Fusion Of Hyperspectral And LiDAR Models
Characterizing
Semi-arid Vegetation (Sagebrush)

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Outline of Presentation

• Study Area and Data
• Hyperspectral Data and Analysis
• LiDAR Data and Analysis
• Product Fusion
• Conclusions
• Questions
Study Area

- Reduced vegetation cover
- Spectrally ‘intermediate’
- Dry
- Abundant litter and dry grass
- Increased soil exposure
- Soil variability
- Non-linear mixing
Data

Hyperspectral (HyMap 3.5m pixels)

Field GPS

LiDAR
(Airborne 1 – 1.2 m postings)
Objectives

• To effectively map the distribution of sagebrush.
• Applications to range management and habitat inventory.
• To constrain potential difficulties and benefits of utilizing high resolution remote sensing data in a semiarid environment.
"Sagebrush"

‘*Artemisia tridentata*’ or mixed ecosystem?
Hyperspectral Processing

• Spectral subsets
• Different endmembers
• Classification strategy
• Interpretative assessment
Hyperspectral Results

Producer’s Accuracy = 91%
User’s Accuracy = 64%
Total Accuracy = 75%

Sagebrush Classification Error Matrix

<table>
<thead>
<tr>
<th>Classified</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>Absent</td>
<td>Present</td>
</tr>
</tbody>
</table>
LiDAR Processing
LiDAR Results

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

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

Polynomial Resampling to 16 GCPs

Residual Error of 11.5 m (9 ICPs) – Local Variance

Resampled to 13.8 m (3 hyperspectral pixels)
Fused (Coregistered) 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
Fusion Hypothesis

LiDAR variables can enhance classification accuracy and stand structure descriptions.

<table>
<thead>
<tr>
<th></th>
<th>Sagebrush Absent</th>
<th>Sagebrush Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (cm)</td>
<td>7.0</td>
<td>9.1</td>
</tr>
<tr>
<td>Median (cm)</td>
<td>5.8</td>
<td>8.1</td>
</tr>
<tr>
<td>Integer Mode (cm)</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Standard Deviation (cm)</td>
<td>4.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Number of Samples</td>
<td>88</td>
<td>64</td>
</tr>
<tr>
<td>F - Statistic</td>
<td></td>
<td>1.57</td>
</tr>
<tr>
<td>F - Critical</td>
<td></td>
<td>1.48</td>
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<tr>
<td>P</td>
<td></td>
<td>0.03</td>
</tr>
</tbody>
</table>
## Fusion Results

<table>
<thead>
<tr>
<th>Classification Strategy</th>
<th>Producer’s Accuracy</th>
<th>User’s Accuracy</th>
<th>Overall Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF greater than 0</td>
<td>91%</td>
<td>64%</td>
<td>75%</td>
</tr>
<tr>
<td>MF greater than 0 AND Feasibility less than ?</td>
<td>72%</td>
<td>75%</td>
<td>74%</td>
</tr>
<tr>
<td>MF greater than 0 AND Roughness between 6.5 and 75</td>
<td>88%</td>
<td>86%</td>
<td>87%</td>
</tr>
<tr>
<td>MF greater than 0 AND Feasibility less than ? AND Roughness between 6.5 and 75</td>
<td>84%</td>
<td>92%</td>
<td>89%</td>
</tr>
</tbody>
</table>

![Plots showing frequency distribution of tallest vegetation height](image)

- **Sagebrush Present**
- **Sagebrush Absent**
Conclusions and Future Work

• Hyperspectral data has a demonstrated ability to discriminate rangeland vegetation and weeds.
• High spatial resolution data provides high spatial resolution maps for inventory and management decision support.
• Semiarid environments are difficult in the context of remote sensing, however intensive processing can result in a worthwhile product.
• The next generation: operational level implementation via focus areas and indicator plots.
Acknowledgements

This study was made possible by a grant from the National Aeronautics and Space Administration Goddard Space Flight Center (NAG5-2301). ISU would also like to acknowledge the Idaho Delegation for their assistance in obtaining this grant.

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Questions?

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