 35 and pct_conifer >= 75 and (cv_shr+cv_hrb) < 20

- /* Behavior Class 11 - Timber Moderate Density with litter */

  update classify set reclass_value = 11 where density <= 35 and pct_conifer <= 100 and (qmdbh >= 15 or (cv_shr+cv_hrb) < 20)
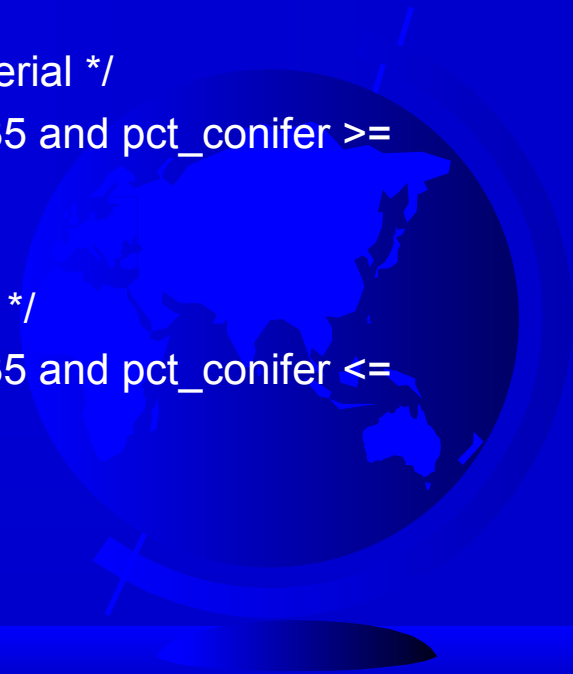
Historical Perspective

- Fire
- Management Treatments

Modify data set to reflect areas where understory is known to be altered or different

Fire Fuel Class Map

Applegate Watershed Land Cover and Anderson Fuel Class Maps

Apple1996
- No Veg Component
- Forb Dominant
- Forb with Timber Overstory
- Shrub Dominant
- Shrub Dominant with Forb and Timber Component
- Mature Shrub Dominant
- Timber Dominant with Compact Litter
- Timber Dominant with Shrub/Forb Component
- Mature Timber Dominant with Woody Debris Component
- Open/Timber Dominant with High Woody Debris Component