Background and Discussion on Fuel Models

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Department of Public Safety

History of Fuel Models

- Fire spread, and fire danger modeling began in the 1930s on a regional basis
- Fire research efforts were consolidated into US Forest Service laboratories in Macon, GA, Missoula, MT, and Riverside, CA in the early 1960s

Origins of NFDRS

- By the 1950s 8 indexes modeled fire danger in different regions of the country
- The growth of destructive fires, and concerns about the prospect of “mass fires” triggered by nuclear war led to the charter for a single national fire danger model
- The design for the National Fire Danger Rating System (NFDRS) was set in 1968, and the system became operational in 1972

Early Fuel Models

- The 1972 NFDRS included 9 fuel models
- NFDRS was revised in 1978 with the number of fuel models increasing to 20
- While these fuel models were pioneers in the field, they were designed to operate with a coarse spatial resolution, making them unsuitable for individual fire modeling

Rothermel Fire Model

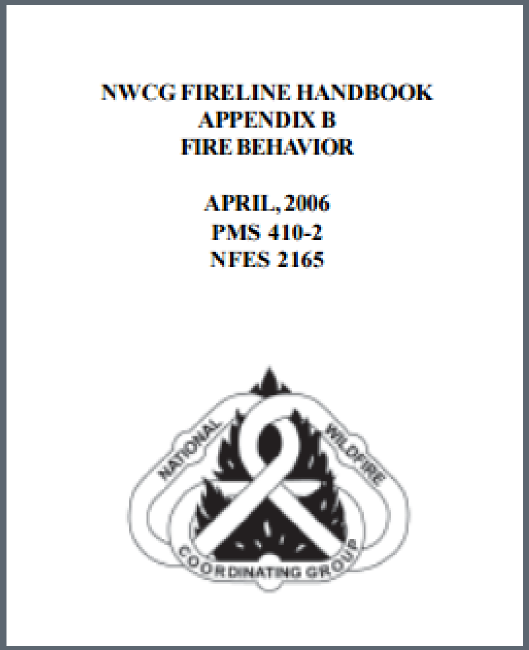
- Richard Rothermel, an aeronautical engineer by training working at Firelab in Missoula, published the first mathmatical formula appraising fire spread and intensity in Jan 1972
- This model is capable of describing surface vegetation and brush fires, NOT crown fires
- Despite its limitations, this model forms the basis for most fire prediction systems in use today

Rothermel and Fuels

- Eleven fuel models were originally available as inputs for the Rothermel equations
- Fuel model attributes such as fuelbed depth and fuel particle size could be customized for each run of the model
- However, factors such as live fuel moisture, and the heterogeneity were not originally accounted for by Rothermel's model

Albini & Anderson and the 'Original 13'

- The now familiar 13 fuel models were developed for use in the Rothermel equations
- Photographic representation of the fuel types and the separation of the models into the categories of grass, shrub, timber, and slash brought fuel models into the mainstream


NWCG FIRELINE HANDBOOK
APPENDIX B
FIRE BEHAVIOR

APRIL, 2006
PMS 410-2
NFES 2165

So Why Have a Fuel Model?

- Per Anderson: “The mathematical (fire behavior) models require descriptions of fuel properties as inputs to calculations of fire danger indices or fire behavior potential.”

- A fuel model represents vegetation, and can be used to describe wildlife habitat, evaluate vegetation change, and plan fuel treatments

What Does a Fuel Model Look Like?

Fuel model	Typical fuel complex	Fuel loading 1 hour	10 hours	100 hours	Live	Fuel bed depth	Moisture of extinction dead fuels
		Tons/acre				*Feet*	*Percent*
	Grass and grass-dominated						
1	Short grass (1 foot)	0.74	0.00	0.00	0.00	1.0	12
2	Timber (grass and understory)	2.00	1.00	.50	.50	1.0	15
3	Tall grass (2.5 feet)	3.01	.00	.00	.00	2.5	25
	Chaparral and shrub fields						
4	Chaparral (6 feet)	5.01	4.01	2.00	5.01	6 0	20
5	Brush (2 feet)	1.00	.50	.00	2.00	2.0	20
6	Dormant brush, hardwood slash	1.50	2.50	2.00	.00	2.5	25
7	Southern rough	1.13	1.87	1.50	.37	2.5	40
	Timber litter						
8	Closed timber litter	1.50	1.00	2.50	0.00	0.2	30
9	Hardwood litter	2.92	41	.15	.00	.2	25
10	Timber (litter and understory)	3.01	2.00	5.01	2.00	1.0	25
	Slash						
11	Light logging slash	1.50	4.51	5.51	0.00	1.0	15
12	Medium logging slash	4.01	14.03	16.53	.00	2.3	20
13	Heavy logging slash	7.01	23.04	28.05	.00	3.0	25

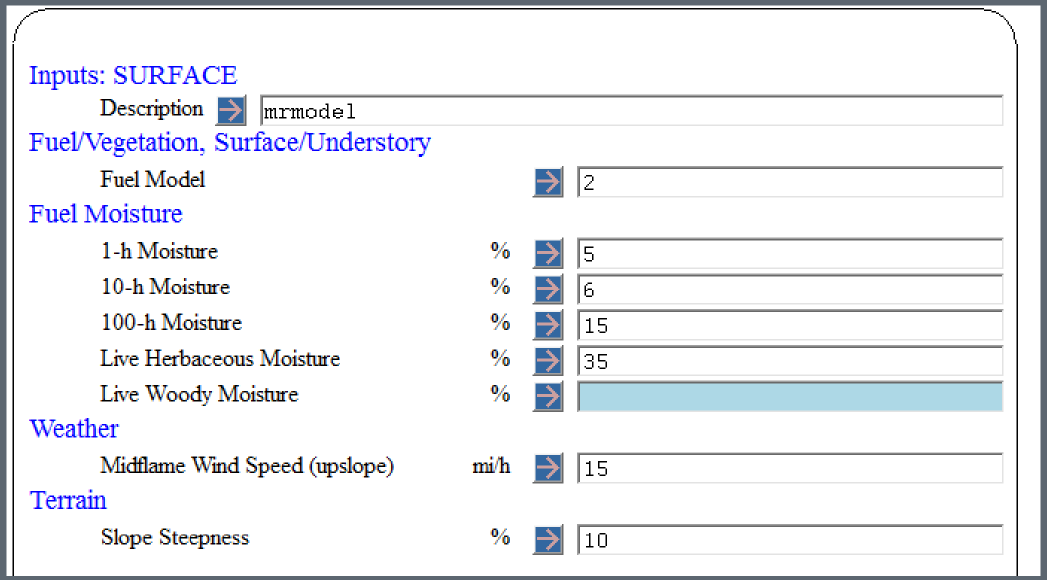
Mapping of Fuel Models

- Tabular and early calculator / computer based outputs of the Rothermel equations rely on the user selecting the correct fuel model manually
- With the rise of spatially aware fire modeling systems such as FARSITE, the need for computer readable maps of fuels arose

TABLE 35: FUEL MODEL 5—0% SLOPE

Fuel Moisture % (1-Hour)		Midflame Wind, mi/h 0.	2.	4.	6.	8.	10.	12.
		Rate of Spread/Chains per Hour						
3.0	120-90	1	7-10	16-23	28-39	42-58	56-78	72-100
6.0	120-90	1	4-8	9-20	16-34	24-50	32-67	42-87
9.0	120-90	1	2-5	6-13	10-22	14-32	19-44	•20-56
12.0	120-90	0	2-3	5-6	9-11	13-16	•18-22	•18-22
15.0	120-90	0	2	4-5	8-9	11-14	•12-15	•12-15
18.0+	120-90	0	1	3	•4	•4	•4	•4
21.0	120-90	0	0	0	0	0	0	0
		Flame Length/Feet						
3.0	120-90	1-2	3-4	5-6	7-8	8-10	9-11	10-12
6.0	120-90	1	2-4	3-6	4-7	5-8	6-10	6-11
9.0	120-90	1	1-2	2-4	2-5	3-6	3-7	•3-7
12.0	120-90	1	1	2	2	3	•3	•3-4
15.0	120-90	1	1	2	2	3	•3	•3
18.0+	120-90	<1	1	1	•1	•1	•1	•1
21.0	120-90	0	0	0	0	0	0	0

• MEANS YOU HIT THE WIND LIMIT



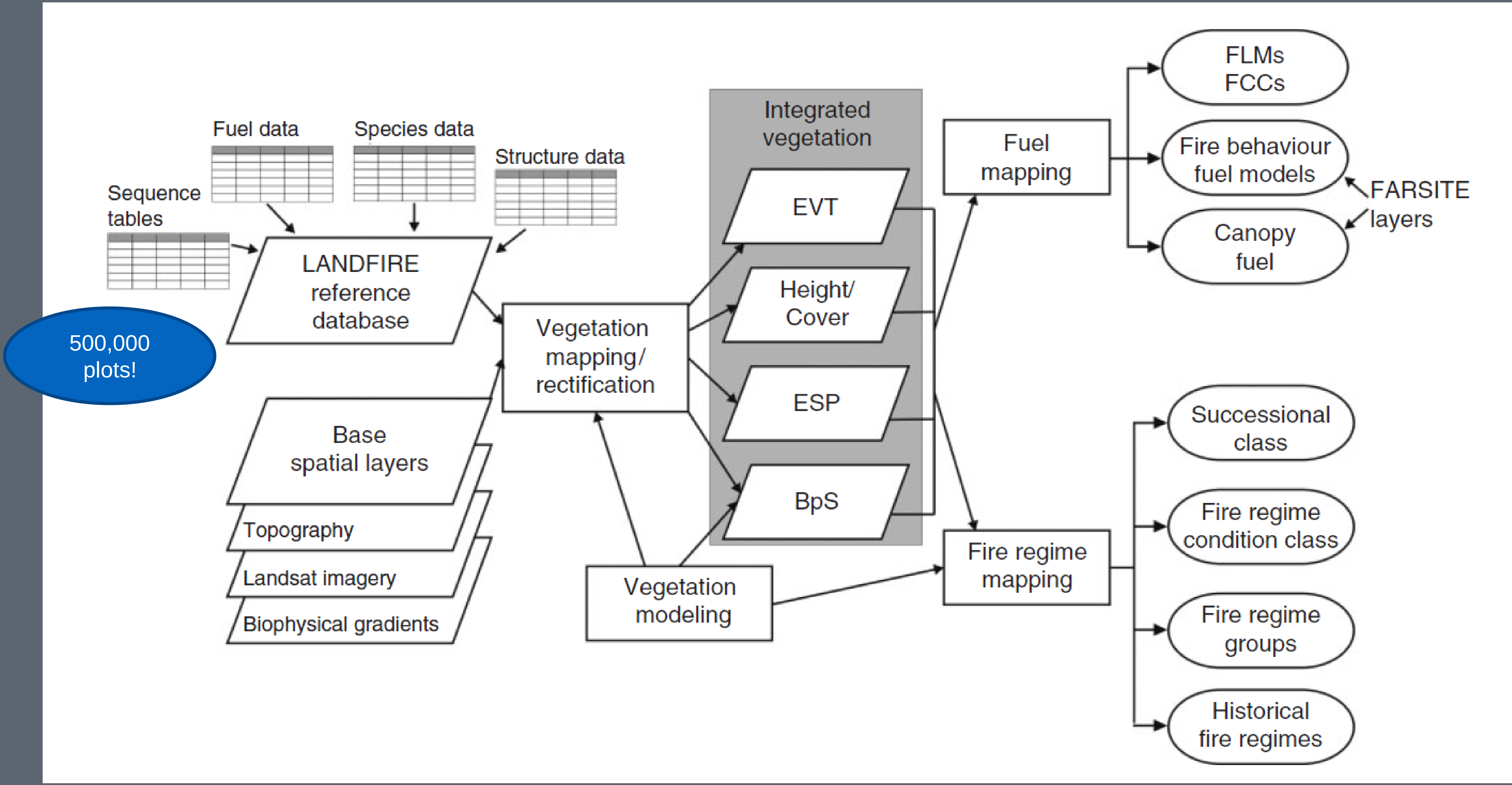
Mapping Origins

- Starting in the 1980s researchers began assigning fuel model types to vegetation maps created using newly available satellite data
- Accurate fuel maps are difficult to generate using this method as aerial images cannot reveal the surface vegetation under a forest, and do not account for stand age and fire history
- Ground-based surveying was found to be required to produce an accurate map, but was done in a patchwork fashion

The Entrance of LANDFIRE

- LANDFIRE was commissioned in 2000 as part of the National Fire Plan to create a nation-wide fuel model
- Prototype maps were created by 2002, and the system was fully operational by 2005
- Over 20 data products are available for all 50 states, at a 30 meter resolution

How LANDFIRE Makes the Map



Time For a New Fuel Model

- The old 13 fuel models were too broad to account for the variety of vegetation surveyed under LANDFIRE

- Under the old model fuel type rarely changed after a fuel treatment was completed, limiting efforts to quantify fuel mitigation results

- Scott and Burgan developed a suite of 40 fuel models in 2005 for use in LANDFIRE. These models can be used in updated versions of BEHAVE and FARSITE

LANDFIRE Quality Control

Most recent data

LANDFIRE	LF National	LF 2001	LF 2008	LF 2010	LF 2012	LF 2014	LF Remap
Description	Original products	Refresh update: vegetation type, cover, height w/ Improvement - Conus ^:	Refresh update: Disturbances*, succession, fire, and fuels	Update: Vegetation, disturbances*, succession, fire, fuels, and Islands~	Update: Vegetation, disturbances*, succession, fire, fuels, and Islands~	Planning	Planning TBD
Completed	2009	2011	2011	2014	2015 Estimated	2016 Estimated	TBD 18 maybe 19
Imagery Date	1999-2003	99-03 Base	99-03 *99-2008	99-03 09-10	99-03 *11-12	99-03 Base	2013-2015 base

Submitting Data to LANDFIRE

- Geospatial data on disturbances such as fires, insect damage, and fuel treatments can be submitted to LANDFIRE
- Vegetation plot data can also be submitted to further train and refine the model
- Submitted data will appear in the next LANDFIRE update, which occurs every 2 years

LANDFIRE 2.0

- LANDFIRE still relies on satellite imagery from 2001, with land cover changes entered manually by the land management community

- With the launch of Landsat 8, new spectral data has become available, and LANDFIRE will be re-mapped starting in this year, with remapped products appearing starting in 2019

CO-WRAP

- The Colorado Wildfire Risk Assessment was developed by the Colorado State Forest Service to provide a consistent, comparable set of scientific results to be used as a foundation for wildfire mitigation and prevention planning in Colorado.
- The Colorado Wildfire Risk Assessment Portal (CO-WRAP) displays data from the assessment for use by the general public and professionals
- Fuel model data is available as part of this project

CO-WRAP Fuel Model

- CO-WRAP fuel model data is based on the 2008 revision of LANDFIRE, with corrections made to account for recent fires and the pine beetle outbreak through 2010
- The CO-WRAP fuel model is formatted as the Scott & Burgan 40 fuel classes
- There is currently no mechanism for ingesting outside information on disturbances to update the fuel model

Case Study

- We will see fuel model data presented as:
- LANDFIRE Anderson 13 classes
- LANDFIRE Burgan 40 classes
- CO-WRAP Burgan 40 classes

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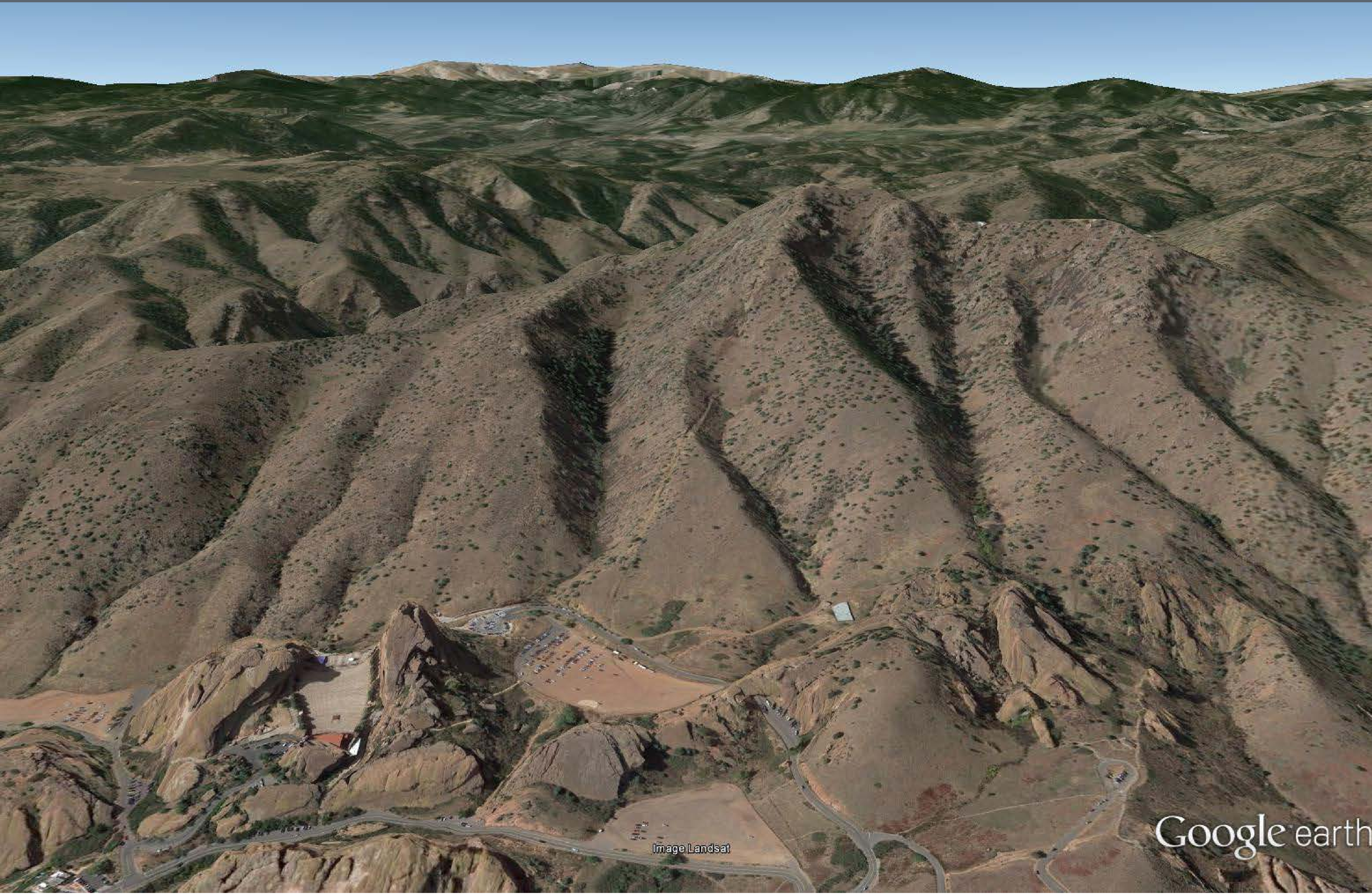
Image Landsat
Google earth

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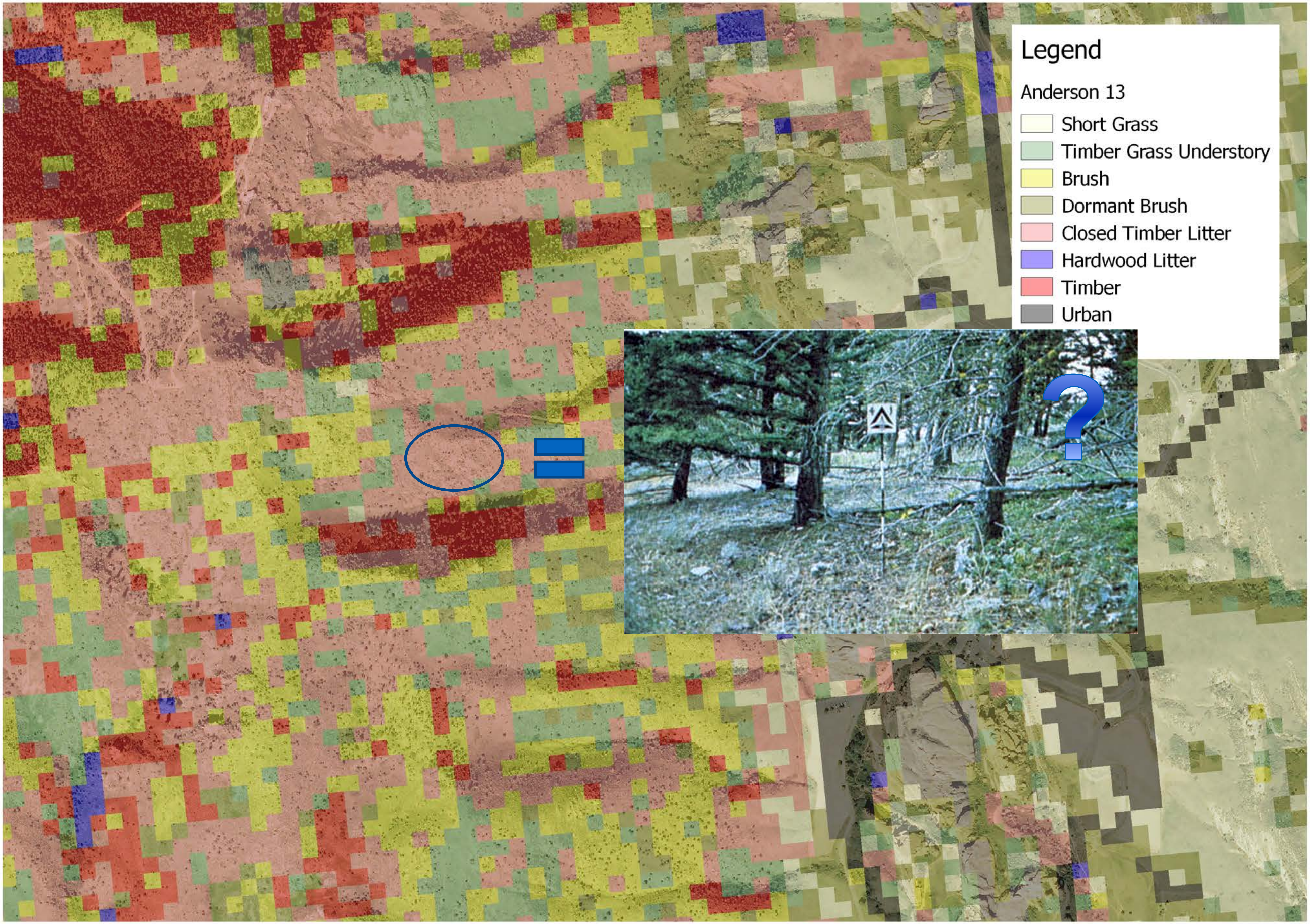
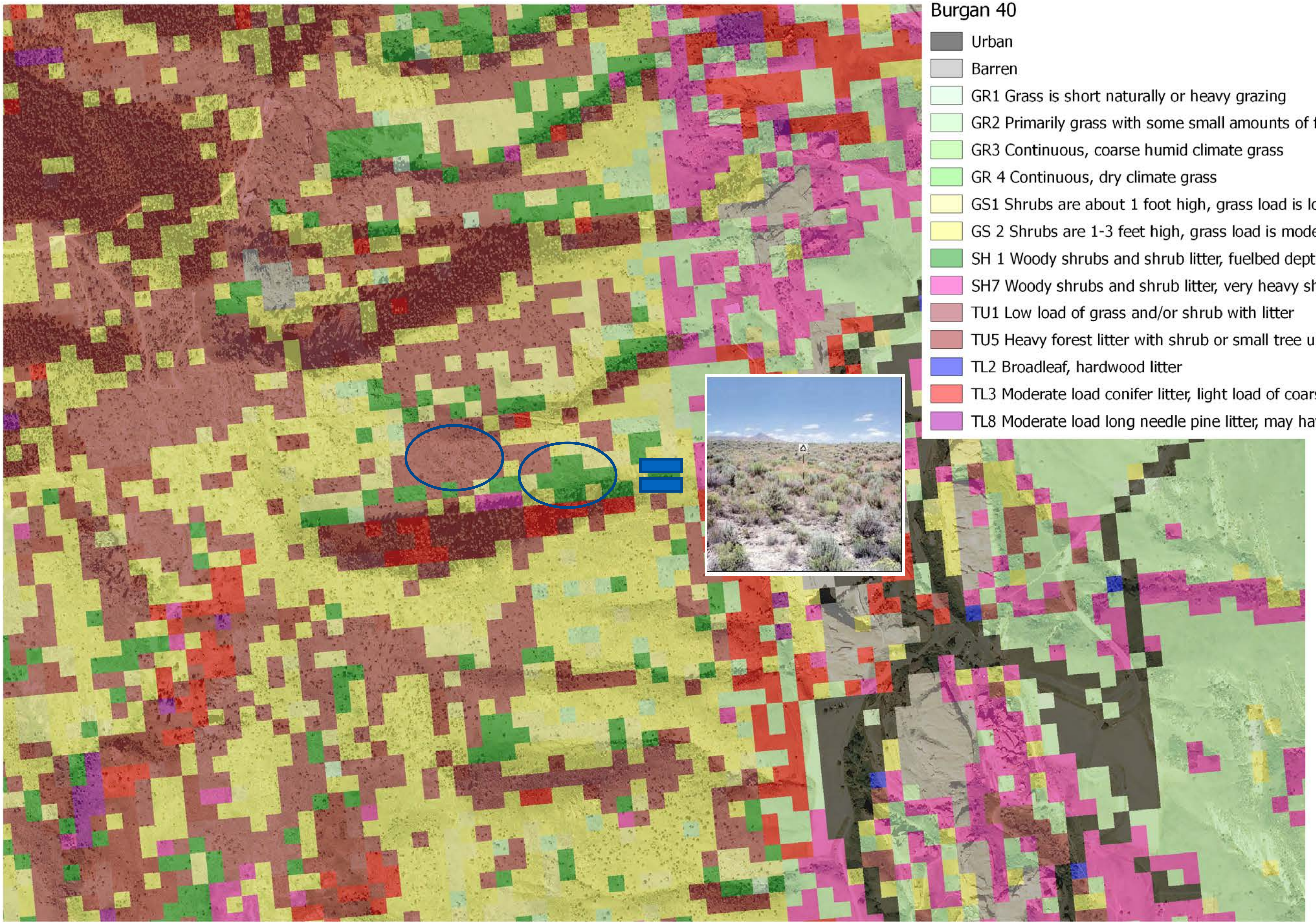
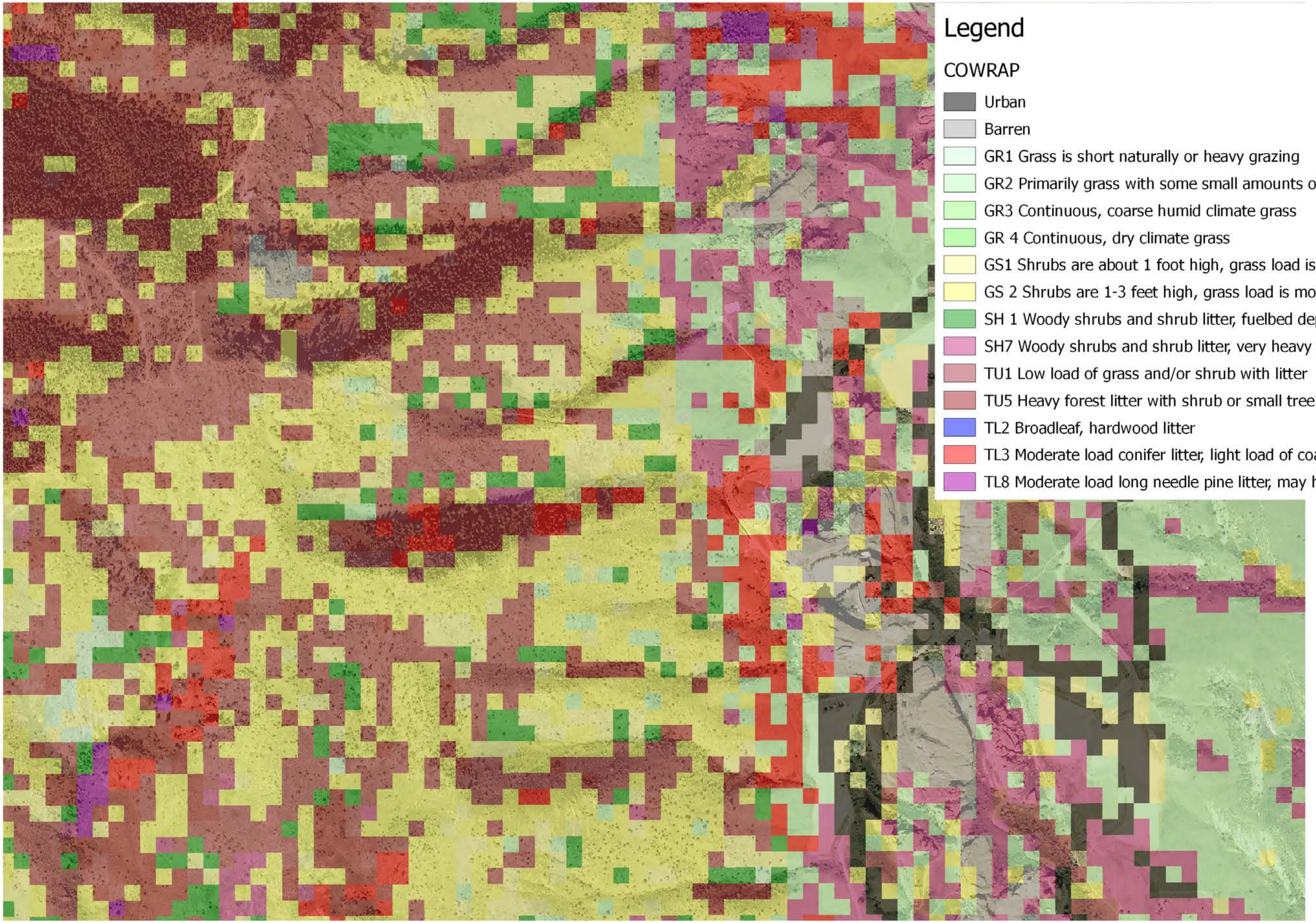

Legend
Anderson 13
Short Grass
Timber Grass Understory
Brush
Dormant Brush
Closed Timber Litter
Hardwood Litter
Timber
Urban


Burgan 40
Urban
Barren
GR1 Grass is short naturally or heavy grazing
GR2 Primarily grass with some small amounts of fir
GR3 Continuous, coarse humid climate grass
GR 4 Continuous, dry climate grass
GS1 Shrubs are about 1 foot high, grass load is low
GS 2 Shrubs are 1-3 feet high, grass load is moder
SH 1 Woody shrubs and shrub litter, fuelbed depth
SH7 Woody shrubs and shrub litter, very heavy shr
TU1 Low load of grass and/or shrub with litter
TU5 Heavy forest litter with shrub or small tree und
TL2 Broadleaf, hardwood litter
TL3 Moderate load conifer litter, light load of coarse
TL8 Moderate load long needle pine litter, may have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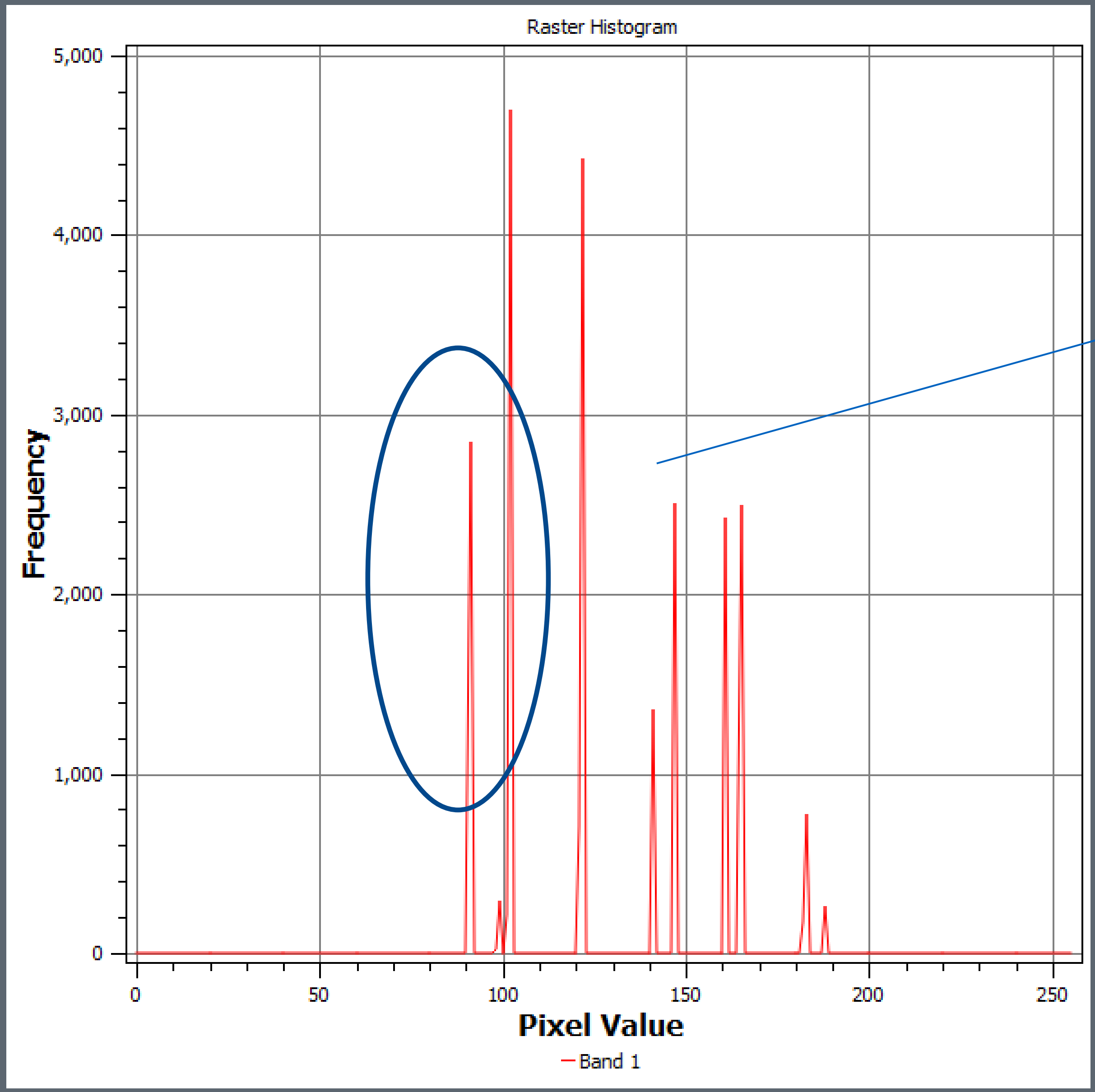
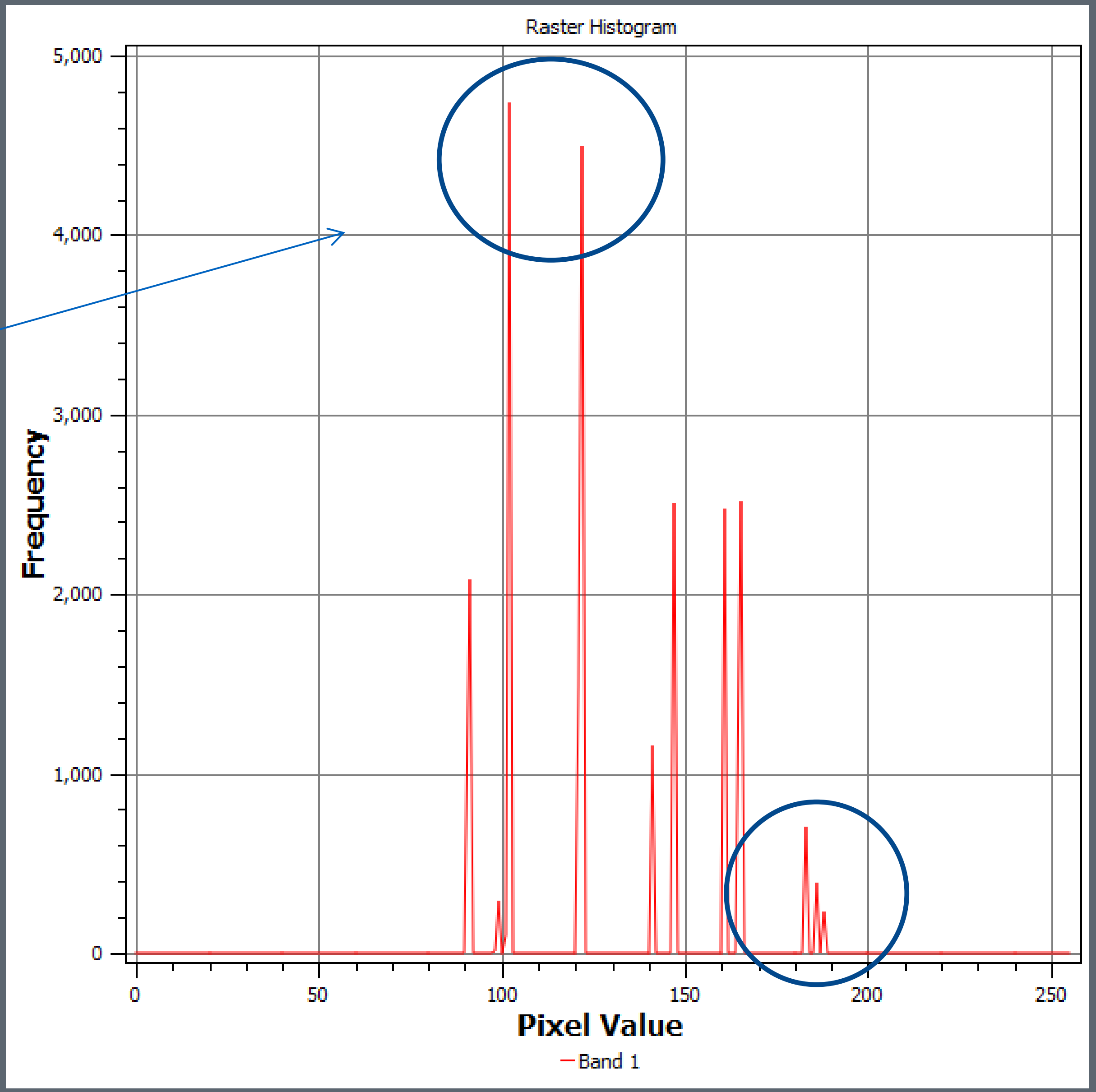
Quantitative Comparison

LANDFIRE Histogram



CO-WRAP Histogram



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Discussion

- How necessary is accurate fuel model data toward achieving the goal of creating an accurate fire behavior prediction?
- How many fuel type classes are necessary to accurately model fire behavior?
- Are a few pixels of an incorrect fuel type going to have a notable impact on a model?
- How out-of-date can a fuel model be before causing the fire predictions to suffer?


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Feedback on Stakeholder Committee Process

- What was planned?
- What actually (is happening?)
- What can we do better on?
- What topics would you like to discuss in the future?