Leveraging multitemporal Landsat for soil and vegetation in semiarid environments: Fine tuning with LiDAR

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Many others: Jessica Mitchell, Carol Moore, Nagendra Singh, Lucas Spaete, ++
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Objectives

• Presence/absence
• Subpixel abundance
• Develop innovative approaches for semiarid vegetation & soil – sparse, spectrally indeterminate targets and mixed pixels
  – Multitemporal stacking
  – Fusing with LiDAR
Hyperspectral Analysis With Multitemporal Landsat
Cheatgrass

Cheatgrass

• Presence / absence
  – User’s accuracy: 82% / 64%
  – Overall accuracy: 77%

• Abundance
  – Overall accuracy: 61%
  – Two categories: low and high worked best
Leafy Spurge

Leafy Spurge

- **Presence / absence:**
  - Producer’s accuracy: 59% / 75%
  - Overall accuracy: 62%

- **HyMap TM simulation:**
  - Dependent upon cover >0% to 90%:
  - Producer’s accuracy: 63-83%
  - Overall accuracy: 72–93 %


NRCS Soil Survey

NRCS Soil Survey

• Landsat imagery can successfully detect basalt presence
• Selective band choices for multitemporal stack
• Focus on methods to detect lichen
  – Many basalt samples had > 80% lichen cover
• Further investigation needed to obtain more accurate subpixel abundance values
USFS: Aspen Change Detection

- Presence/absence, $R^2=0.49$, $p < 0.0001$
- NDVI approach (92% overall accuracy)
- Include LiDAR:
  - 9-13% increase in user’s accuracies
  - 5% increase in overall accuracy

Juniper Change Detection

A. Landsat
B. LiDAR
C. Fused – juniper presence 88% accurate

Comparison to 1965 juniper data: 85% juniper encroachment (corroborated with tree ring data)

Sankey, T.T., Glenn, N., Ehinger, S., Boehm, A., Hardegree, S., Characterizing western juniper (Juniperus occidentalis) expansion via a fusion of Landsat TM5 and LiDAR data. Rangeland Ecology and Management (in press).
Landsat & LiDAR

- Presence / absence works well for semiarid vegetation and soil
- Small geographic areas (minimize variability and noise) + local endmembers provide best results
- Large geographic areas = spectral confusion with areas such as ag/riparian areas – different endmembers and user intensive for success
- Similar trend, worse results with subpixel abundances
- Overcome challenges with data integration of airborne LiDAR
Sankey, T.T., Glenn, N., Ehinger, S., Boehm, A., Hardegree, S., Characterizing western juniper (Juniperus occidentalis) expansion via a fusion of Landsat TM5 and LiDAR data. Rangeland Ecology and Management (in press).
BCAL LiDAR Analysis Tools

Open source
Works in ENVI or IDL
Robust, well tested in low height vegetation environments


http://bcal.geology.isu.edu/Envitools.shtml
Bare Earth Validation

Spaete et al., Vegetation and slope effects on accuracy of a LiDAR-derived DEM in the sagebrush steppe (in review).
LiDAR Height Classes – 3 m pixels

Sankey, T.T., Glenn, N., Ehinger, S., Boehm, A., Hardegree, S., Characterizing western juniper (Juniperus occidentalis) expansion via a fusion of Landsat TM5 and LiDAR data. Rangeland Ecology and Management (in press).
Sagebrush – 3 m pixels

Individual Sagebrush on Slopes

Shrub Crown Area

- Point cloud – elliptical area
- Field area underestimated by 49%

Shrub Crown Area

- Point cloud data – TIN
- Underestimated by 33%

Conclusions

- Landsat works well for presence/absence classification
  - Comprehensive veg-soil analysis in semiarid environments
- Important to leverage:
  - multitemporal Landsat
  - decadal scale data for change detection (e.g. aspen and juniper)
- Challenging for subpixel abundance measurements
  - Endmember variation, noise, spectral confusion
- Integration of LiDAR derivatives provides improvement on presence/absence as well as subpixel abundance
  - Provides a complimentary scale to Landsat
  - Can be used for targeted areas until nationwide data are available
Conclusions

• Hyperspectral provides important validation data

• Future Landsat:
  – Improved SNR will provide regional monitoring for semiarid vegetation and soil
    • Low cover detection
    • Many new research opportunities
Fire Severity

- Tested multiple indices for fire severity using pre- and post-burn data
- Best index for fire severity was RdNBR (73% overall accuracy)

\[
\text{RdNBR} = \frac{\text{dNBR}}{\sqrt{\text{NBR}_{\text{pre-fire}}}}
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# Leafy Spurge

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<th>Spencer HyMap using MTMF</th>
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<th>Entire Landsat 5 TM image using SAM and transformed input bands</th>
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