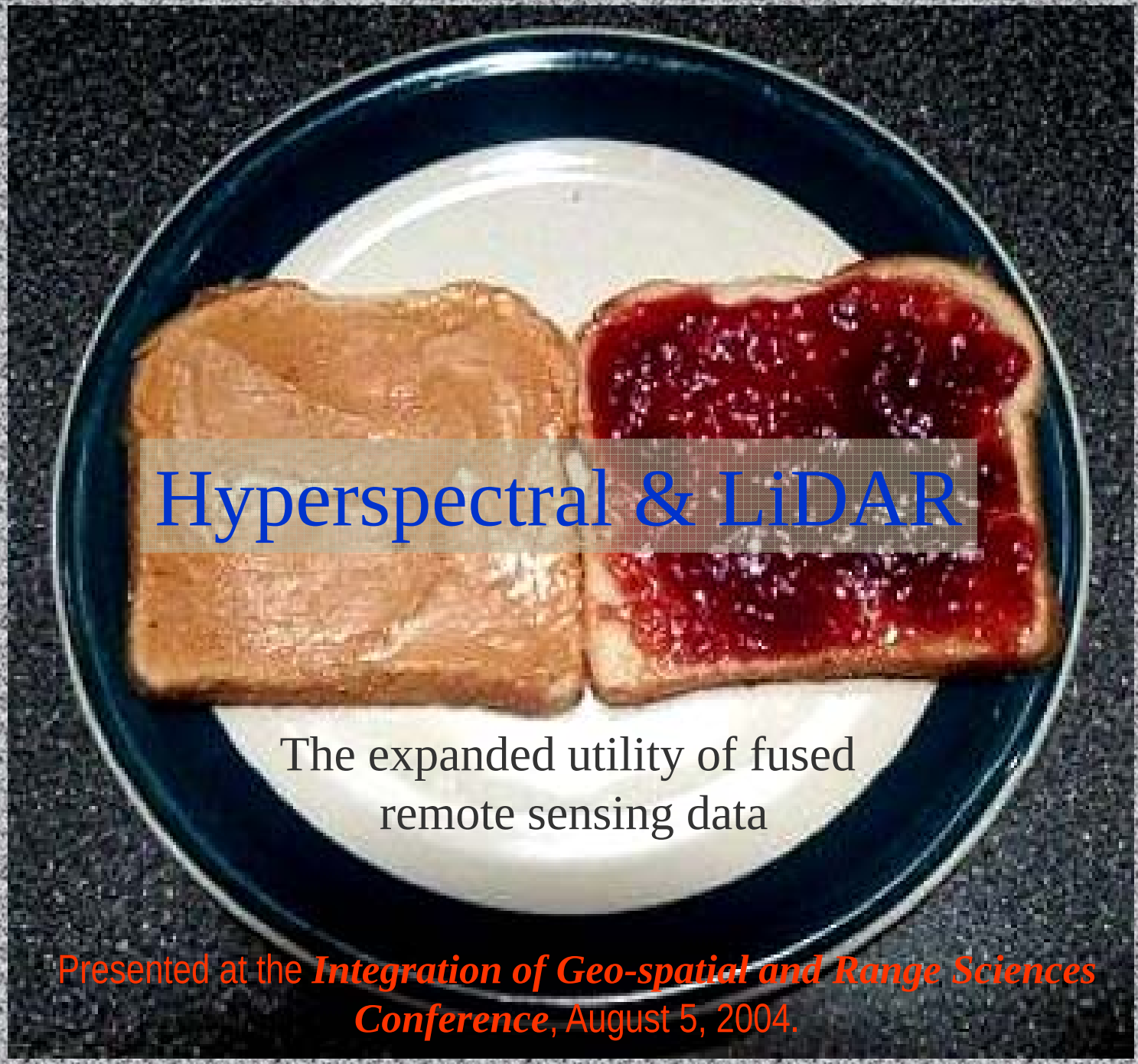
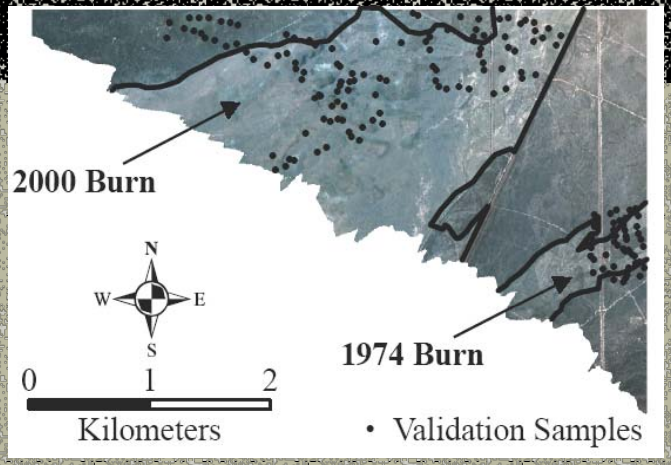


Hyperspectral & LiDAR

The expanded utility of fused remote sensing data

Presented at the ***Integration of Geo-spatial and Range Sciences Conference***, August 5, 2004.

Outline



- Introduction
- Coregistration
  - Warping, error assessment, and resampling
- Fusion
  - Stacking and products
- Results and Benefits
- Conclusions and Future Work

Two Sensors = Two Outputs

Hyperspectral

- Passive reflectance
- Distribution map for sagebrush

LiDAR Products

- Active laser pulse data
- Stand structure descriptions

Objectives

Benefits:
Increase accuracy
Better stand descriptions

Challenges:
Geometric accommodation
Spatial relationships
Data relationships

Study Objective: To apply the output from both classifications to make a more comprehensive product

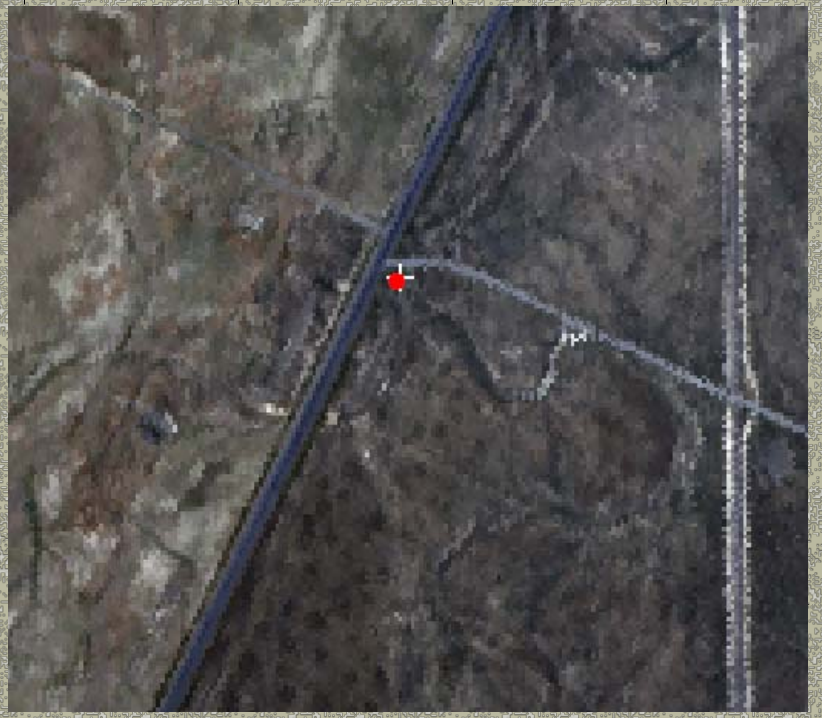
Coregistration - Overview

The process of assigning exactly the same spatial properties to two images such that when overlain, the pixels in each image represent exactly the same feature.

- Warping
  - Aligns data spatially
- Assess residual errors
  - Not accommodated by the warp
- Data resampling
  - to ‘absorb’ the residual error

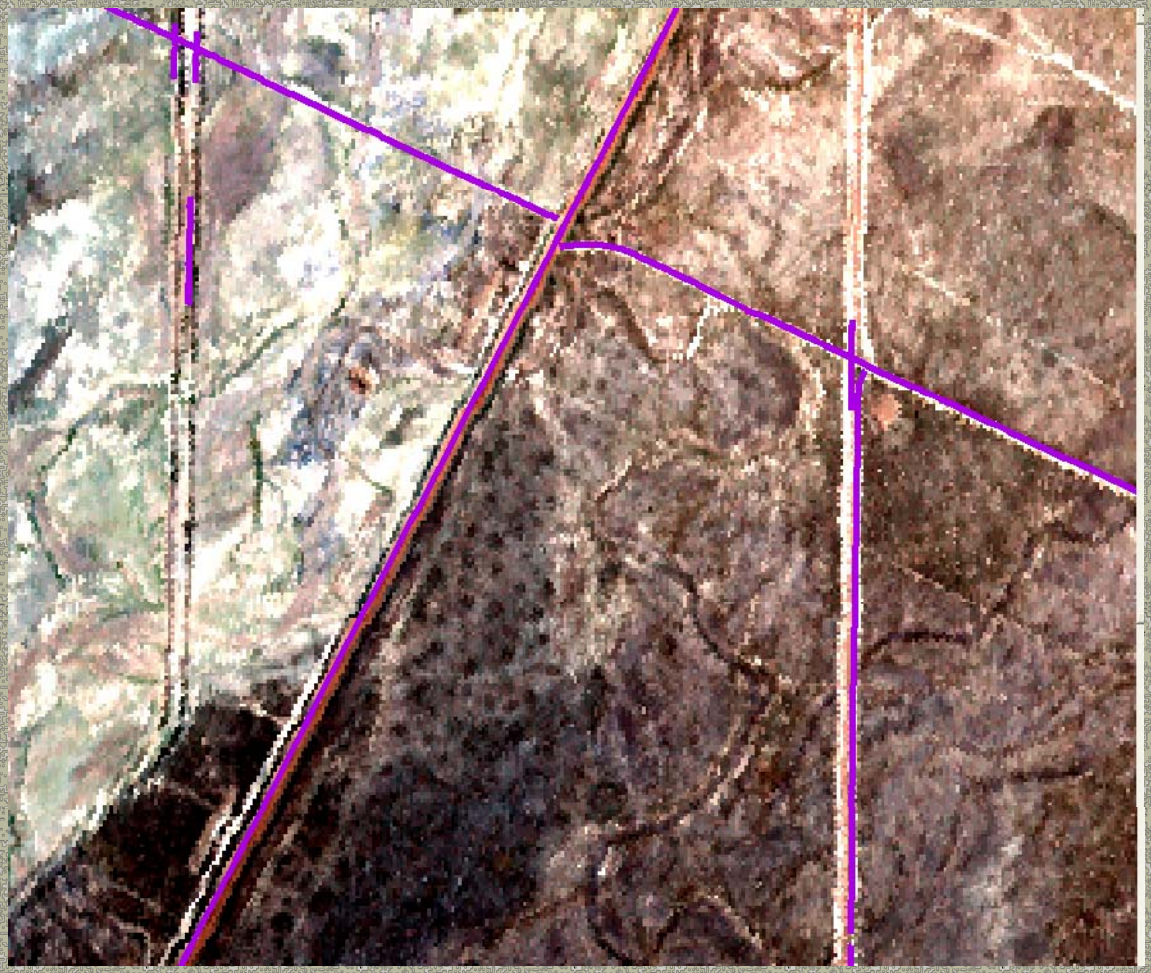
Warping

- Offset of 20 m (HyMap)
- Warp to 16 GCP



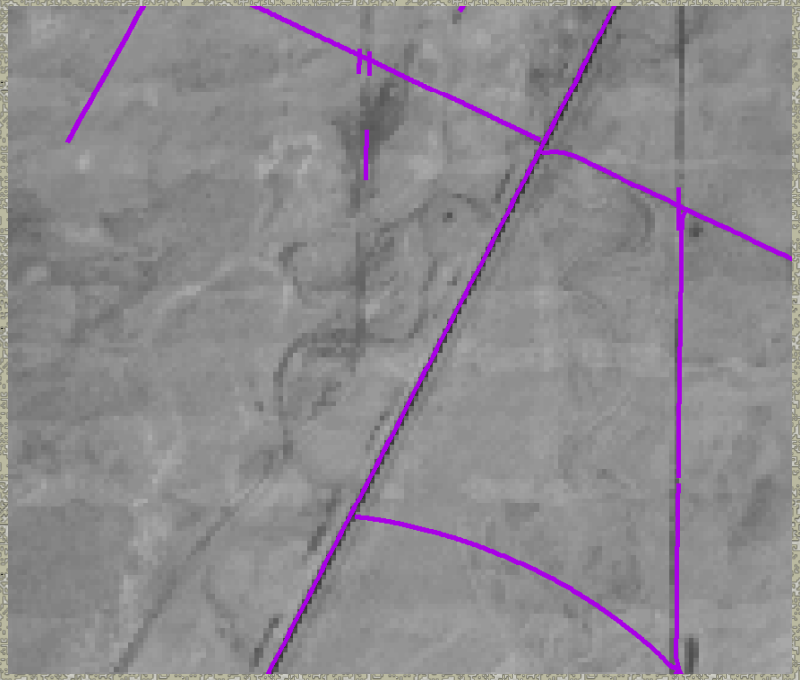
Assessment of Residual Geometric Error

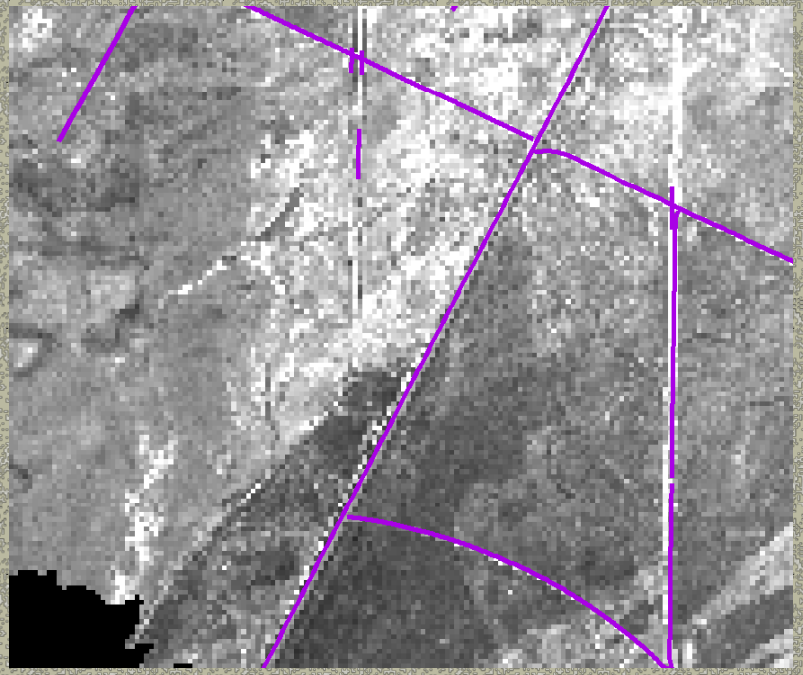
- 9 control points
- Re = 11.5 m (3m stdev)



Data Resampling

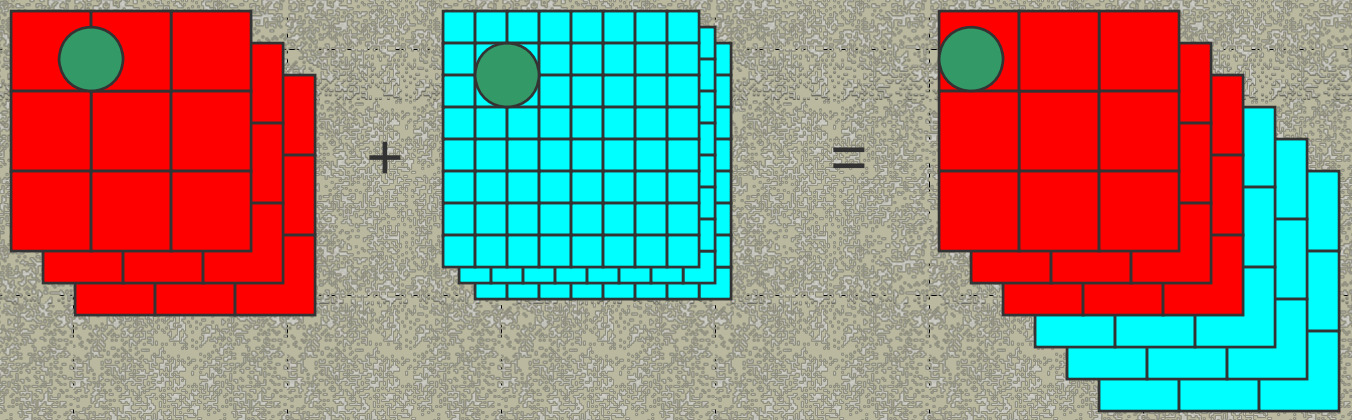
- Resampled to 13.8 m (3 hyperspectral pixels)
- No discernable residual error
- Both datasets coregistered to GPS data

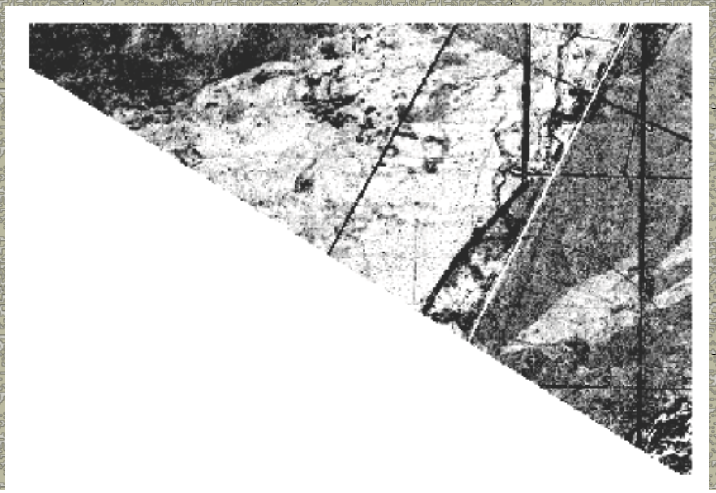


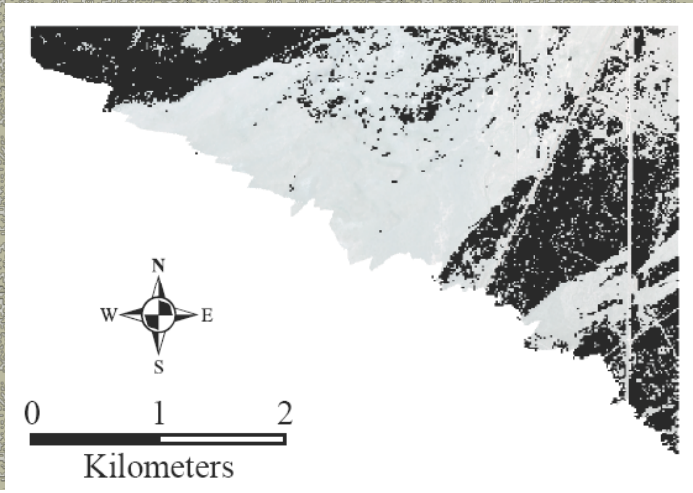


Fusion - Overview

Fusion -a merging of diverse, distinct, or separate elements into a unified whole



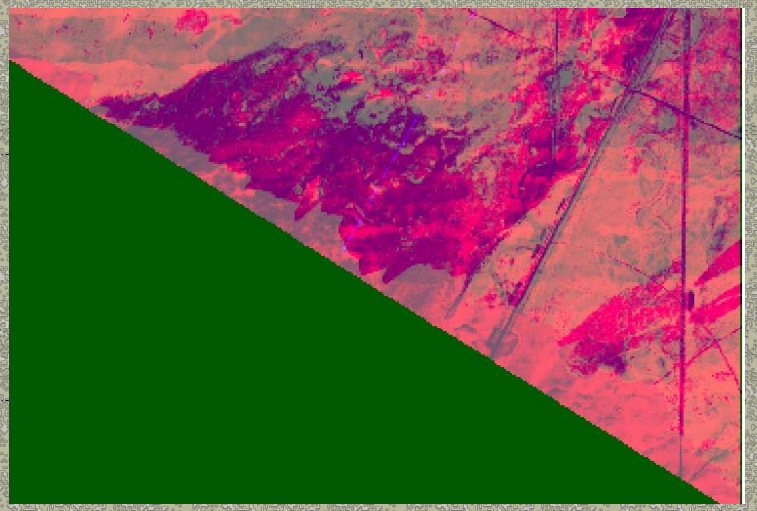




Fused Product

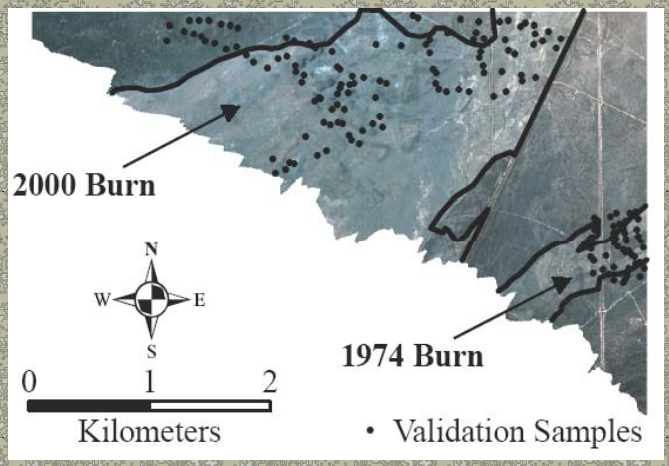
12 Band Product

- MTMF classification (2)
- Hyperspectral Reflectance (4)
- LiDAR Intensity
- LiDAR Roughness
- LiDAR Mean Heights (2)
- LiDAR Tallest Vegetation
- LiDAR Percent Bare Soil



Hypothesis

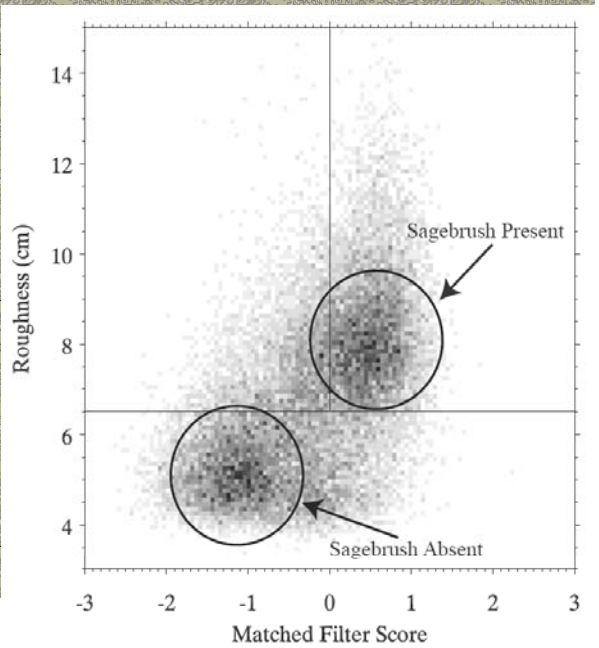
LiDAR variables can enhance classification accuracy and stand structure descriptions.



	Sagebrush Absent	*Sagebrush Present*
Mean (cm)	7.0	9.1
Median (cm)	5.8	8.1
Integer Mode (cm)	5	8
Standard Deviation (cm)	4.5	3.6
Number of Samples	88	64
F - Statistic	1.57	
F - Critical	1.48	
P	0.03	

Results – Enhanced Accuracies

Hyperspectral alone ~75%
LiDAR alone ~60%
Fused products ~ 89%



Classification Strategy	Producer's Accuracy	User's Accuracy	Overall Accuracy
MF greater than 0	91%	64%	75%
MF greater than 0 AND Infeasibility less than 7	72%	75%	74%
MF greater than 0 AND Roughness between 6.5 and 75	88%	86%	87%
MF greater than 0 AND Infeasibility less than 7 AND Roughness between 6.5 and 75	84%	92%	89%

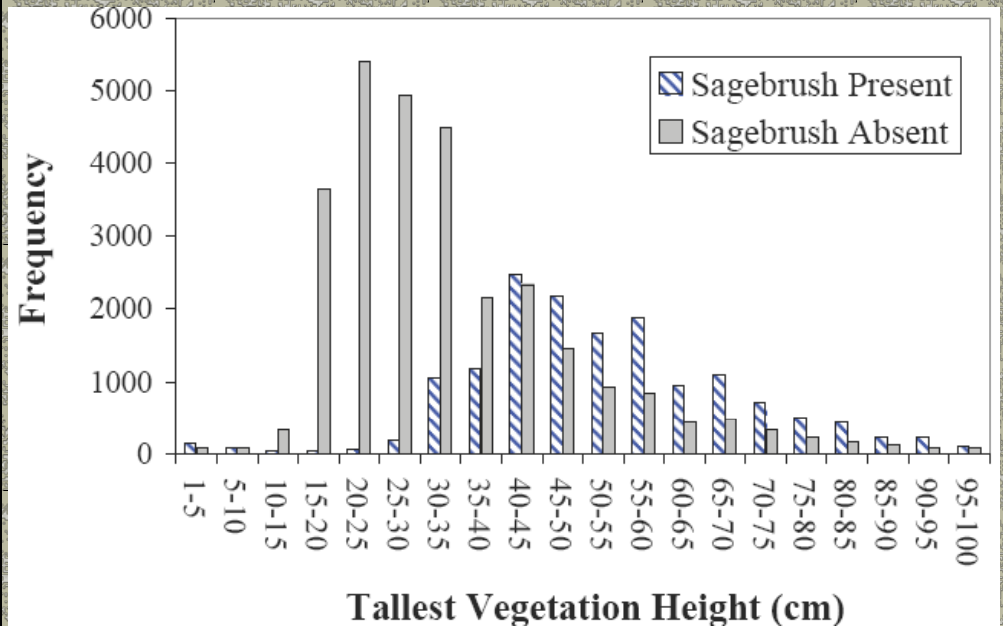
Results - Stand Structure Descriptions

- Statistically separable populations
- Greater understanding of vegetative structure
- Quantifiable results at very high resolution
- Higher quality obtainable than just using field measurements

	Mean	Median	Standard Deviation	F-Statistic (F_{crit}= 1.02)
Mean Pixel Height (cm)	7.8 / 9.6	7.1 / 9.2	3.5 / 2.8	1.52
Mean Vegetation Height (cm)	10.0 / 11.9	9.0 / 11.3	4.2 / 3.2	1.72
Percent Bare Soil	7.0 / 19.4	6.0 / 18.2	4.5 / 4.3	2.50
Roughness (cm)	6.8 / 9.2	5.9 / 8.5	3.8 / 3.5	1.17
Tallest Vegetation (cm)	34.1 / 53.2	30.0 / 51.0	15.2 / 16.4	1.17

Results - Histograms

- Relatively homogeneous stands
- Tallest vegetation representative of dominant shrub height
- Histograms represent field area well



Conclusions

- Remote sensing mapped rangelands more efficiently than field surveys.
- Multi sensor remote sensing data fusion increases the ability to describe rangeland systems.
- Increased accuracy by 14%.
- Generates robust products useful in further analyses.

Future Work

- Develop methods to measure biomass, including detailed stand structure maps.
- Refine measures of (hyperspectral) target abundance and vegetation heights (LiDAR).
- Develop methods to evaluate ecosystem health.
- Implement products into management strategy (*e.g.* forage capacity and range conservation).

Questions?

Acknowledgements

This work was supported by the Idaho National Environmental and Engineering Laboratory (INEEL) through the Idaho State University - INEEL Partnership for Integrated Environmental Analysis Education Outreach Program. We are also thankful to Ron Rope, Shane Cherry, and Tanya Johnson for field and office assistance.