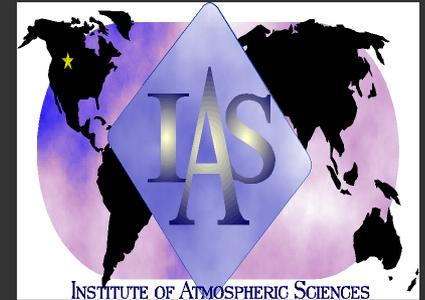


Relationships Among IKONOS Imagery, Landsat ETM⁺ Imagery, Airborne Scanning LIDAR, and Vegetation Structure in a Ponderosa Pine Forest: A Multiple Endmember Approach



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Objectives

- Determine relationships among ground-collected forest structure data, IKONOS imagery, and airborne scanning LIDAR data
- Research relationships among Enhanced Vegetation Index (EVI), LIDAR-derived canopy data, and subpixel tree fraction estimates
- Research how well forest structure can be estimated using IKONOS and Landsat ETM+ imagery

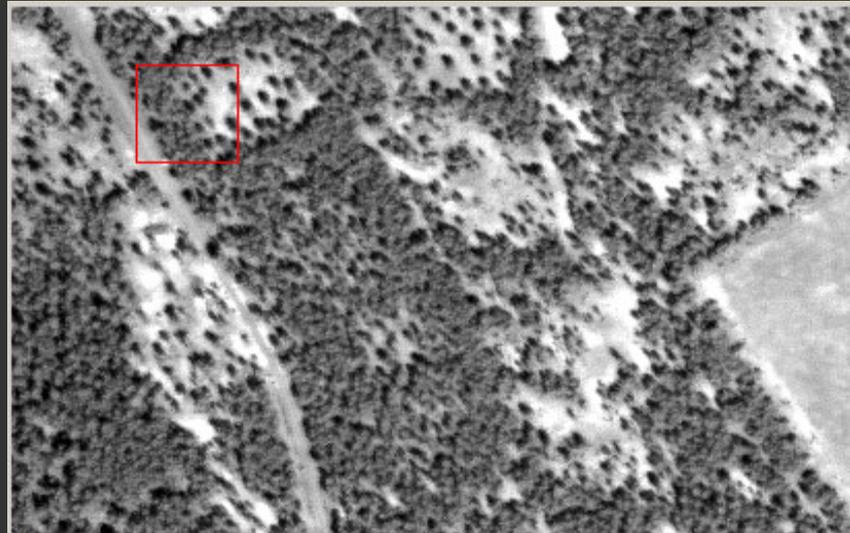
Outline

- Introduction
- Data Collection
 - Research site
 - Ground-based forest inventory data
 - IKONOS image
 - Landsat ETM⁺ image
 - LIDAR data
- Methods
- Analyses and Results
- Conclusions

Introduction

Why this research

270
meters



IKONOS Panchromatic image



3, 2, 1 Band image (July 28th, 2000)

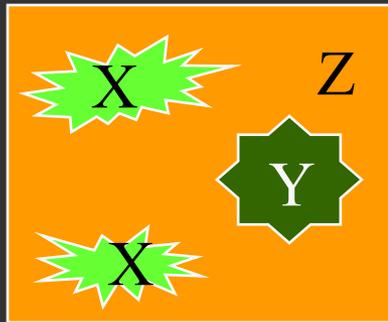
270
meters



**Landsat ETM⁺ image
(August 20th, 2000)**

Introduction

Linear Spectral Unmixing



Total
spectral
signal of a
pixel

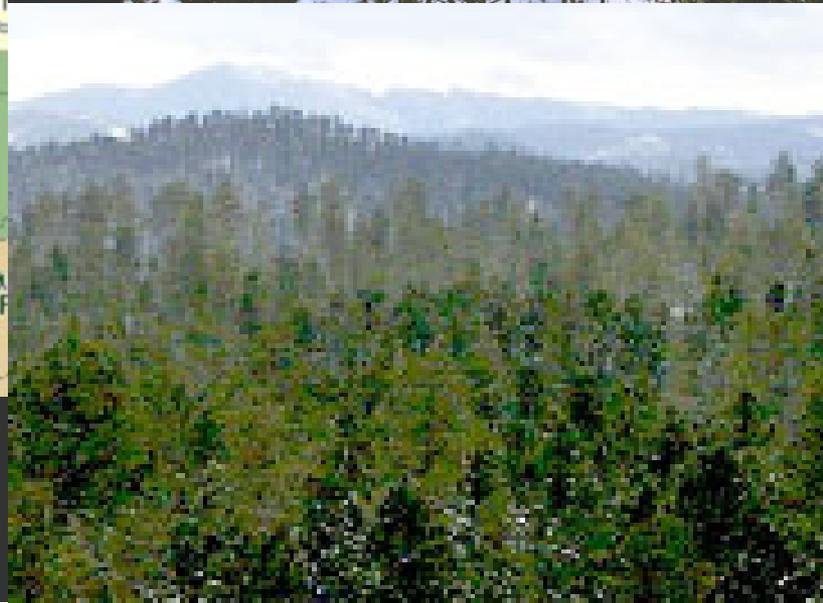


$$a * X + b * Y + c * Z = \text{Total Spectral Signal}$$

$$a + b + c = 1$$

Data Collection

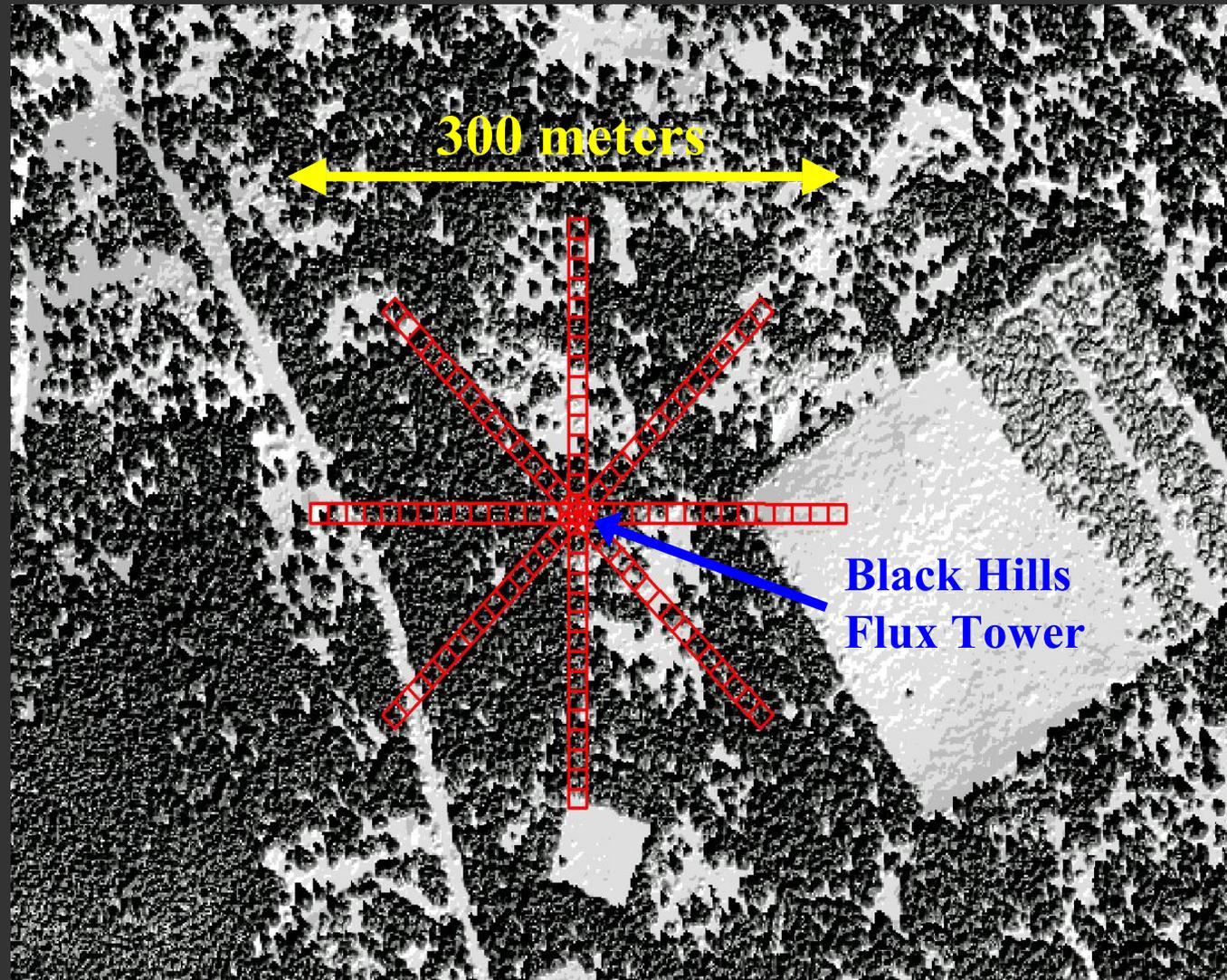
Research Site



Data Collection

Ground-based forest inventory data

- Collected in the summer of 2001
- Tree species
- Diameter at breast height
- Tree height
- Percent and type of ground cover
- Effective leaf area index (LAI_e)



Detail LIDAR Derived Hillshade October 26th, 2001

Data Collection

Remotely Sensed Data

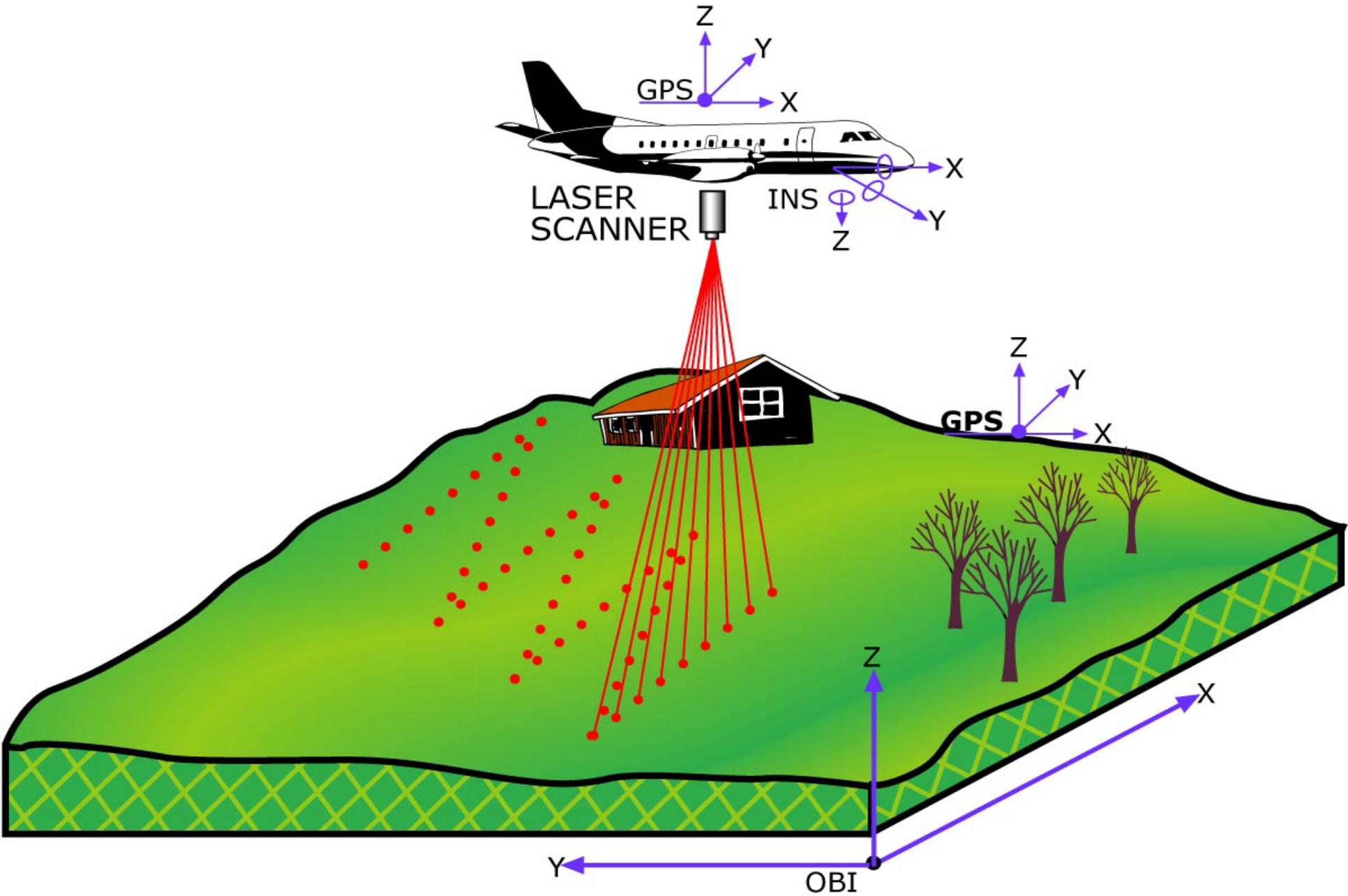
- IKONOS imagery (July 28th, 2000)
 - Precision original
 - Acquired via NASA data purchase
- Landsat ETM⁺ imagery (August 20th, 2000)
- LIDAR data (October 26th, 2001)
- No thinning or fire

Data Collection

LIDAR (**L**ight **D**etection **a**nd **R**anging)

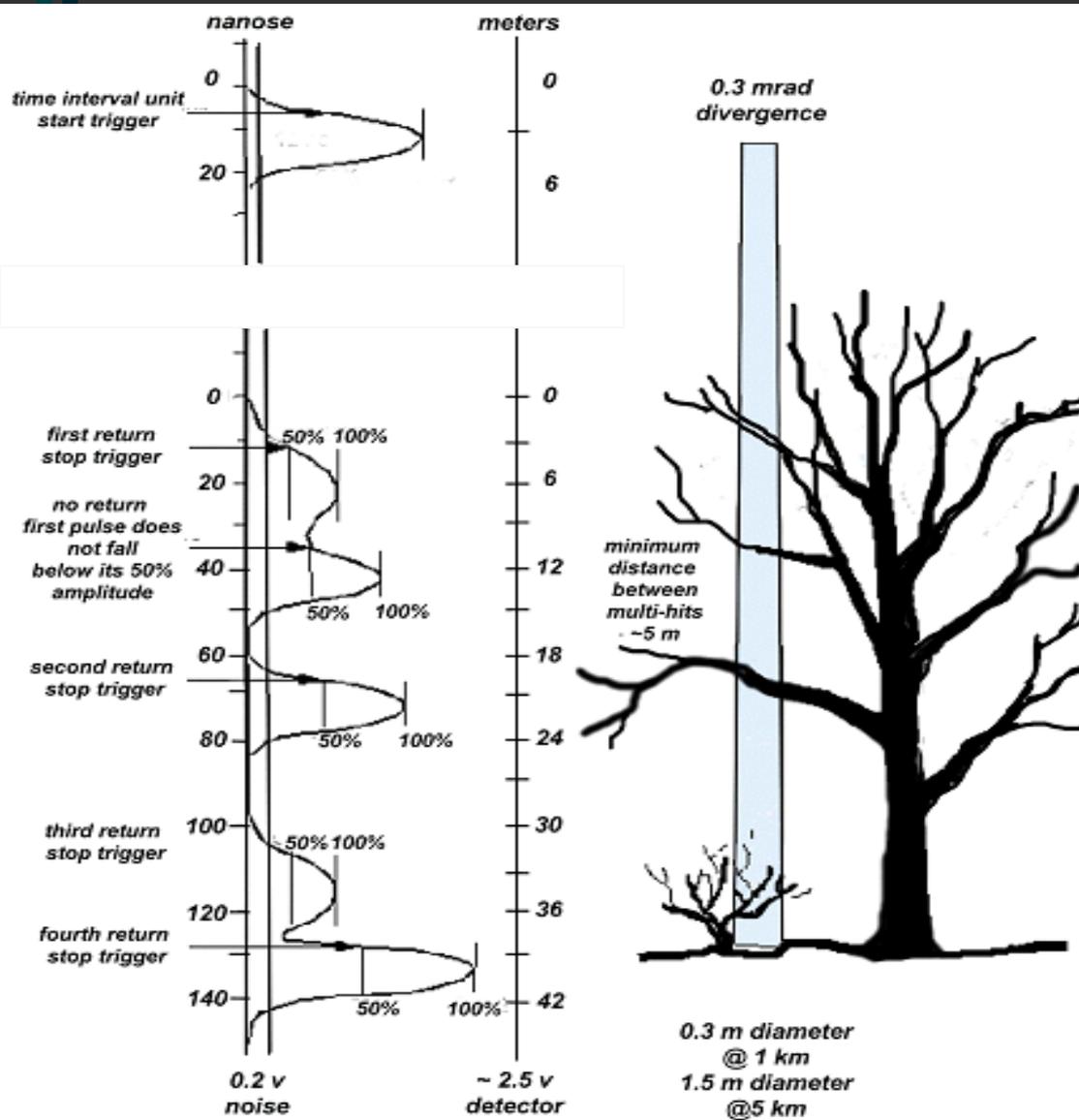
- Measure 1064 nm laser pulse
- Point density
- Vertical resolution
- Three-dimensional data

LASER SCANNING



Data Collection

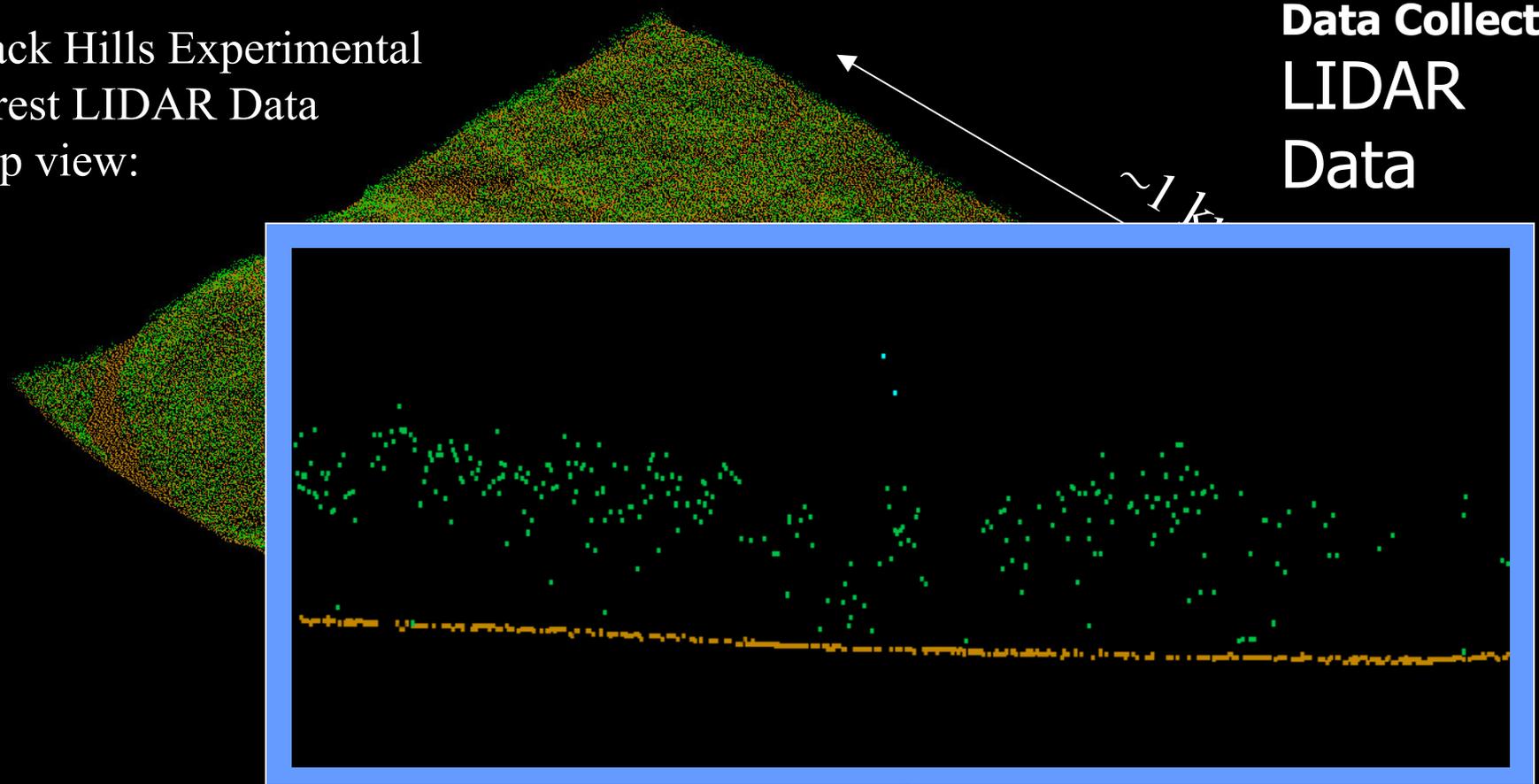
LIDAR Returns



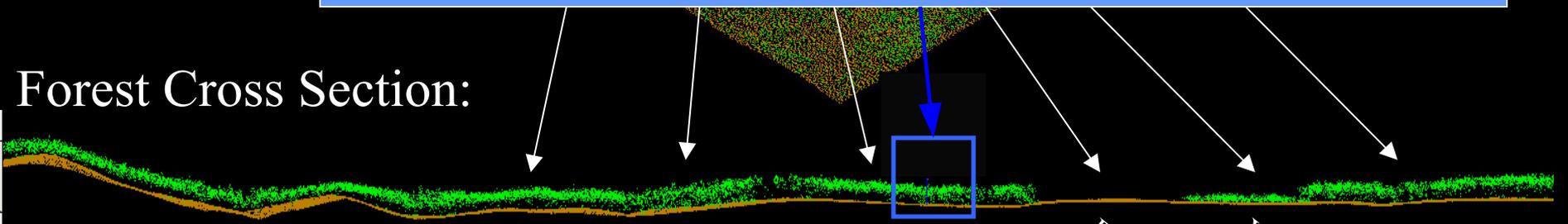
- +/- 30 cm foot print
- Detect a return every 5 meters or 20 nanoseconds
- Up to 5 returns per pulse

Black Hills Experimental
Forest LIDAR Data
map view:

Data Collection
LIDAR
Data



Forest Cross Section:



KEY:
Brown=ground returns
Green=canopy returns

Closed canopy monolayer forest
Closed canopy Multi-layer forest
Research Tower
Forest clearing
Young stand
Closed canopy monolayer forest

E. Rowell and L. Vierling

Data Processing

- Transect data were subdivided into 10x10 m plots and co-registered with the IKONOS-derived endmember fraction data and LIDAR tree response percentage data (analyze 52 plots in four transects)
- LIDAR tree response percentage
= $\text{tree response} / (\text{tree response} + \text{ground response})$
- A combination of panchromatic data and LIDAR data was used to select image endmembers

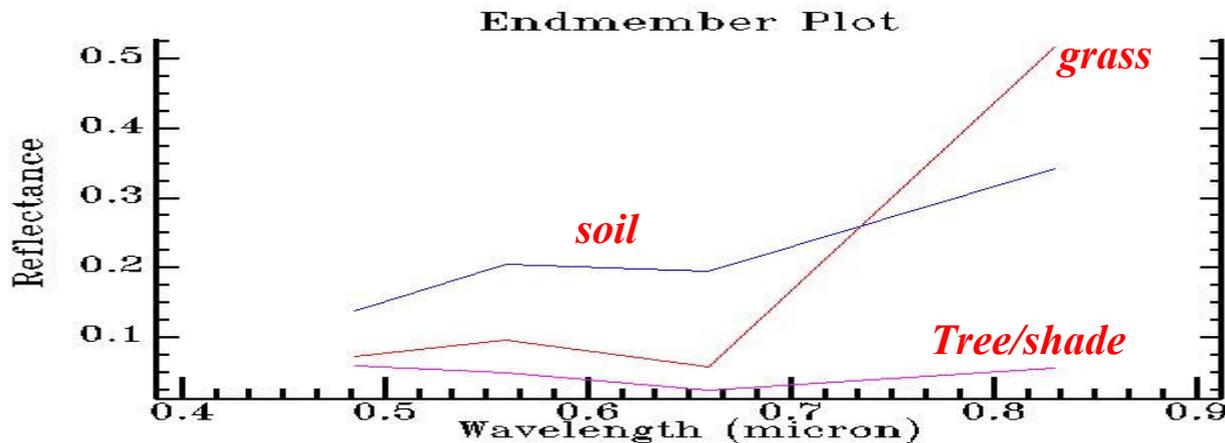
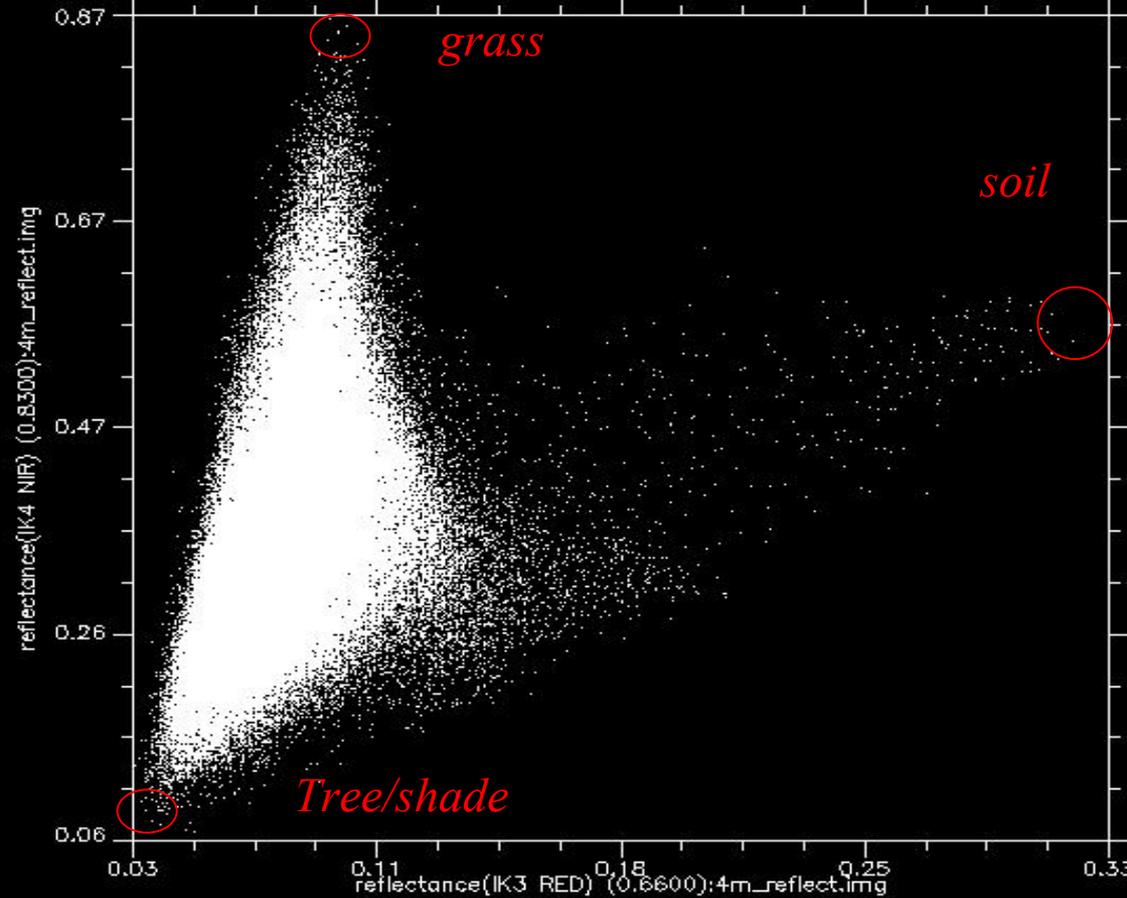
Data Processing

- Spectral Linear Unmixing using 4 m resolution IKONOS imagery, integrated 30 m resolution IKONOS imagery, and ETM⁺ imagery.
(Solar top-of-atmosphere irradiance parameters for IKONOS were obtained by running MODTRAN)
- LIDAR data were converted into 1 m resolution raster data using nearest neighborhood method to use for vegetation index and scale problem analyses.

Data Processing

Endmembers

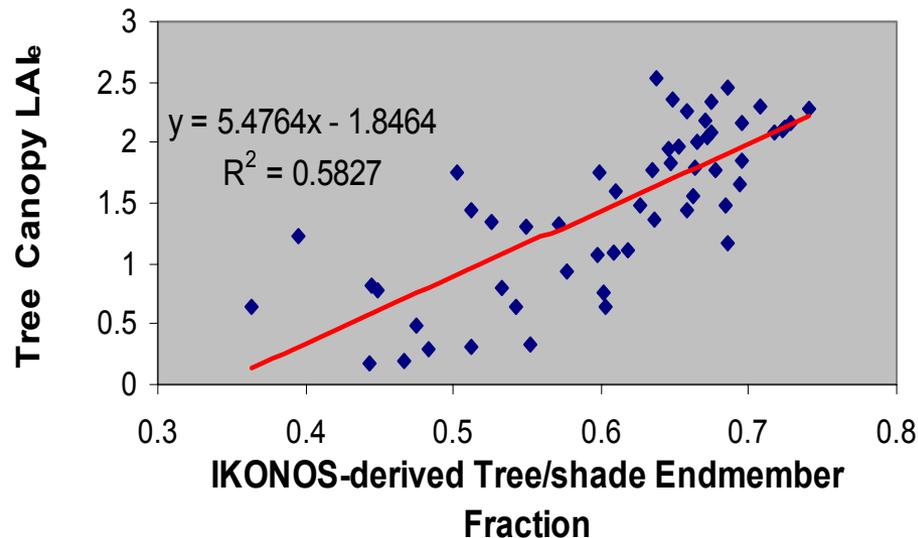
- Combine Panchromatic image and LIDAR raster image to find real endmembers
- Different image had different endmembers



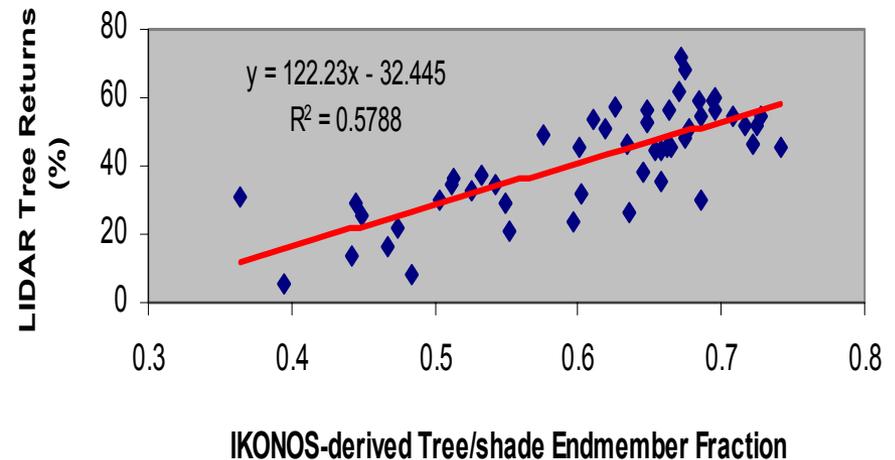
Analyses and Results

- Is the IKONOS-derived tree/shade endmember really measuring trees?

Effective Tree Canopy LAI and IKONOS-derived Tree/shade Endmember Fraction



LIDAR Vegetation Response and IKONOS-derived Tree/shade Endmember Fraction

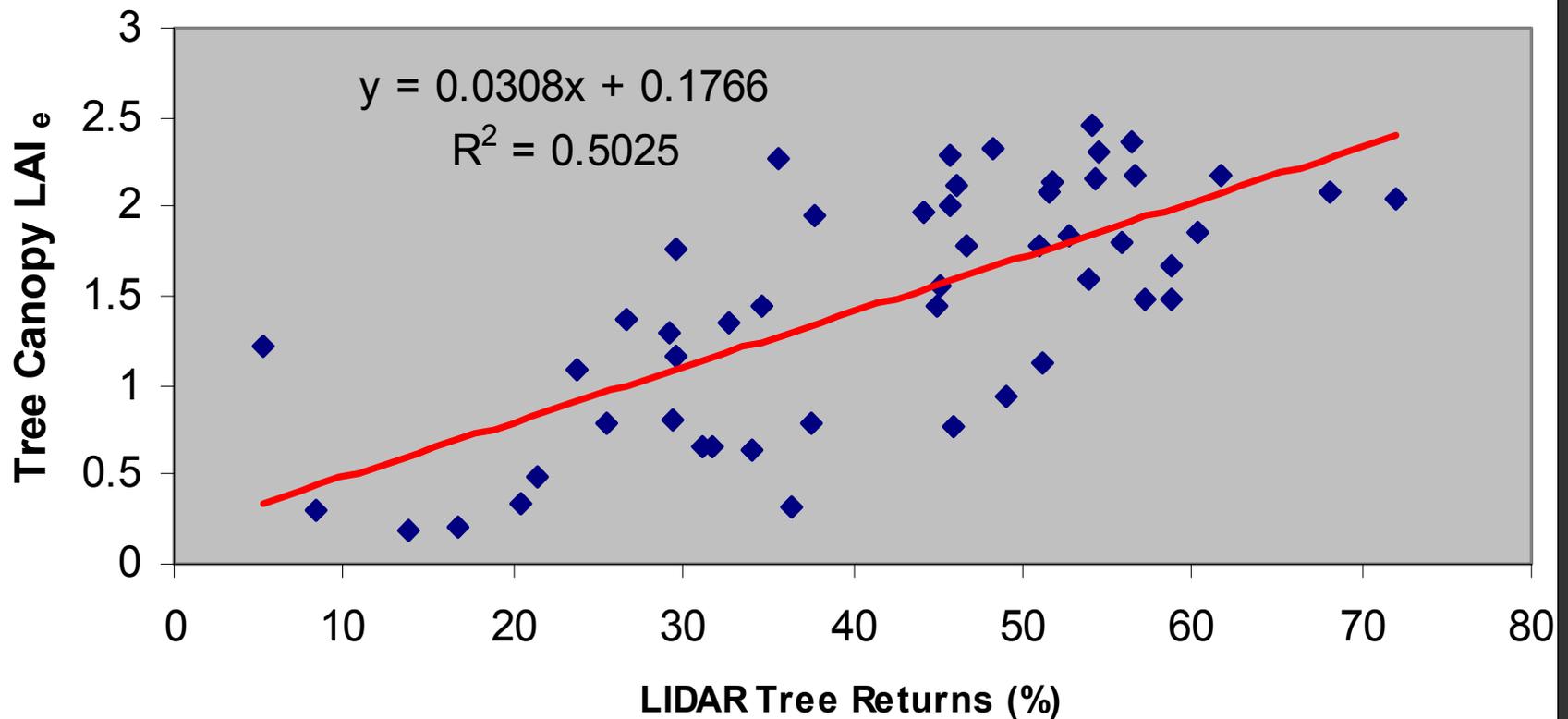


Pearson's correlation coefficient is 0.76

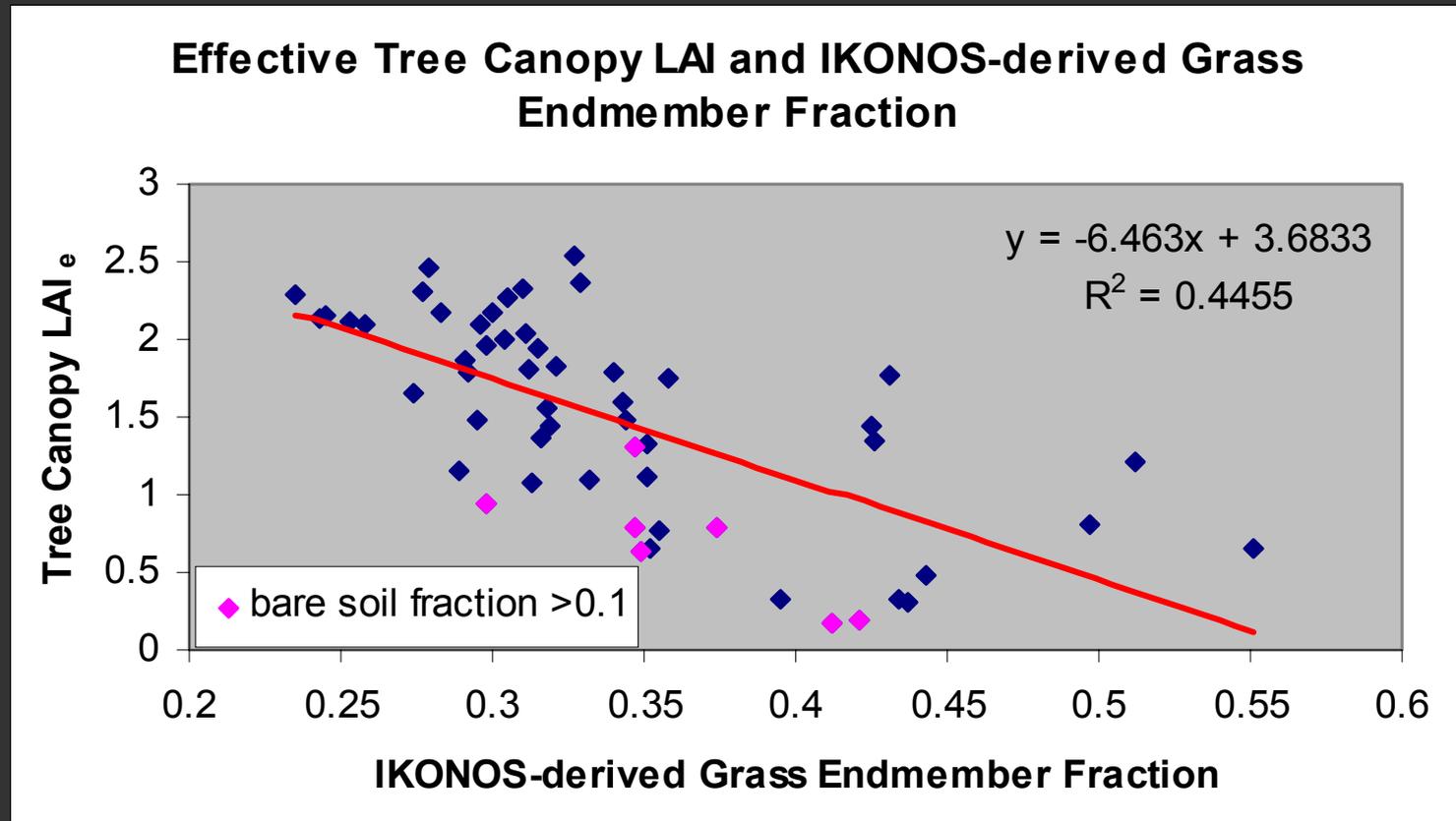
Pearson's correlation coefficient is 0.76

Pearson's correlation coefficient is 0.71

Effective Tree Canopy LAI and LIDAR Vegetation Response



Is the IKONOS-derived grass fraction really measuring grass?



Pearson's correlation coefficient is -0.67

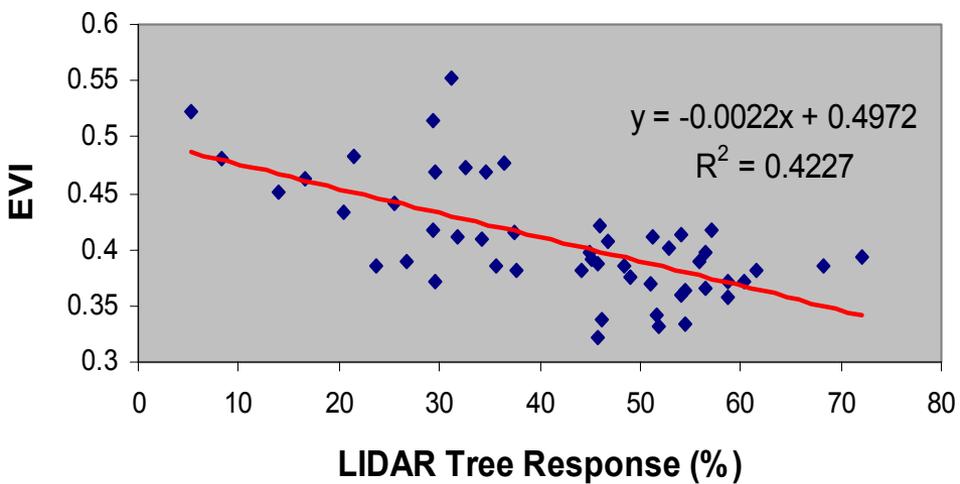
EVI (Enhanced Vegetation Index)

$$EVI = G * \frac{\rho(\lambda_{NIR}) - \rho(\lambda_{red})}{\rho(\lambda_{NIR}) + C_1 \rho(\lambda_{red}) - C_2 \rho(\lambda_{blue}) + L}$$

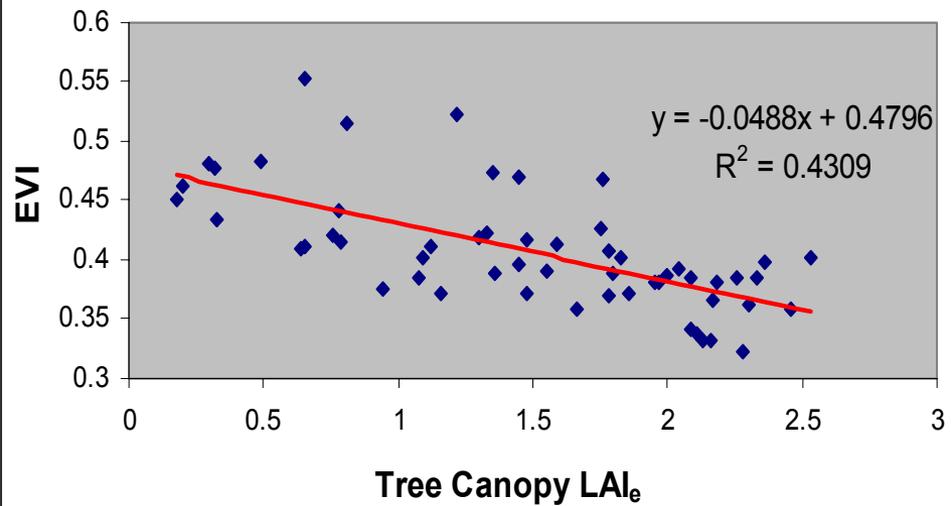
Use the parameters suggested by Huete et al.
(1997, Remote Sensing of Environment, 59, 440-451)

EVI is negatively correlated to the tree coverage

EVI and LIDAR Tree Response

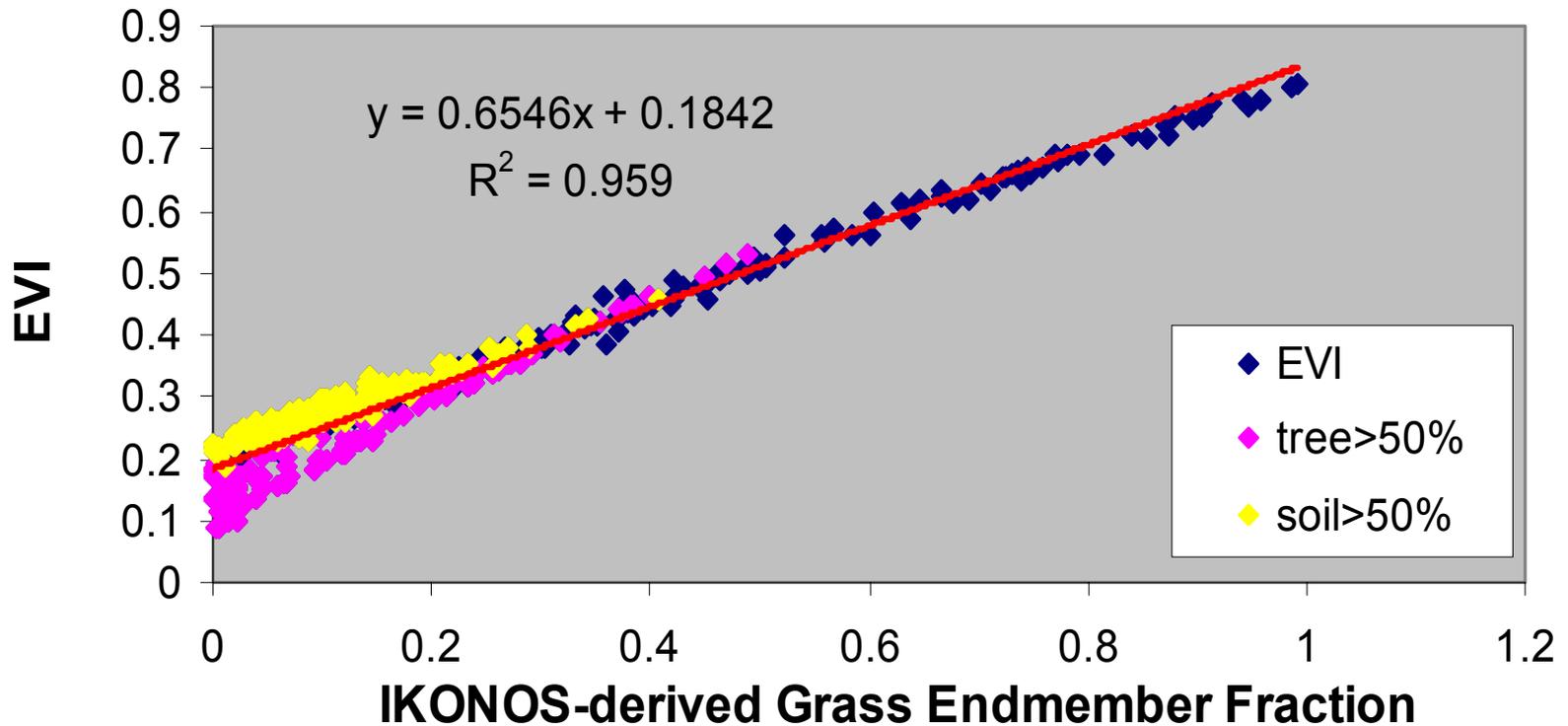


EVI and Effective Tree Canopy LAI



How does EVI relate to the vegetation within a pixel?

EVI and IKONOS-derived Grass Endmember Fraction



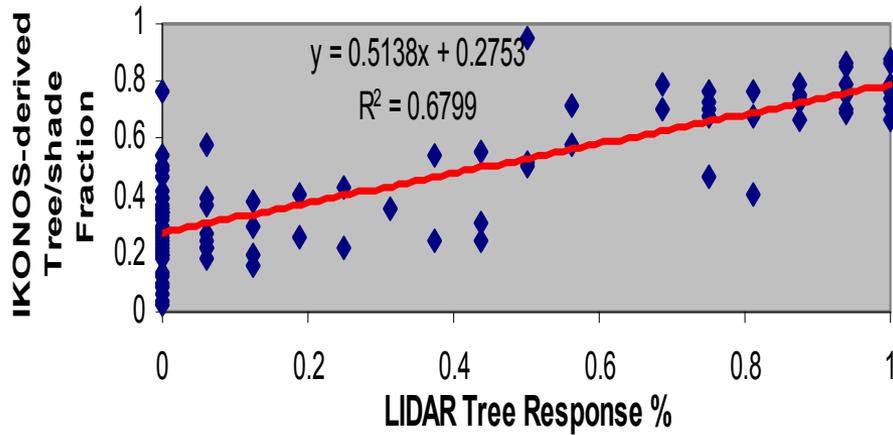
Scale problem

Can a coarse resolution image do as good a job as a high resolution image in spectral linear unmixing?

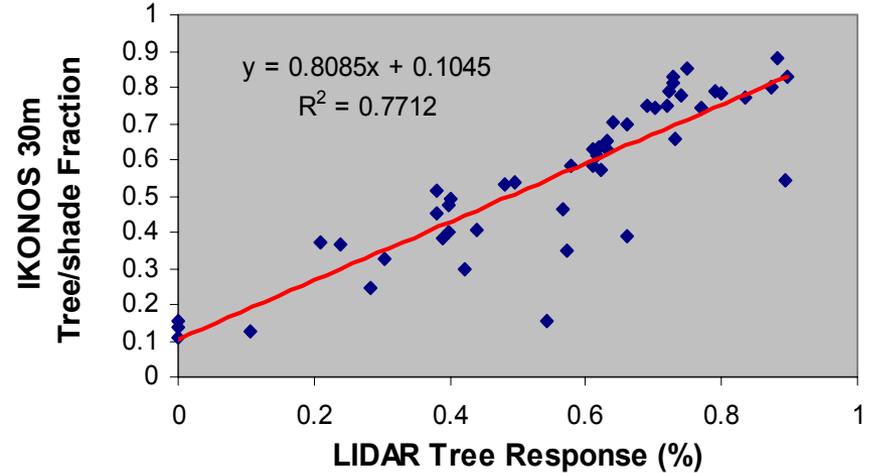
- IKONOS image was shifted 2-10 m from LIDAR raster data
- LIDAR and IKONOS data were co-georegistered to improve overlay

- How does the scale affect the ability to derive forest parameters using IKONOS imagery?

4m IKONOS

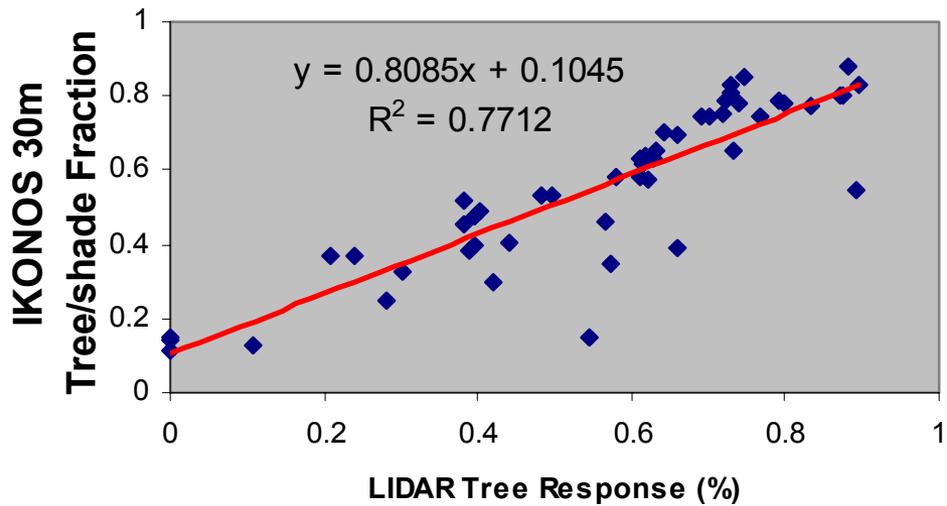


Integrated 30m IKONOS

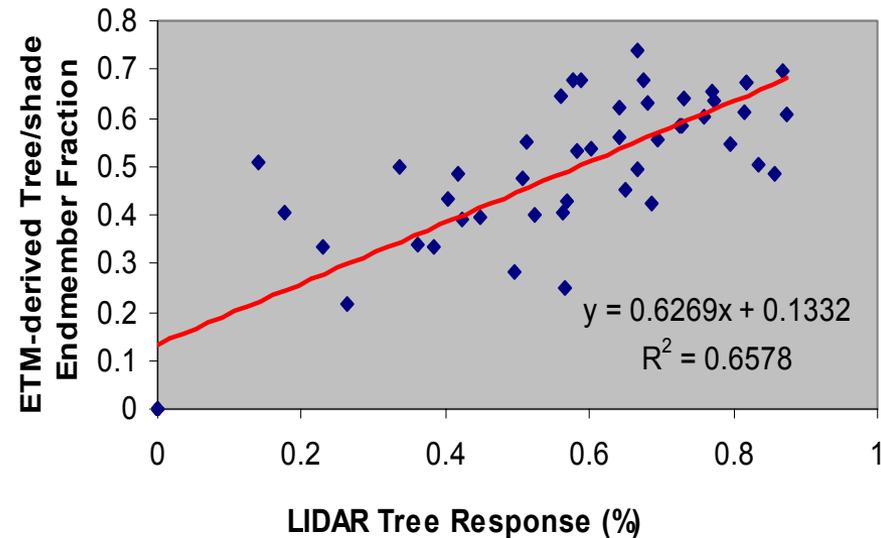


How does 30-meter integrated IKONOS perform relative to 30-meter Landsat ETM+ imagery?

Integrated 30m IKONOS



ETM+ 30m Data



Conclusion (in the study site)

- IKONOS data can serve to make the important distinction between tree canopy coverage and exposed understory grasses near peak summertime greenness.
- EVI is more sensitive to grass fraction than tree fraction within a pixel.
- Georegistration of IKONOS needs improvement before analyzing forest structure at 4 m scale.
- Landsat ETM⁺ estimates of subpixel forest cover compare well to 30 m integrated IKONOS data.