Using Machine Learning and High-Resolution, Color-Infrared Aerial Imagery to Map Tree Canopy Cover and Monitor Forest Disturbance, Hazardous Fuels Reduction, and Restoration Treatments

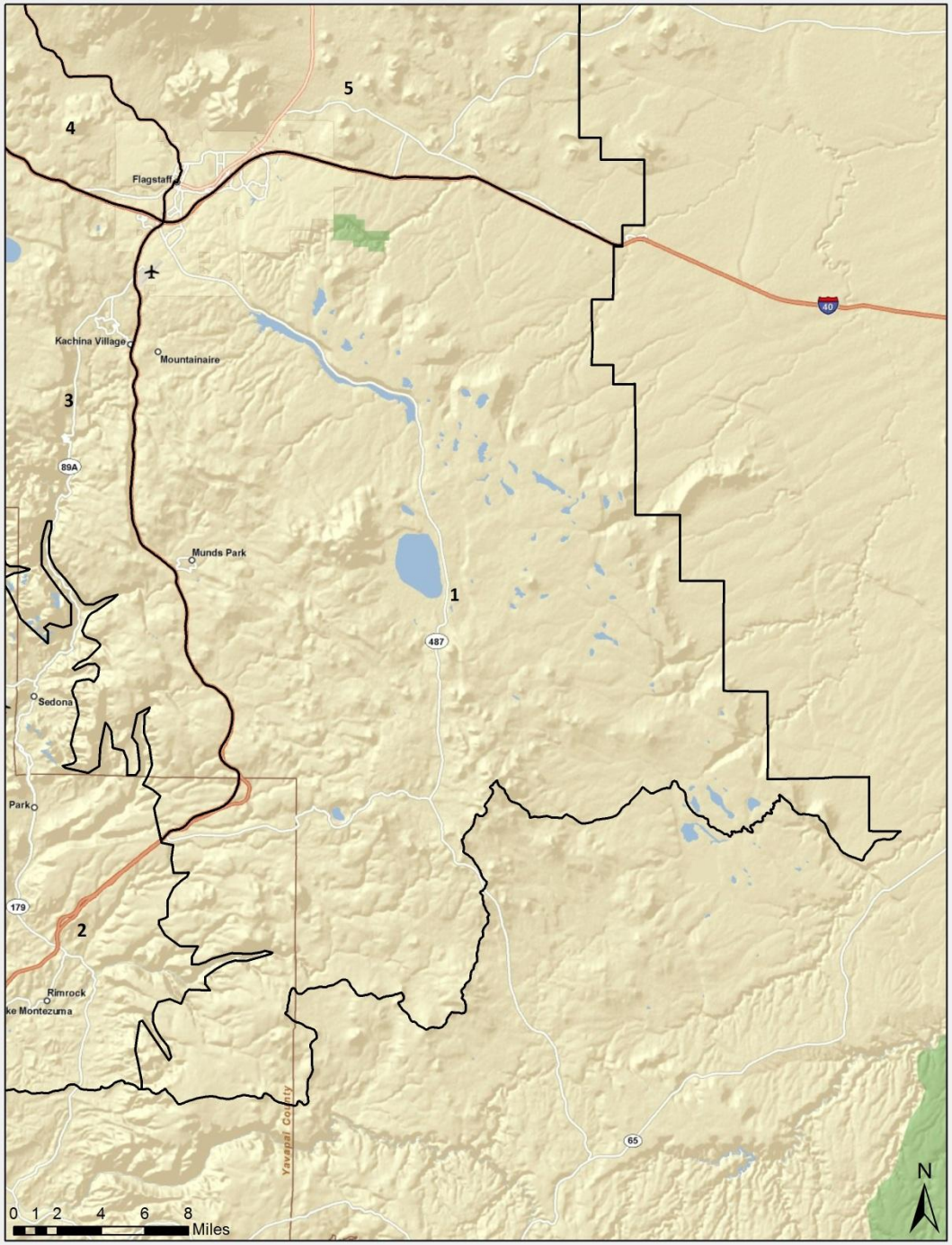
Luke J. Zachmann*, Aaryn D. Olsson, Steven E. Sesnie, and Brett G. Dickson

*luke@csp-inc.org

Conservation Science Partners
11050 Pioneer Trail, Suite 202
Truckee, CA 96161

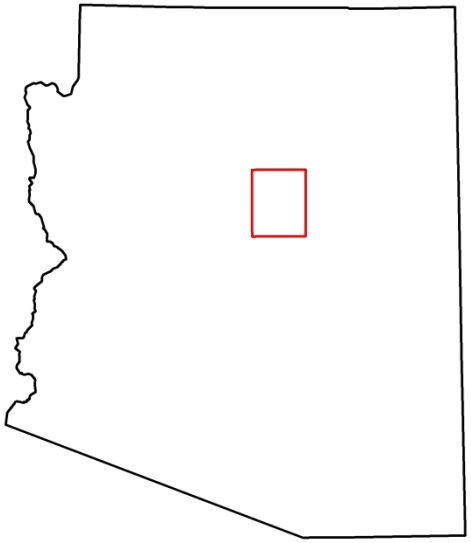
Objectives

1) Develop techniques for rapid and cost-effective assessment of tree canopy cover at broad spatial scales using high-resolution, freely available imagery
2) Develop methods to track changes in tree canopy cover in forest treatment areas over time



Study area

- ½M acres
- 305,000 acres of PIPO



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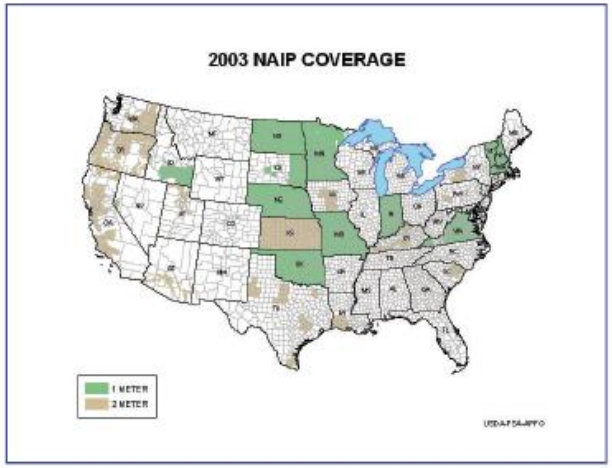
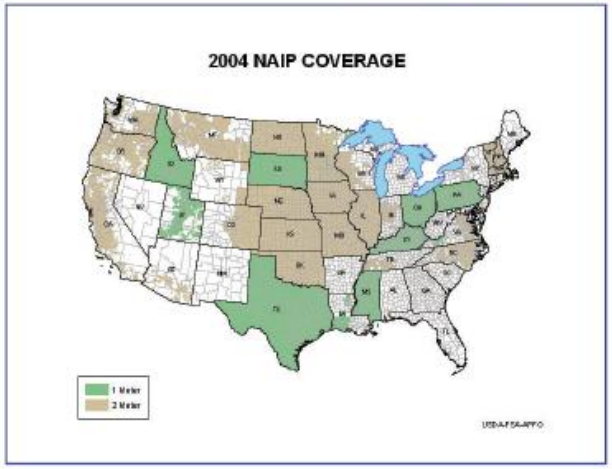
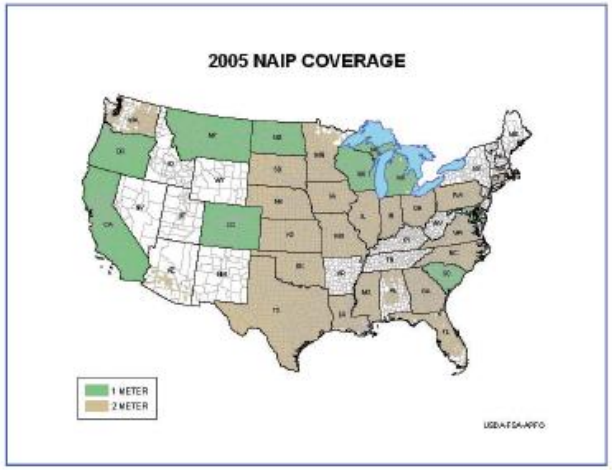
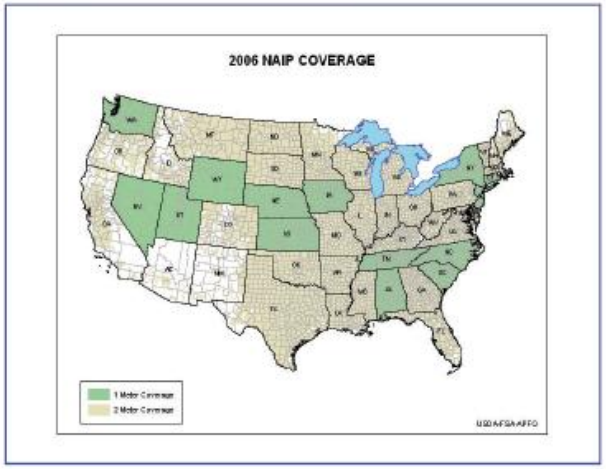
USDA

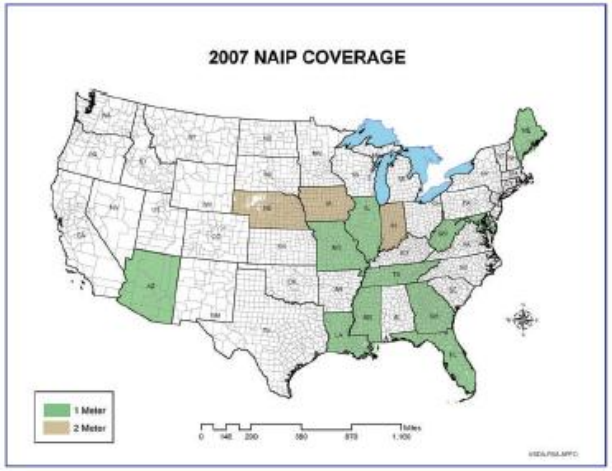
FSA
FARM SERVICE AGENCY

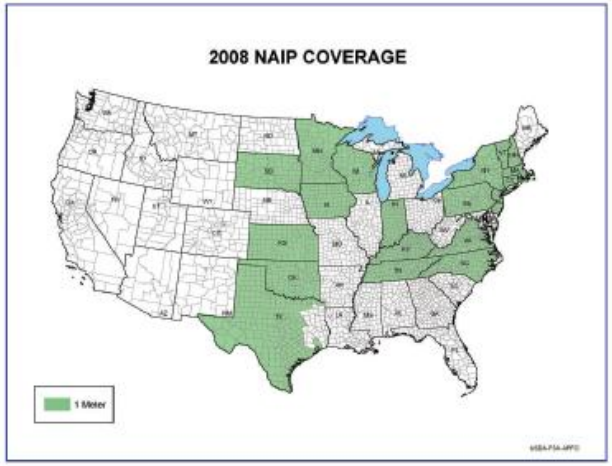


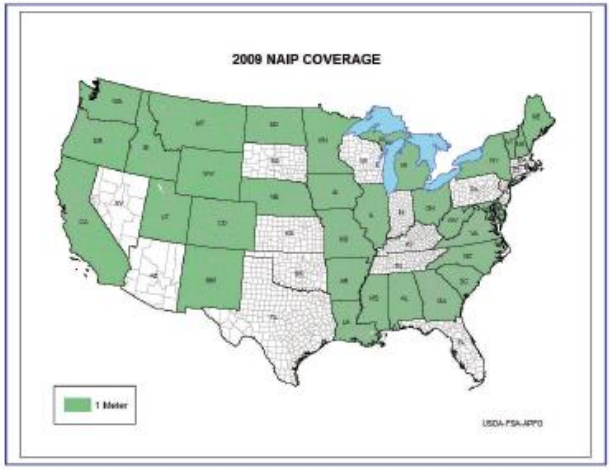


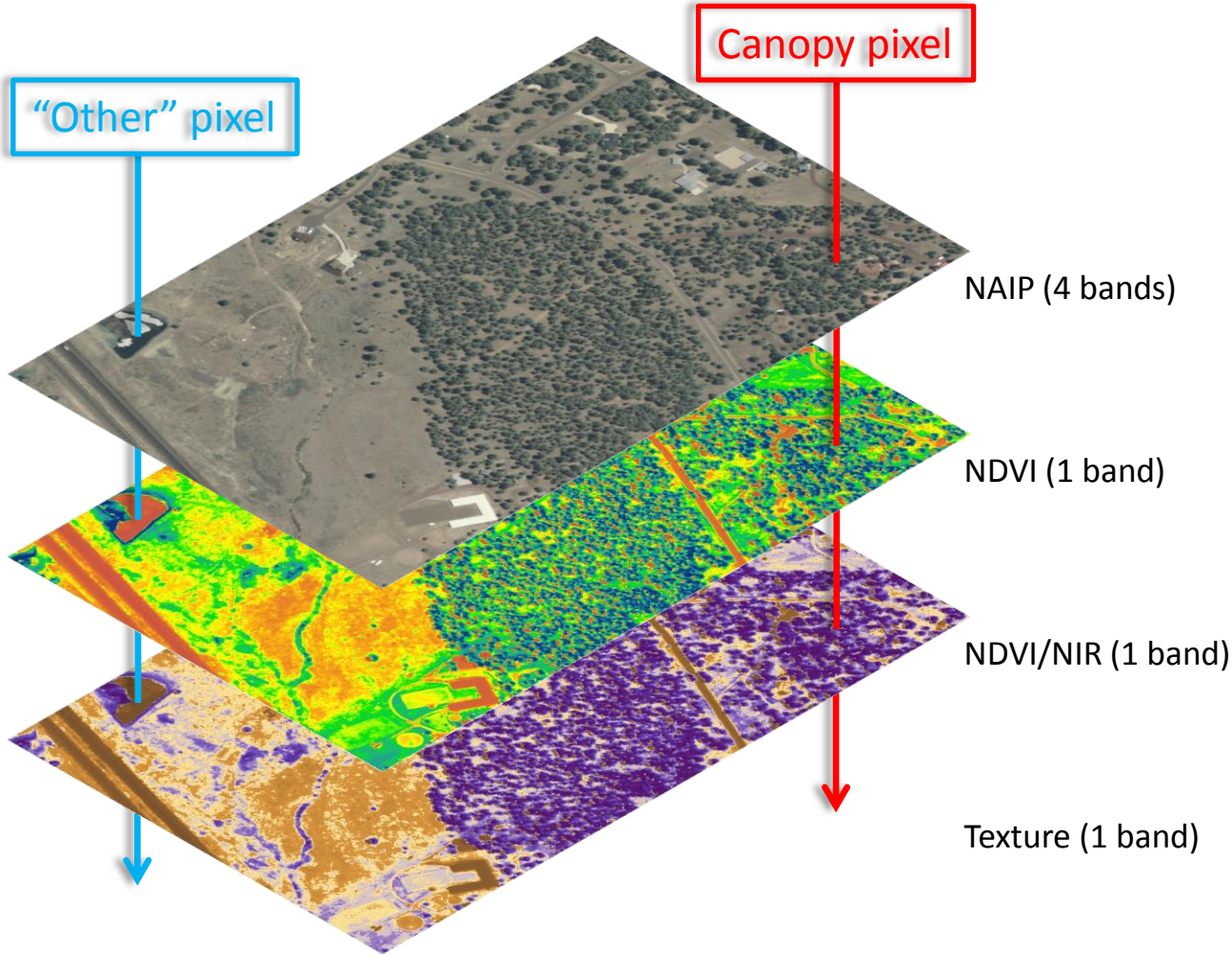












Cover	R	G	B	NIR	NDVI	NDVI/NIR
other	72	86	81	108	1429	13.23
canopy	63	75	76	116	2083	17.96

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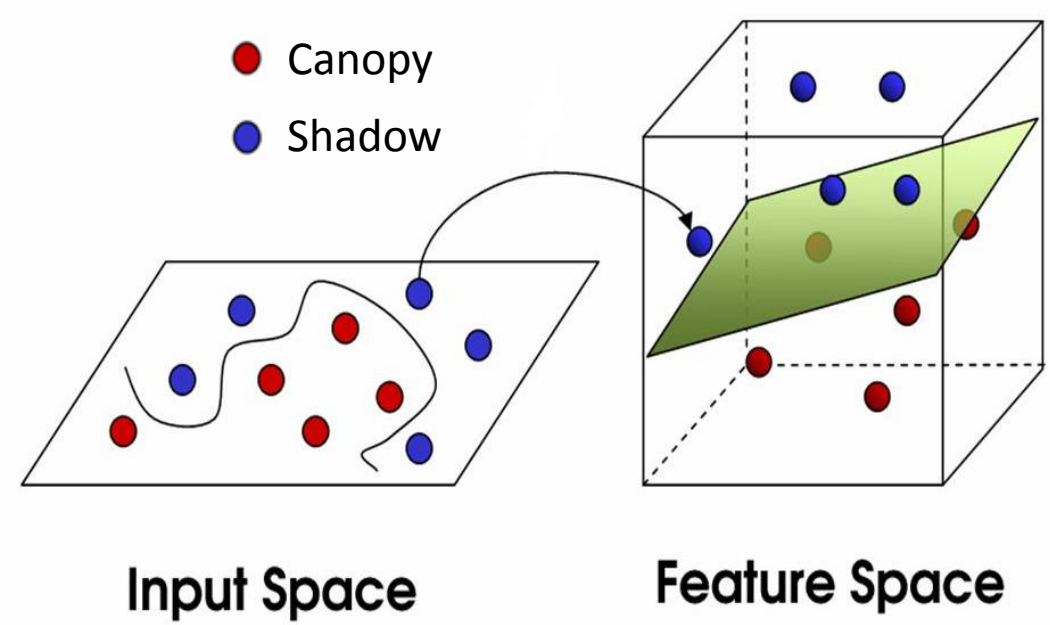
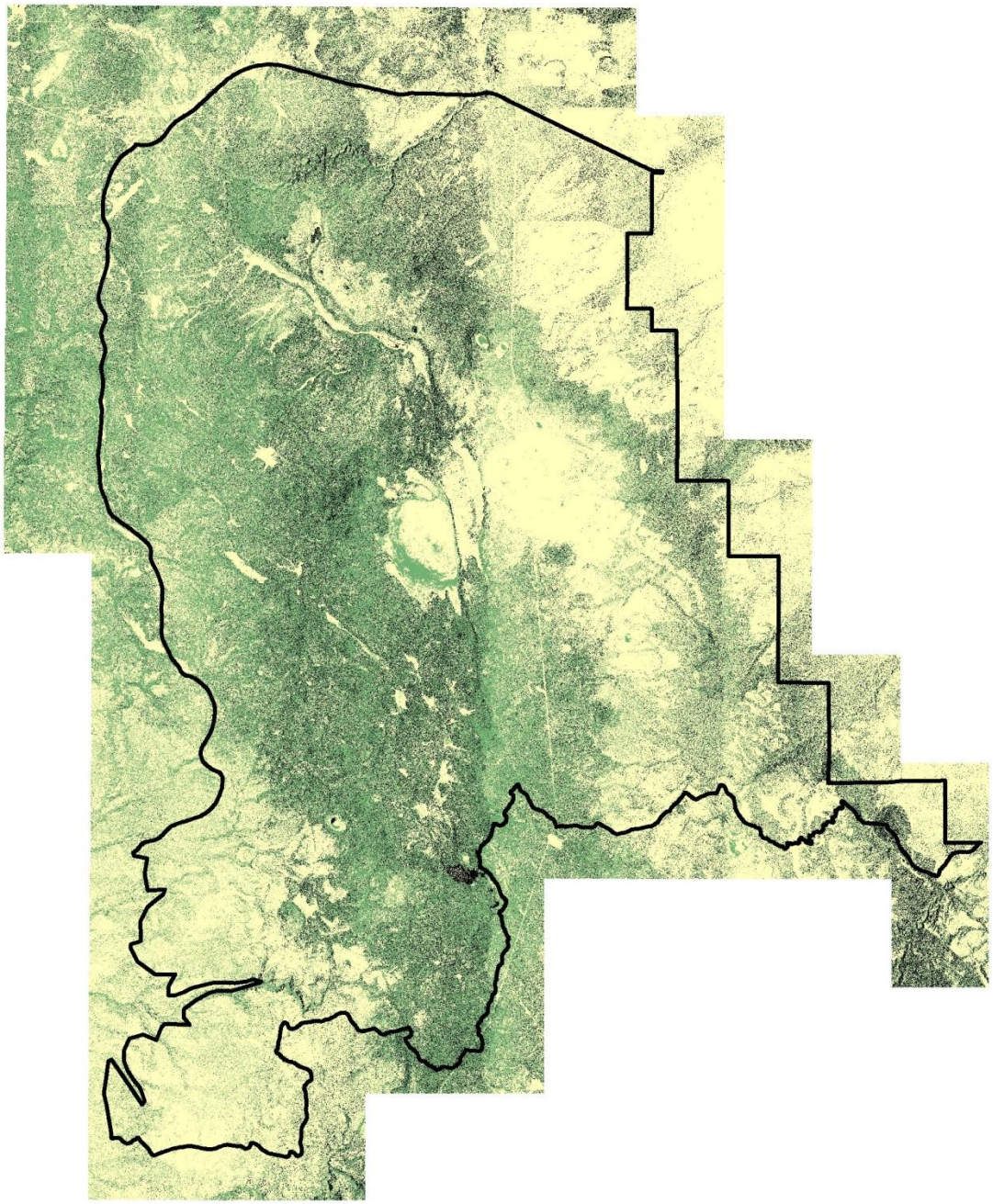
Support vector machines (SVMs): a two-dimensional example

- SVMs have a unique method of fitting separating planes between different classes of data





canopy

other

shadow

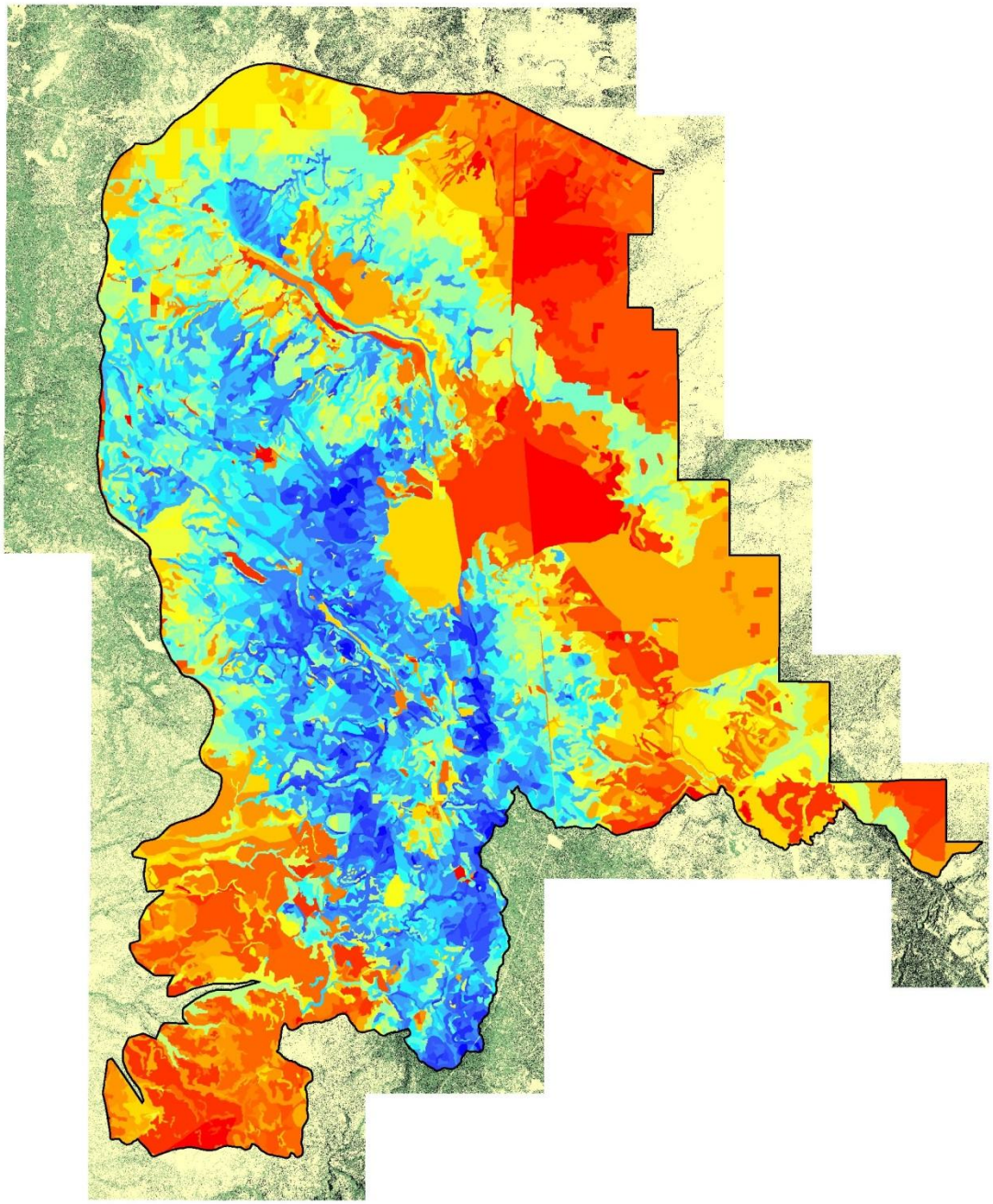
The error matrix: overall accuracy

PREDICTED \ REFERENCE	Canopy	Other	Shadow
Canopy	**1004**	4	44
Other	8	**5921**	11
Shadow	30	4	**824**

Overall accuracy is the sum of the major diagonal (i.e., correctly classified pixels) divided by the total number of sample units in the entire error matrix:

$$\frac{1004 + 5921 + 824}{7850} = 98.7\%$$

Stand-level canopy cover



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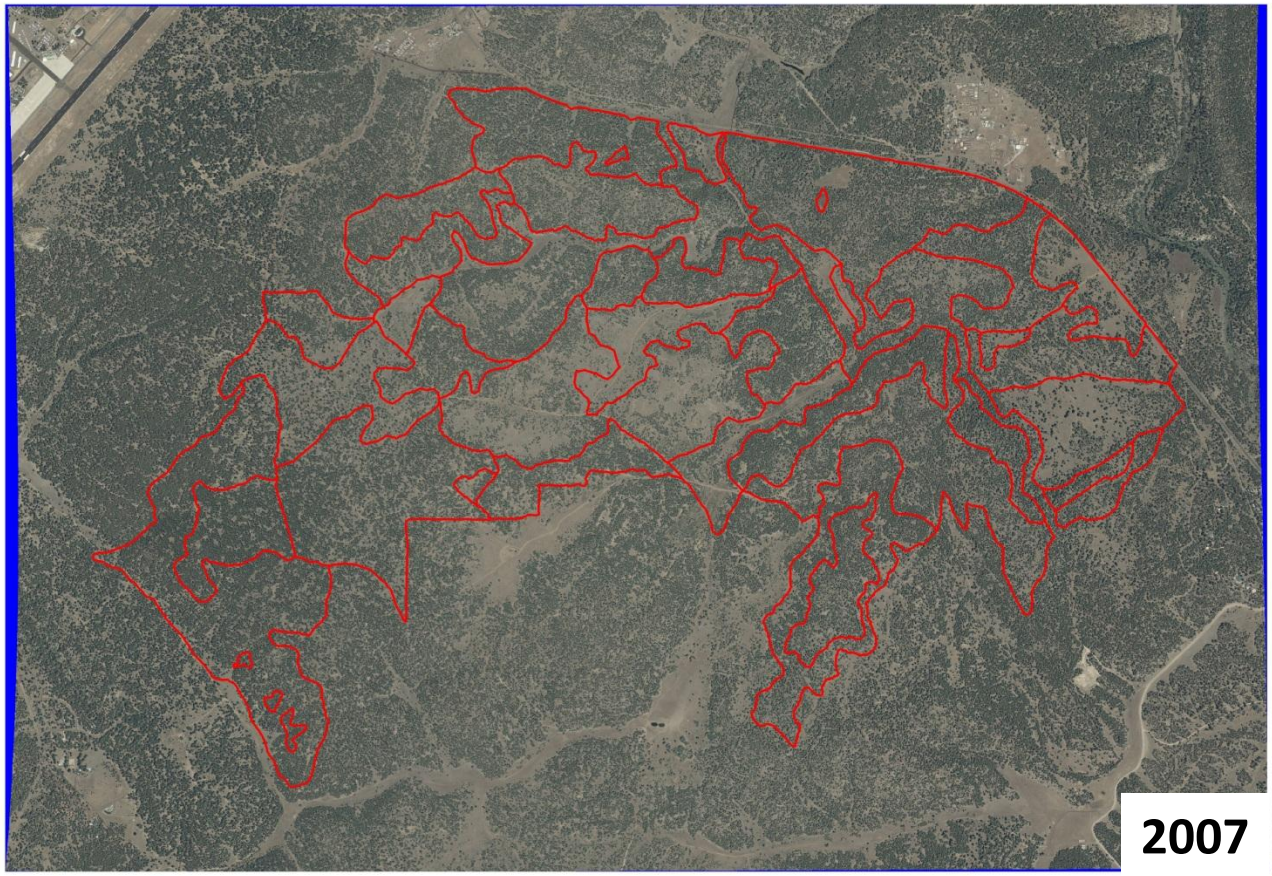
NAIP



Stand boundaries

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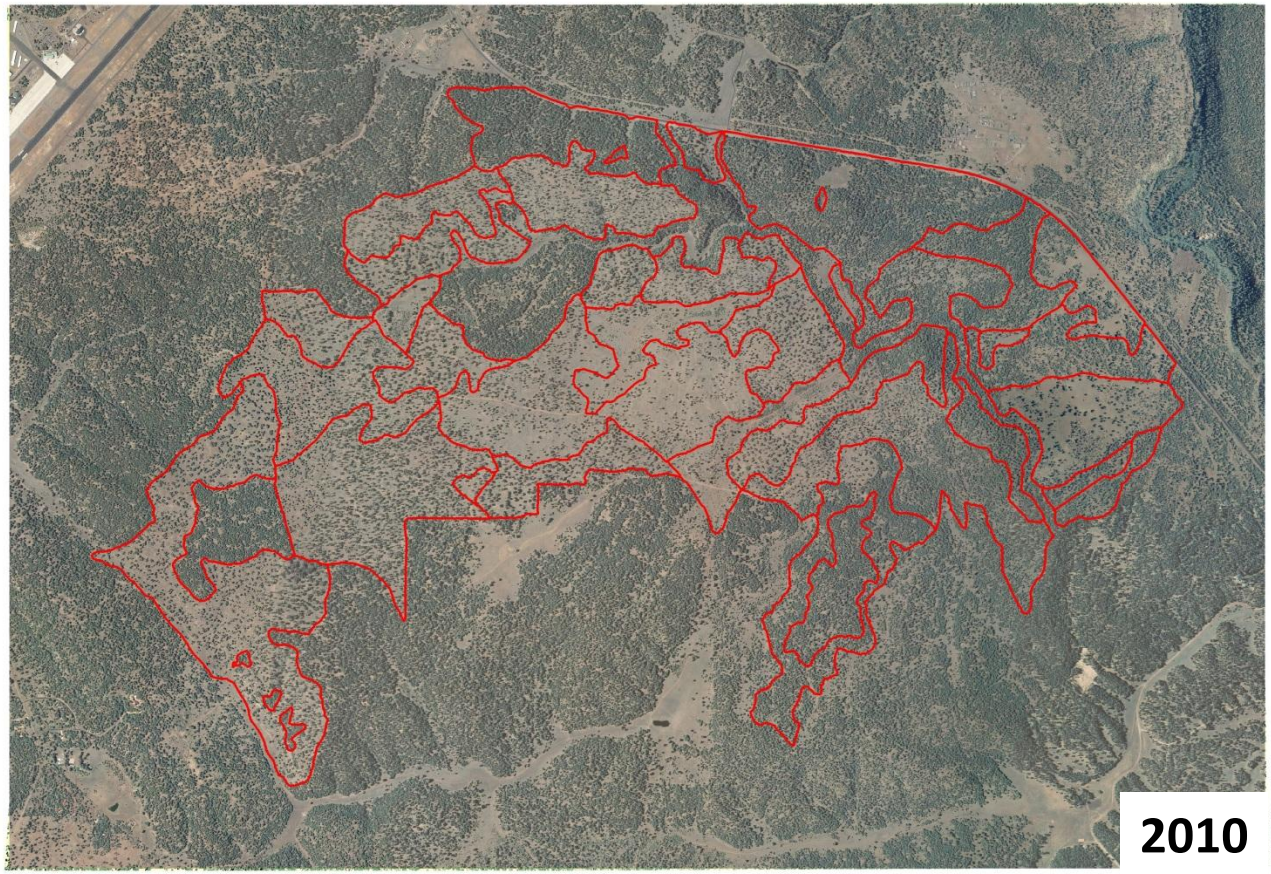
NAIP



Stand boundaries

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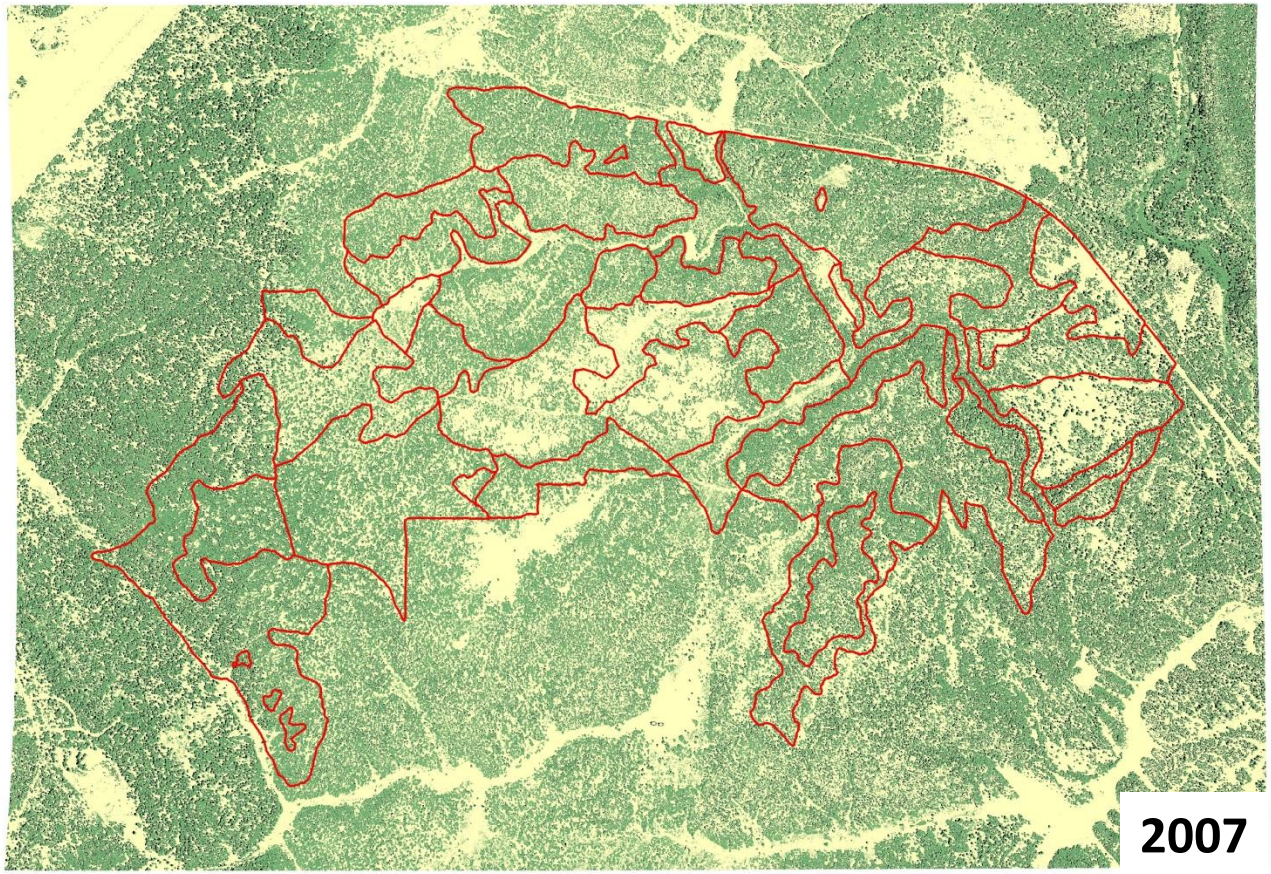
Classification results

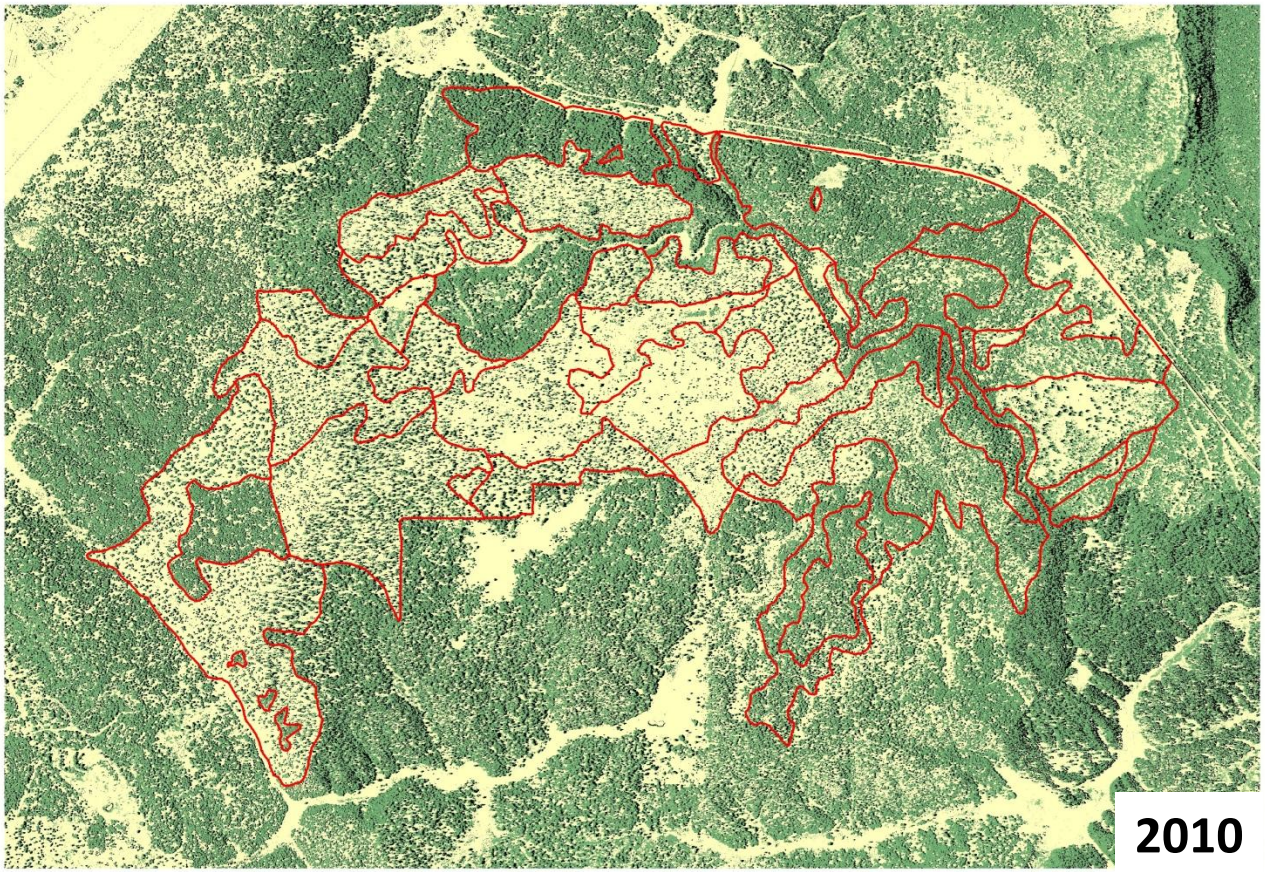


canopy

other

shadow

Classification results

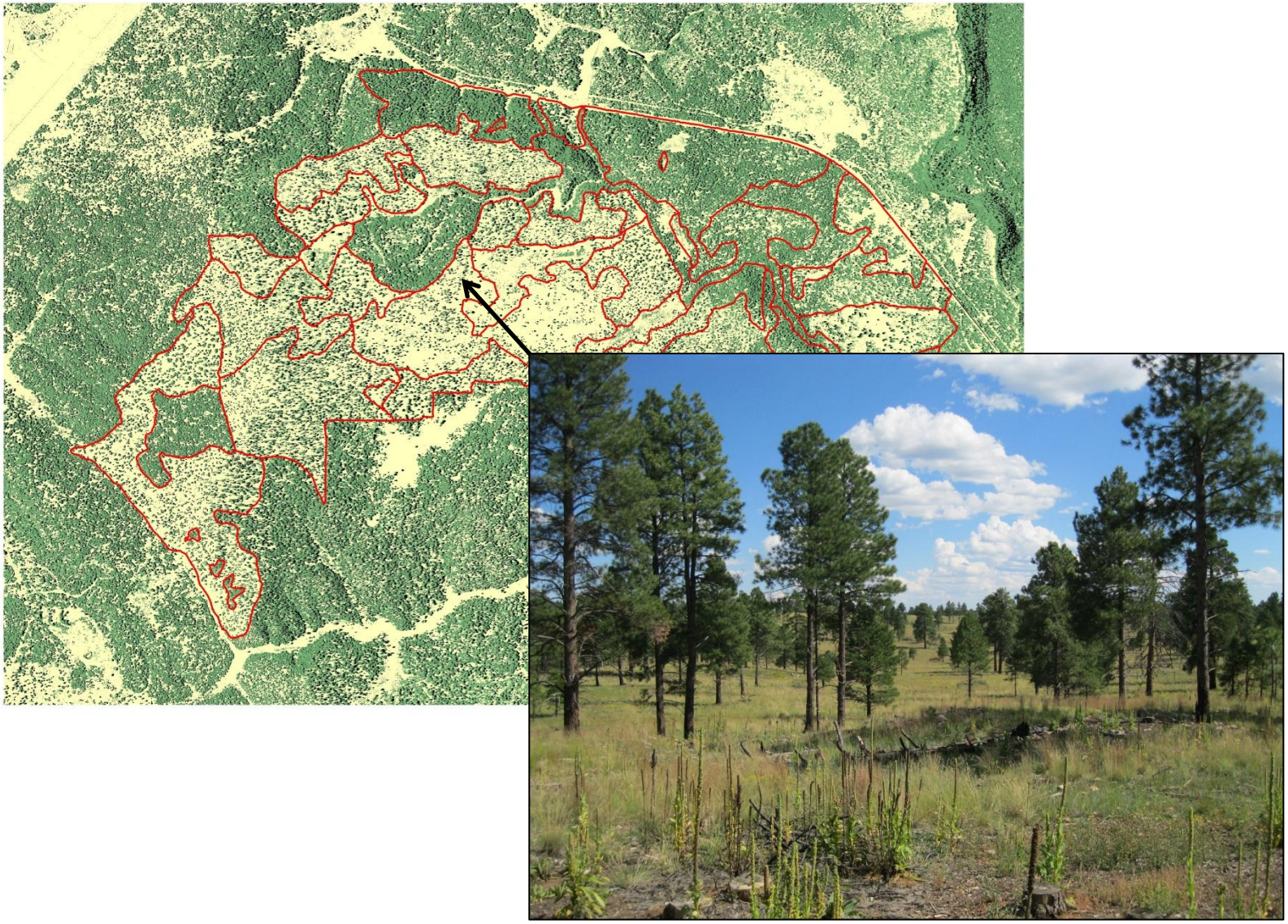


canopy

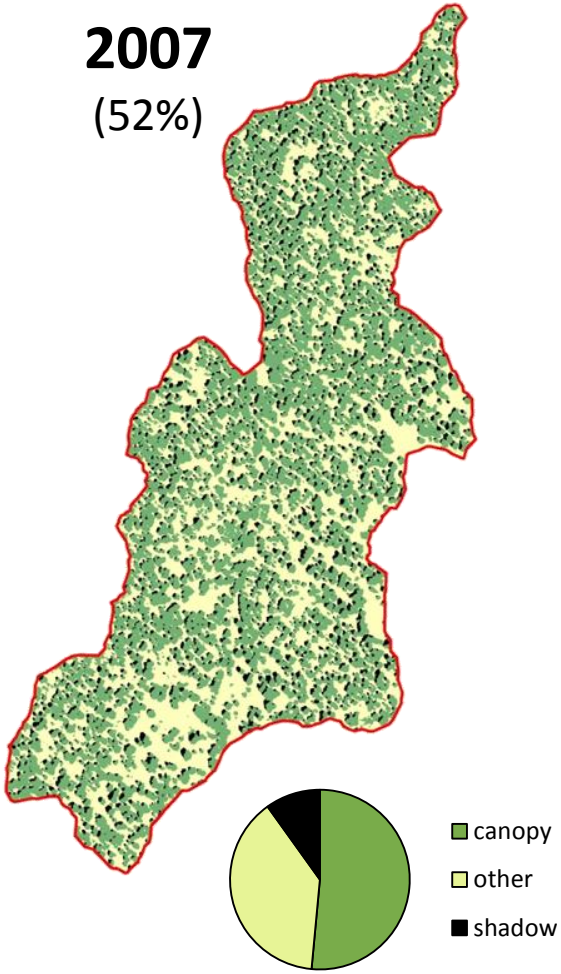
other

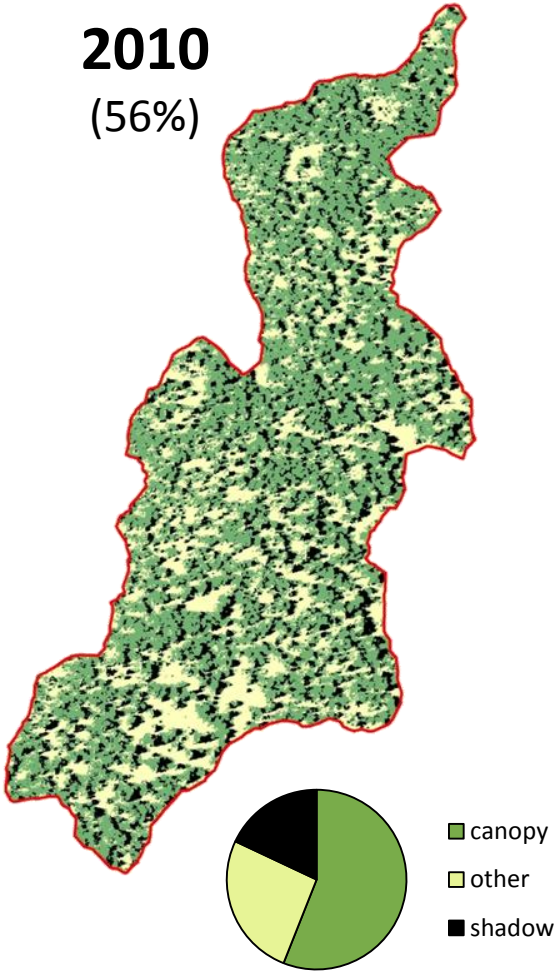
shadow

Classification results

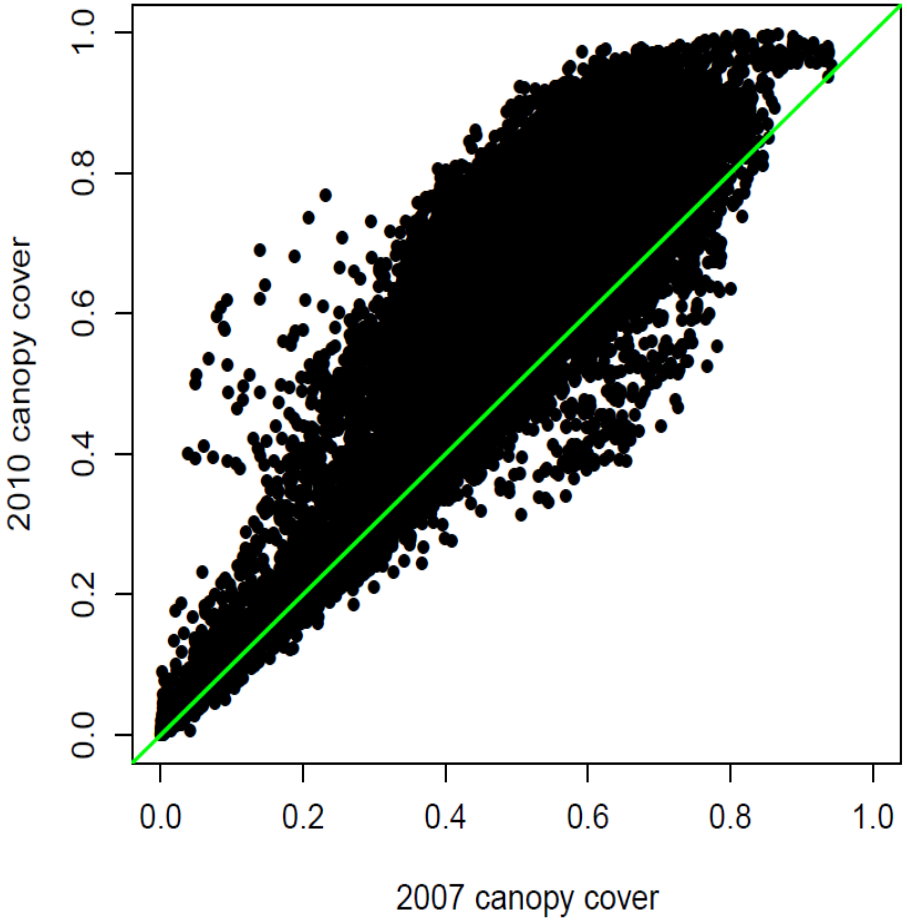


Problem: canopy cover differs even in undisturbed areas





Undisturbed areas



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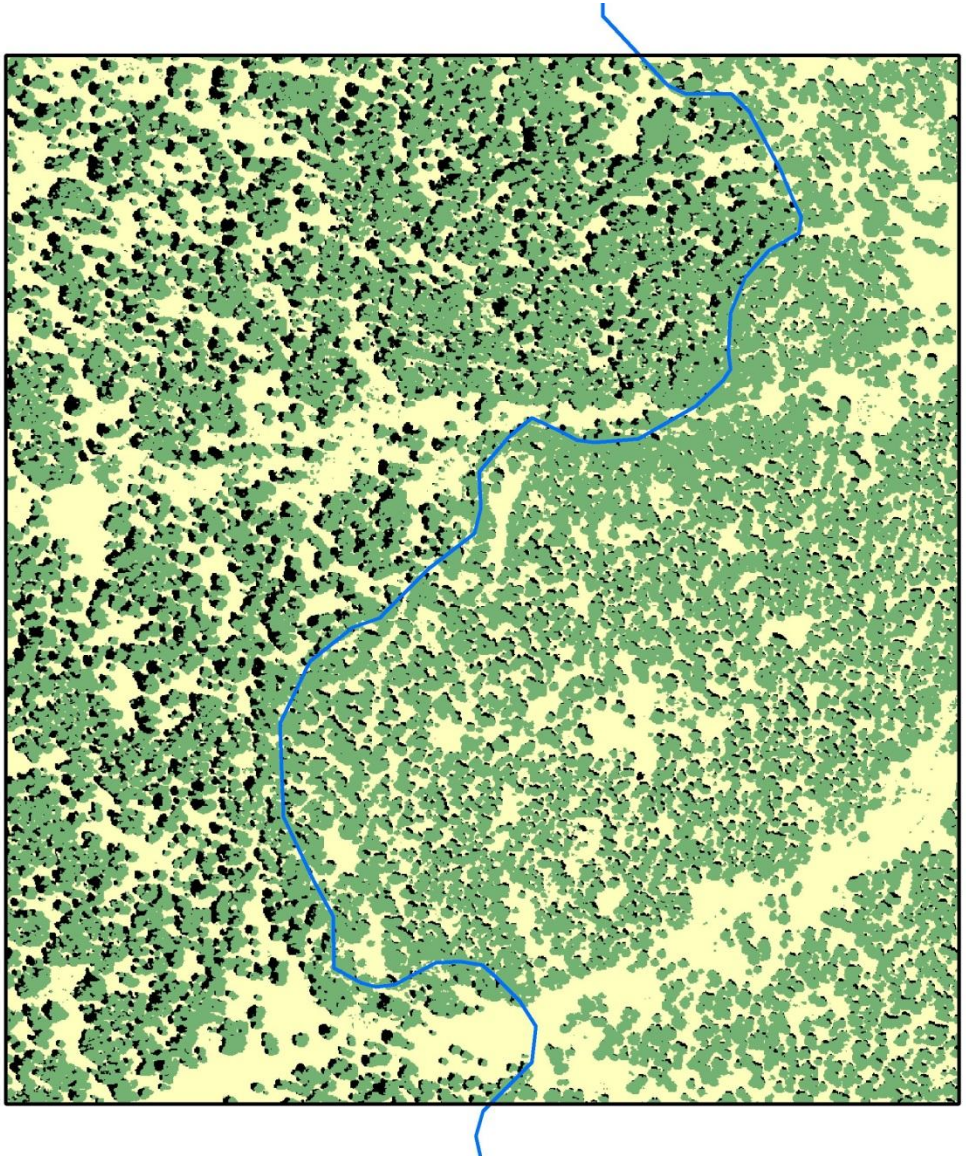
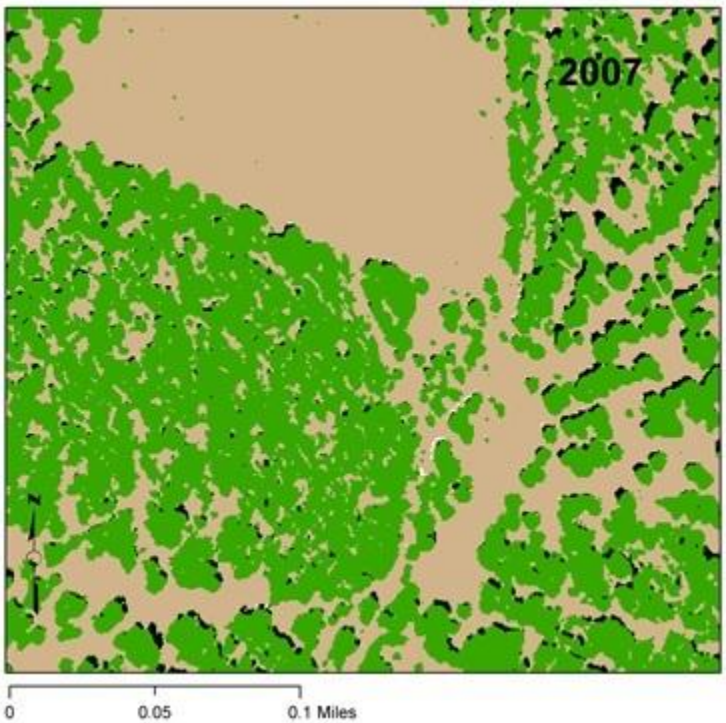
Why do such differences exist?

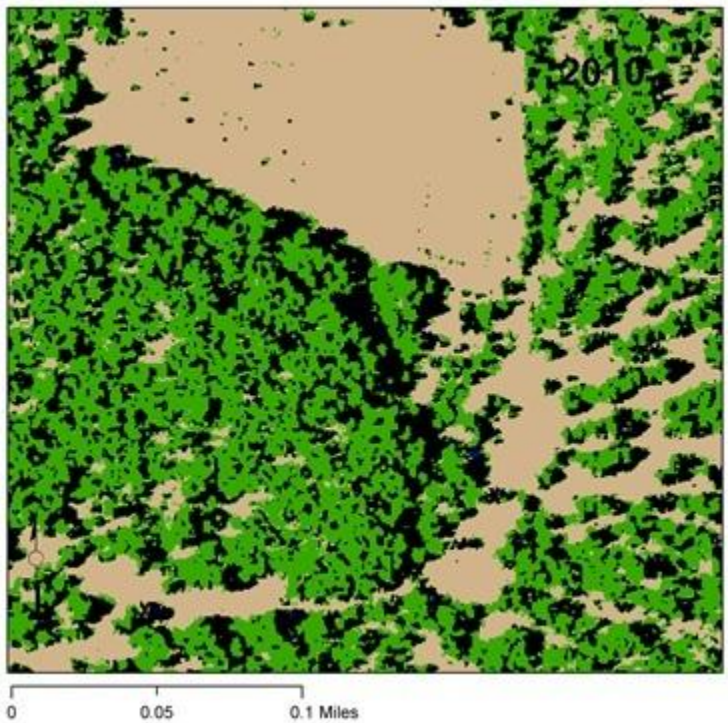
- Camera types
- Time of image acquisition and phenology
- Image alignment
- Illumination and viewing geometries (e.g., bidirectional reflectance and radial distortion)

Spatial shadow affects



Temporal shadow affects





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What do we do?

1) Geometrically correct 2007 predictions using 2010 as the reference
2) Come up with a way to control for differences in image quality using a canopy adjustment factor (CAF):

$$\boldsymbol{\phi} = \frac{C_{2007} - C_{2010}}{C_{2007} + C_{2010}} = f\left\{\begin{matrix} elevation \\ slope \\ aspect \\ position \\ class\ proportions \end{matrix}\right\}$$

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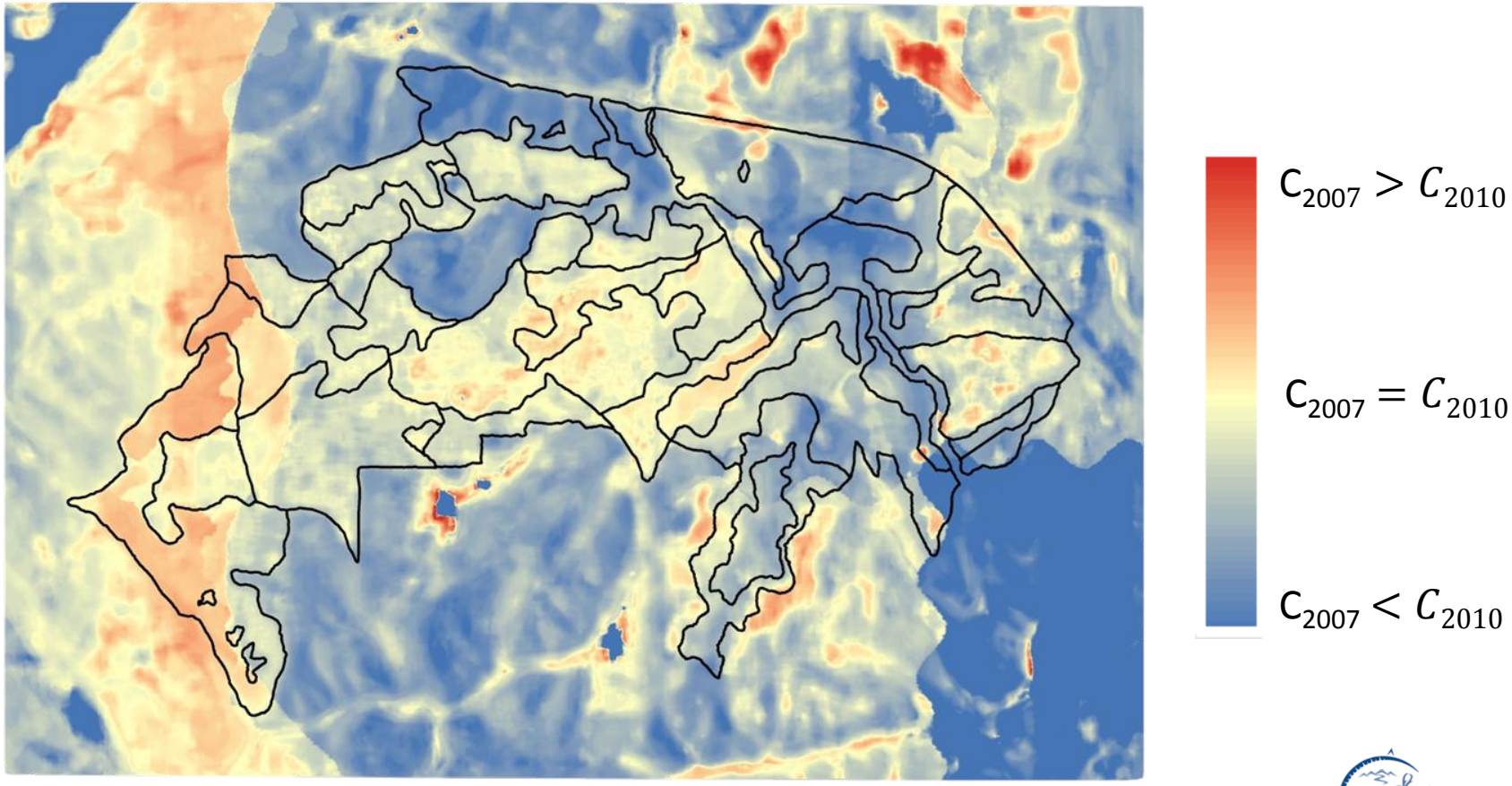
CAF map



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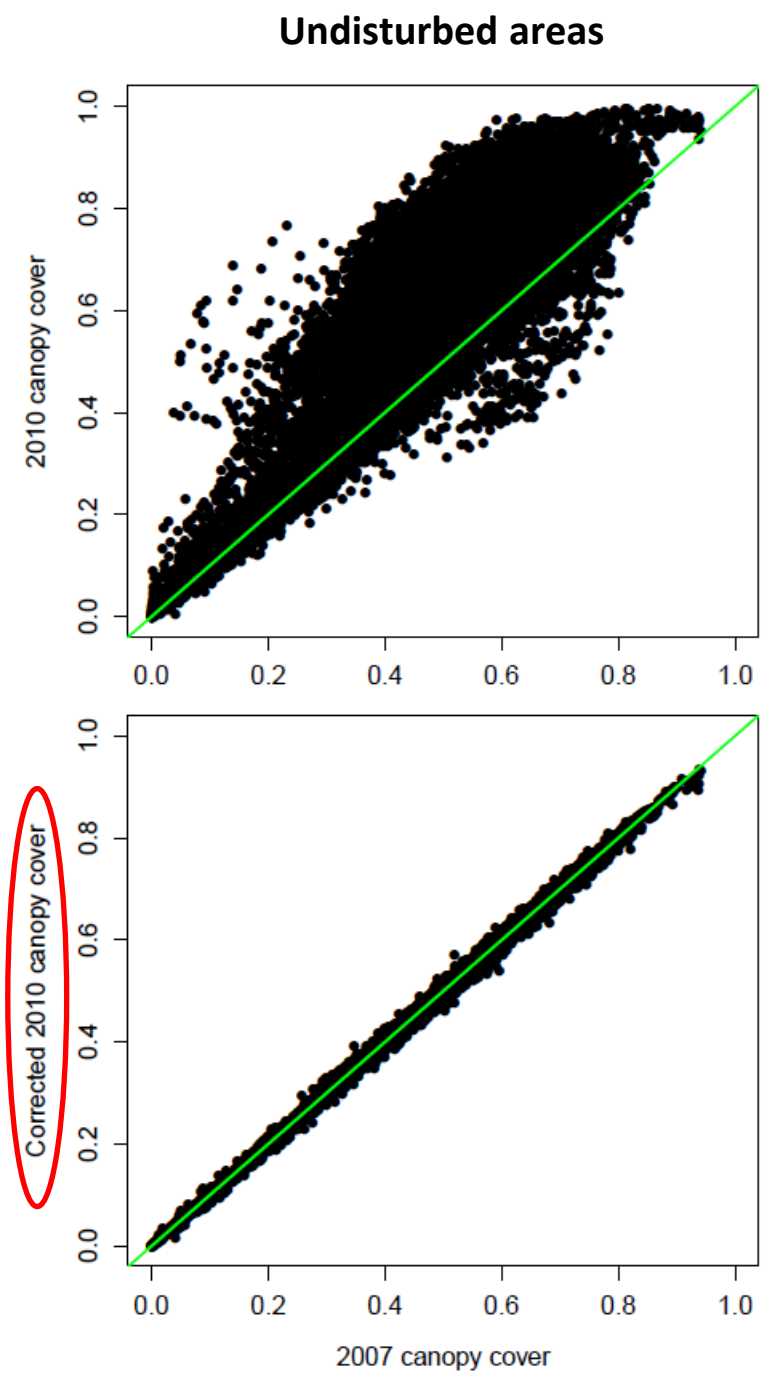
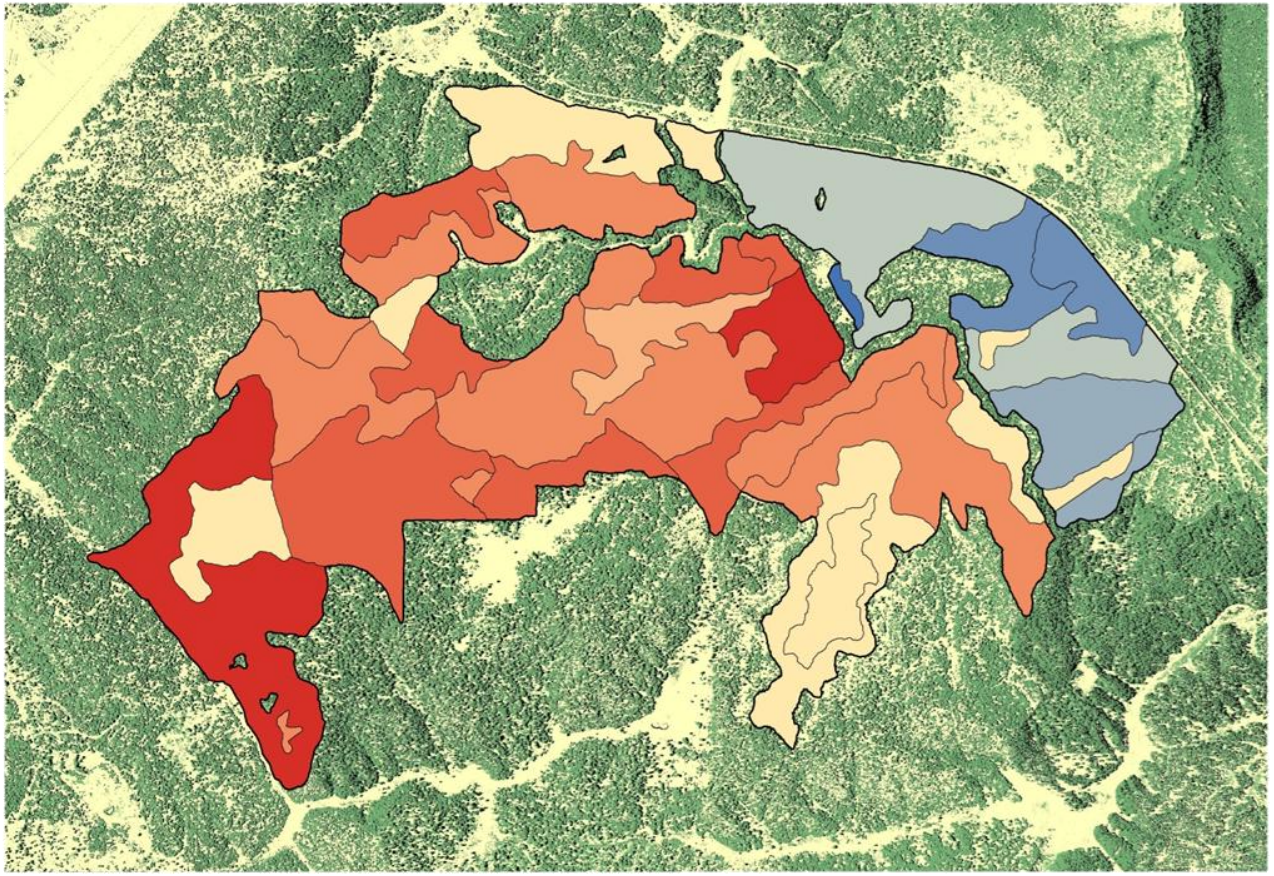
$$C_{2010}\frac{1+\phi}{1-\phi}$$



Absolute tree canopy cover change



Marginal gain

No change

45% loss

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Conclusions

- These data are useful in establishing baseline conditions and monitoring resource trends at broad spatial scales and can be developed quickly and relatively cheaply
- Errors associated with image characteristics can be corrected using a canopy adjustment factor
- These data could be used in many applications, including comparing conditions in “relic” stands to conditions elsewhere, and could also be used in conjunction with other data to help guide management decisions

Acknowledgments

- Grand Canyon Trust
- Co-authors

- Questions?

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Supplementary slides

Image data collection

Leica ADS40 Airborne Digital Sensor (2007)

- Pushbroom type sensor (line by line)
- Potential problems: low sensitivity multispectral channels

Intergraph Z/I Imaging Digital Mapping Camera (2010)

- Framing camera (patch by patch)
- Potential problems: risk of overexposure