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

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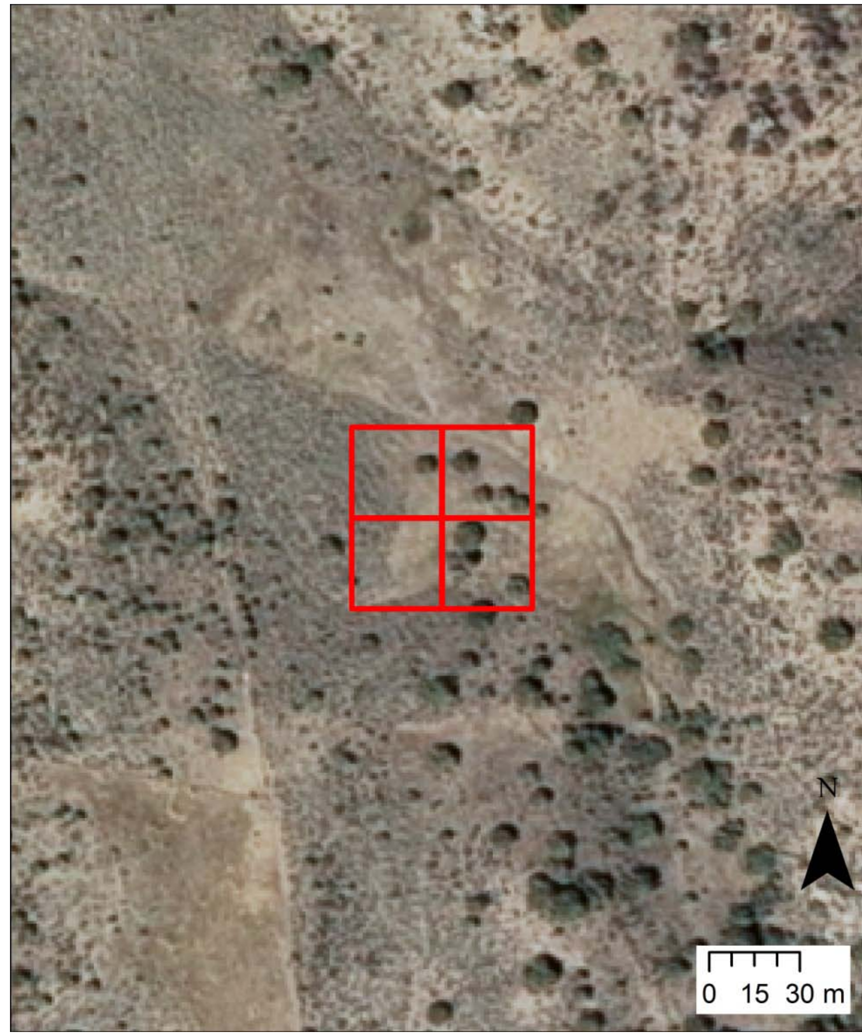
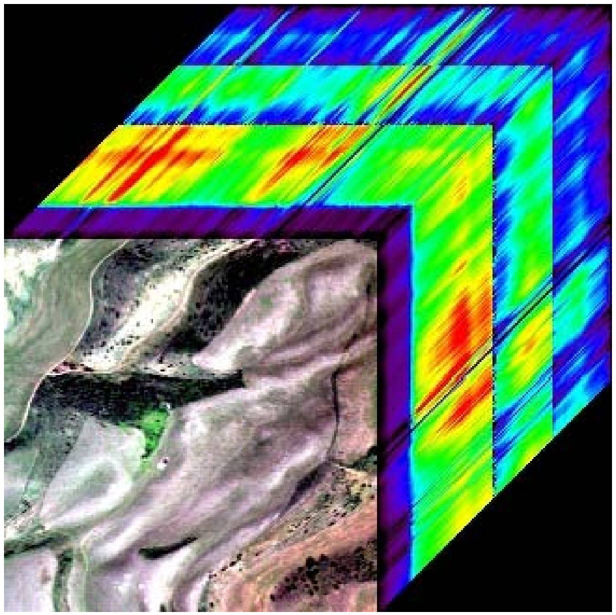
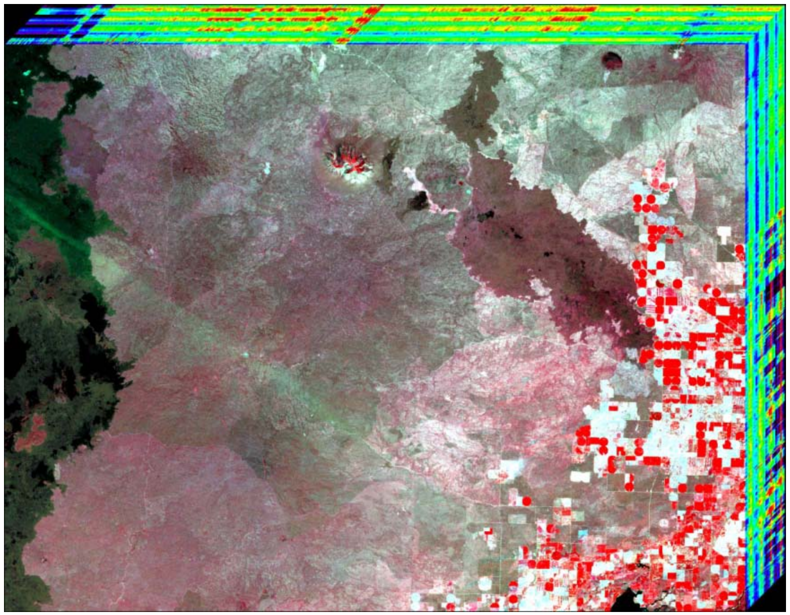
Objectives

- Presence/absence
- Subpixel abundance
- Develop innovative approaches for semiarid vegetation & soil – sparse, spectrally indeterminate targets and mixed pixels
  - Multitemporal stacking
  - Fusing with LiDAR

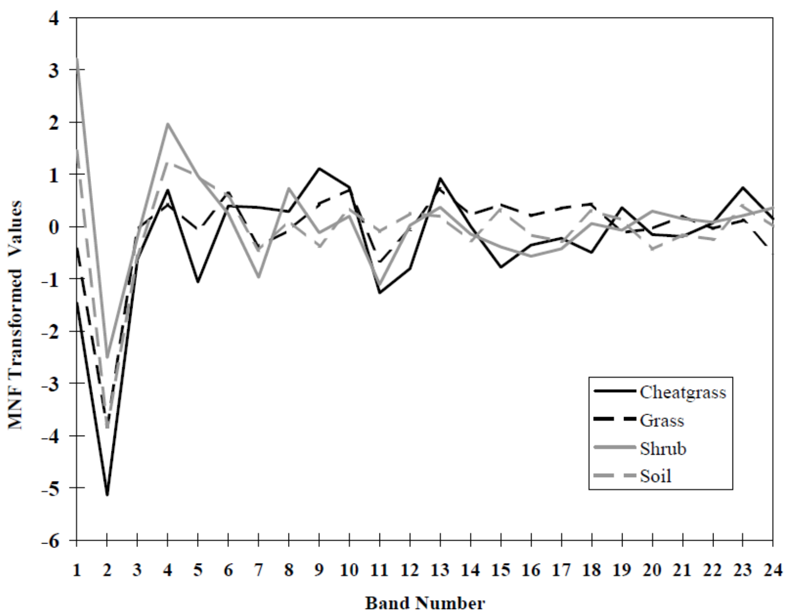


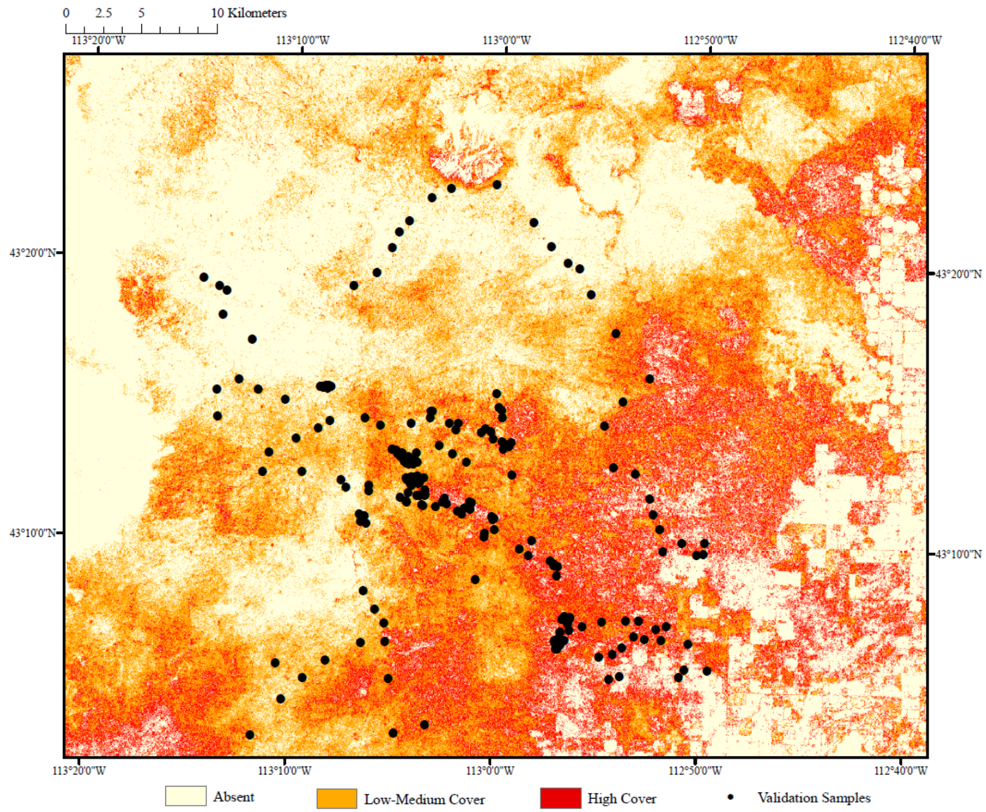
Hyperspectral Analysis With Multitemporal Landsat





Cheatgrass



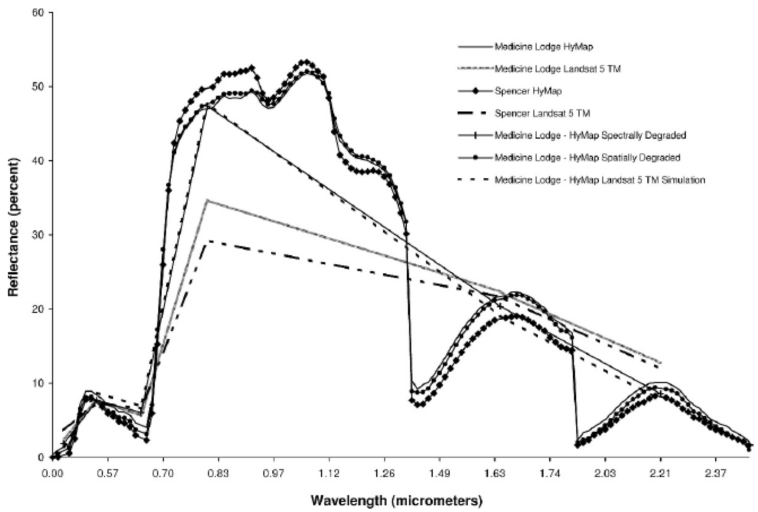


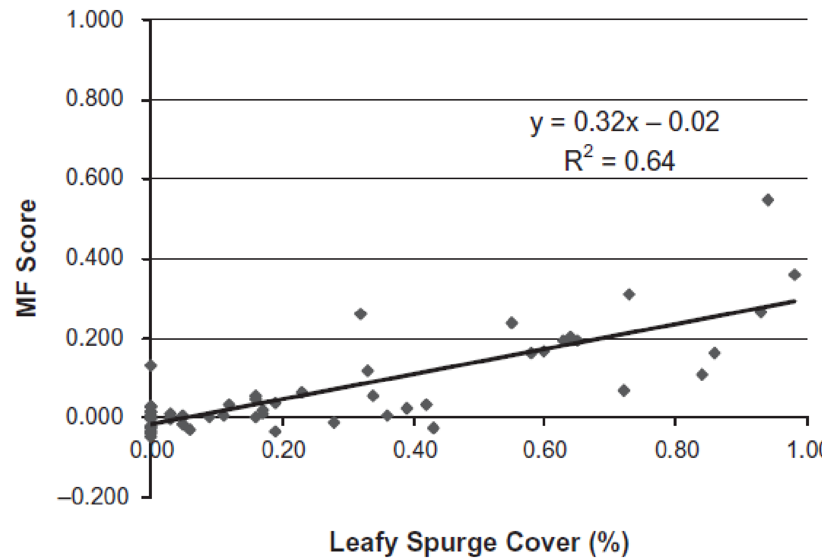
Singh, N., and Glenn, N.F., 2009, Multitemporal spectral analysis for cheatgrass (*Bromus tectorum*) classification, International Journal of Remote Sensing, 30 (13): 3441 – 3462.

Cheatgrass

- Presence / absence
  - User's accuracy: 82% / 64%
  - Overall accuracy: 77%
- Abundance
  - Overall accuracy: 61%
  - Two categories: low and high worked best

Leafy Spurge



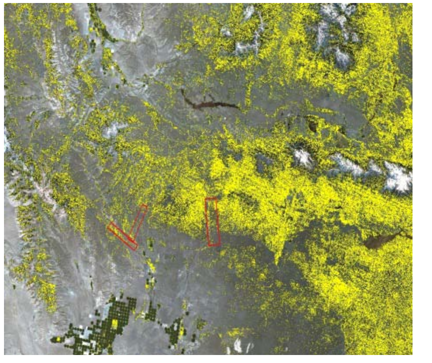


Mitchell, J., and Glenn, N.F., 2009. Leafy Spurge (Euphorbia esula L.) Classification Performance Using Hyperspectral and Multispectral Sensors, Rangeland Ecology & Management, 62

Mitchell, J., and Glenn, N.F., 2009, Matched filtering subpixel abundance estimates in mixture-tuned matched filtering classifications of leafy spurge (Euphorbia esula L.), International Journal of Remote Sensing, 30 (23)

Leafy Spurge

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

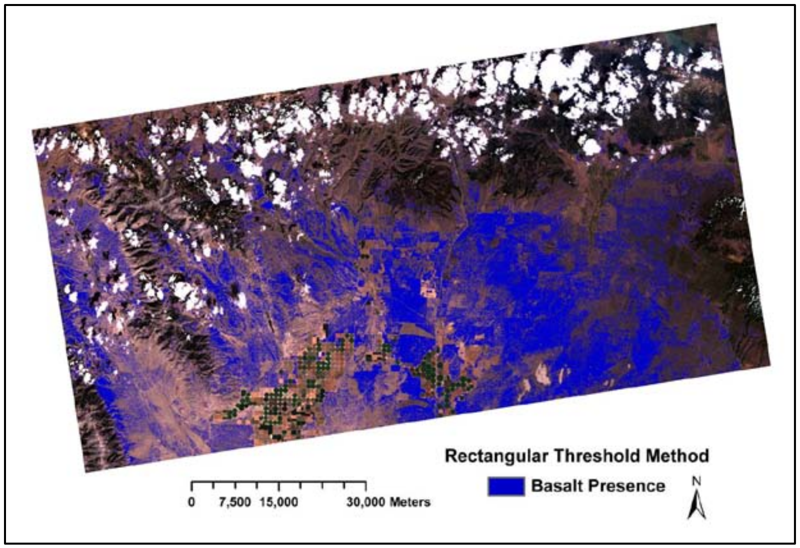


- HyMap TM simulation:
  - Dependent upon cover >0% to 90%:
  - Producer's accuracy: 63-83%
  - Overall accuracy: 72–93 %

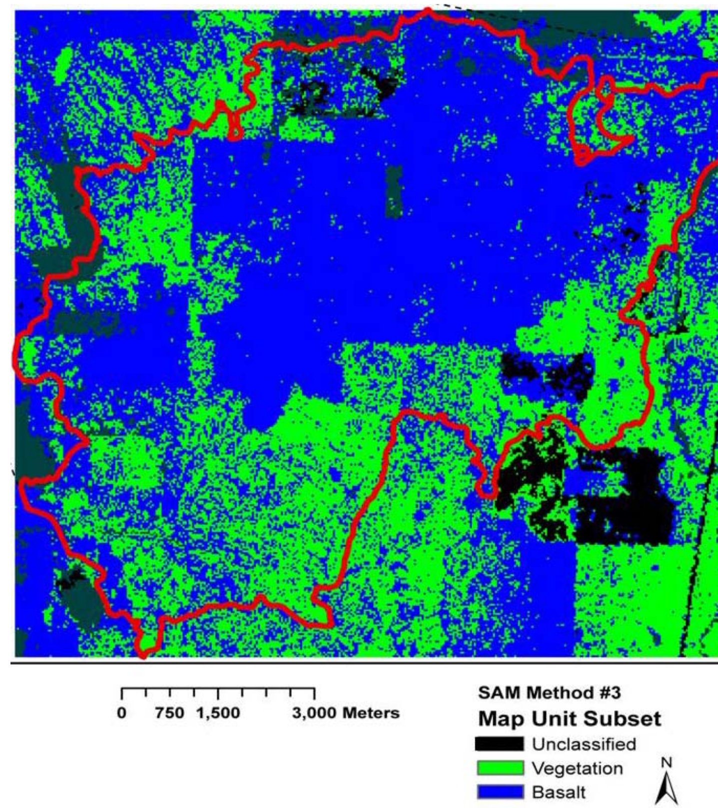
Mitchell, J., and Glenn, N.F., 2009. Leafy Spurge (Euphorbia esula L.) Classification Performance Using Hyperspectral and Multispectral Sensors, Rangeland Ecology & Management, 62

Mitchell, J., and Glenn, N.F., 2009, Matched filtering subpixel abundance estimates in mixture-tuned matched filtering classifications of leafy spurge (Euphorbia esula L.), International Journal of Remote Sensing, 30 (23)

NRCS Soil Survey



67% Accuracy



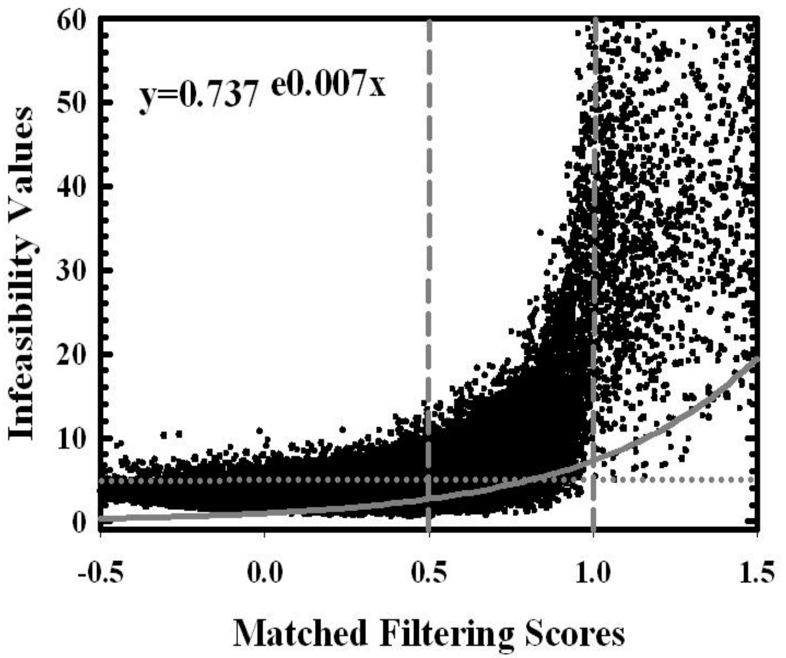
70% Accuracy

Moore, C., Hoffman, G., Glenn, N., 2007. Quantifying Basalt Rock Outcrops in NRCS Soil Map Units Using Landsat-5 Data. Soil Survey Horizons, 48: 59–62.

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

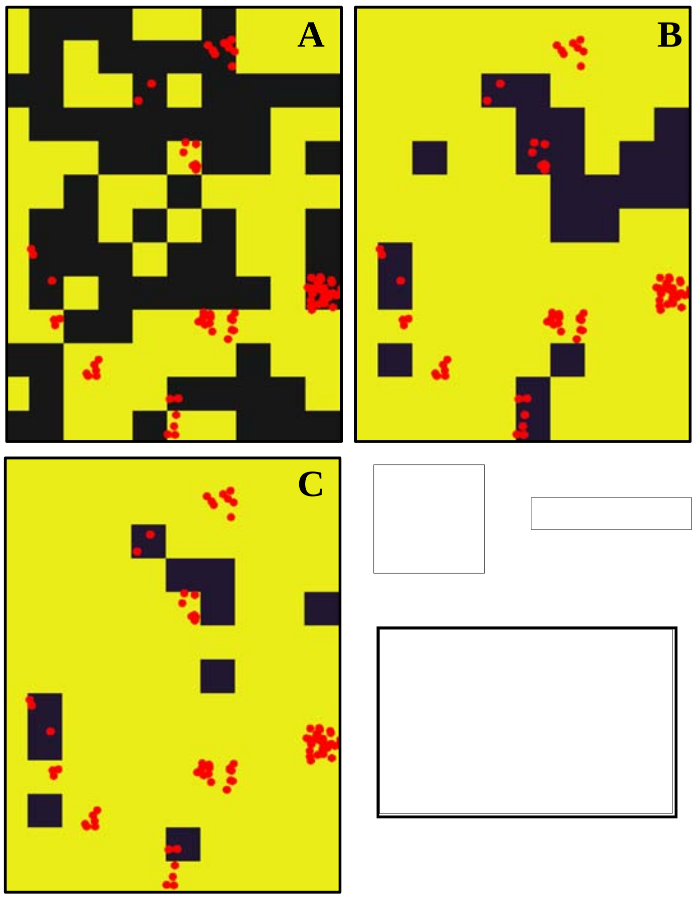


- Presence/absence, R^2=0.49, p < 0.0001
- NDVI approach (92% overall accuracy)
- Include LiDAR:
  - 9-13% increase in user's accuracies
  - 5% increase in overall accuracy

Sankey, T.T. 2009. Regional assessment of aspen change and spatial variability on decadal time scales. Remote Sensing 1:896-914.

Sankey, T.T. Decadal-scale aspen change detection using Landsat 5 TM and lidar data. Applied Vegetation Science (in review).

Juniper Change Detection



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

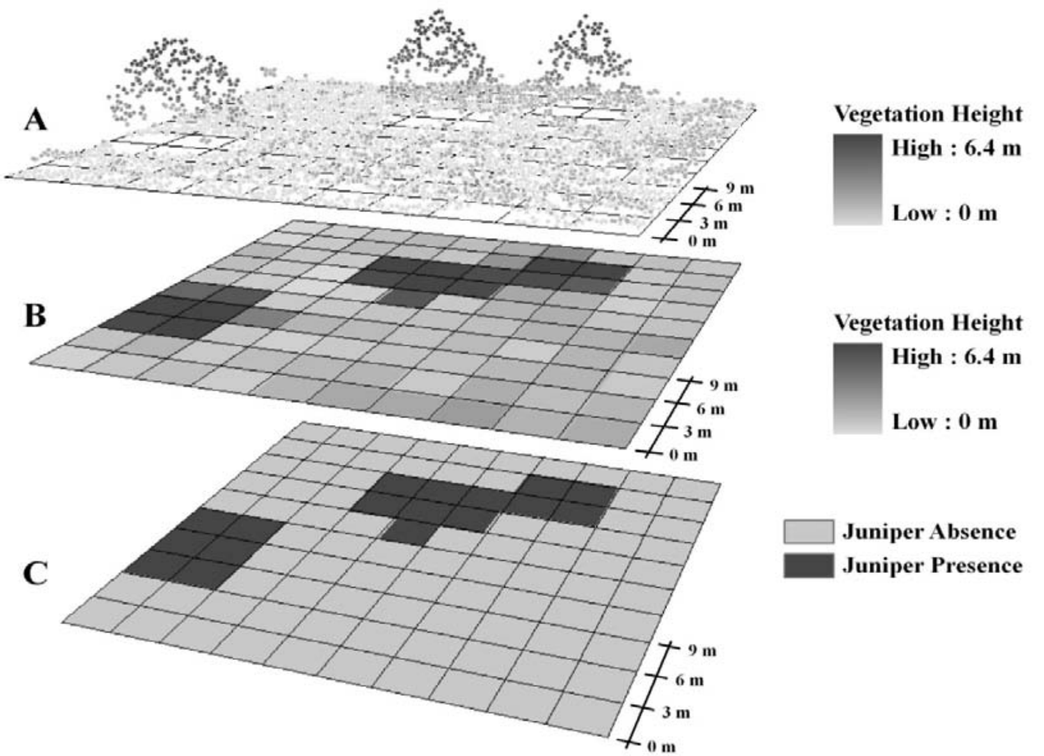
Comparison to 1965 juniper data: 85% juniper encroachment (corroborated with tree ring data)

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

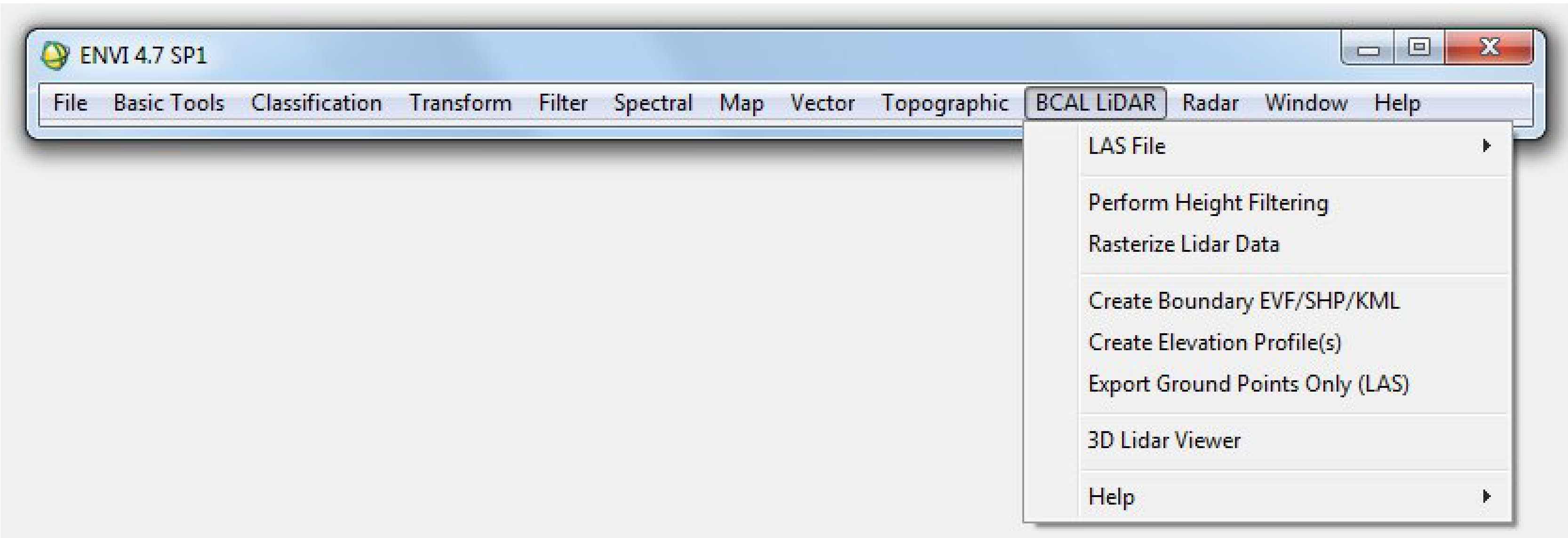
- Presence / absence works well for semiarid vegetation and soil
- Small geographic areas (minimize variability and noise) + local endmembers provide best results
- Large geographic areas = spectral confusion with areas such as ag/riparian areas
  - different endmembers and user intensive for success
- Similar trend, worse results with subpixel abundances
- Overcome challenges with data integration of airborne LiDAR

Juniper



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

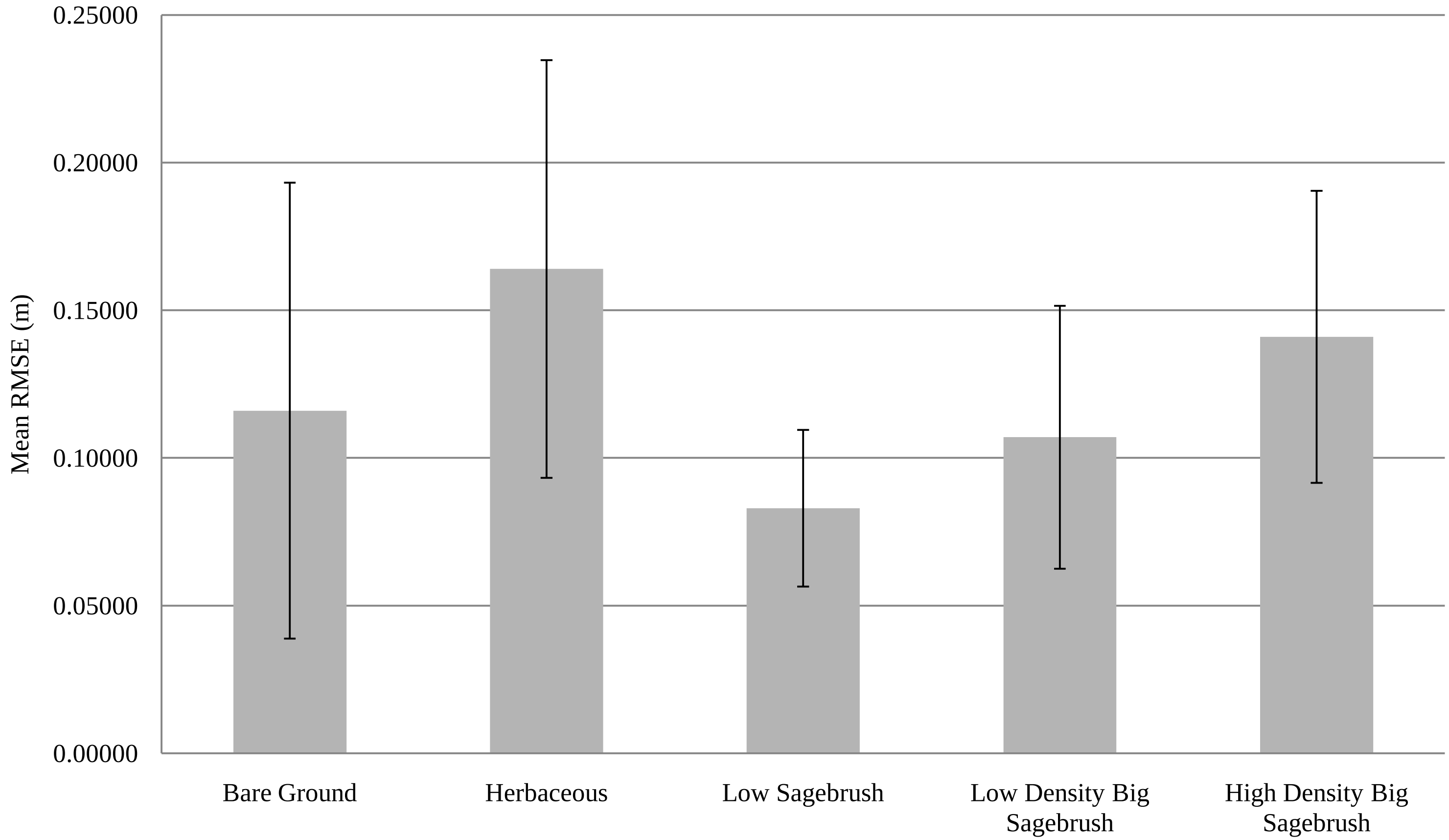


http://bcal.geology.isu.edu/Envitools.shtml

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

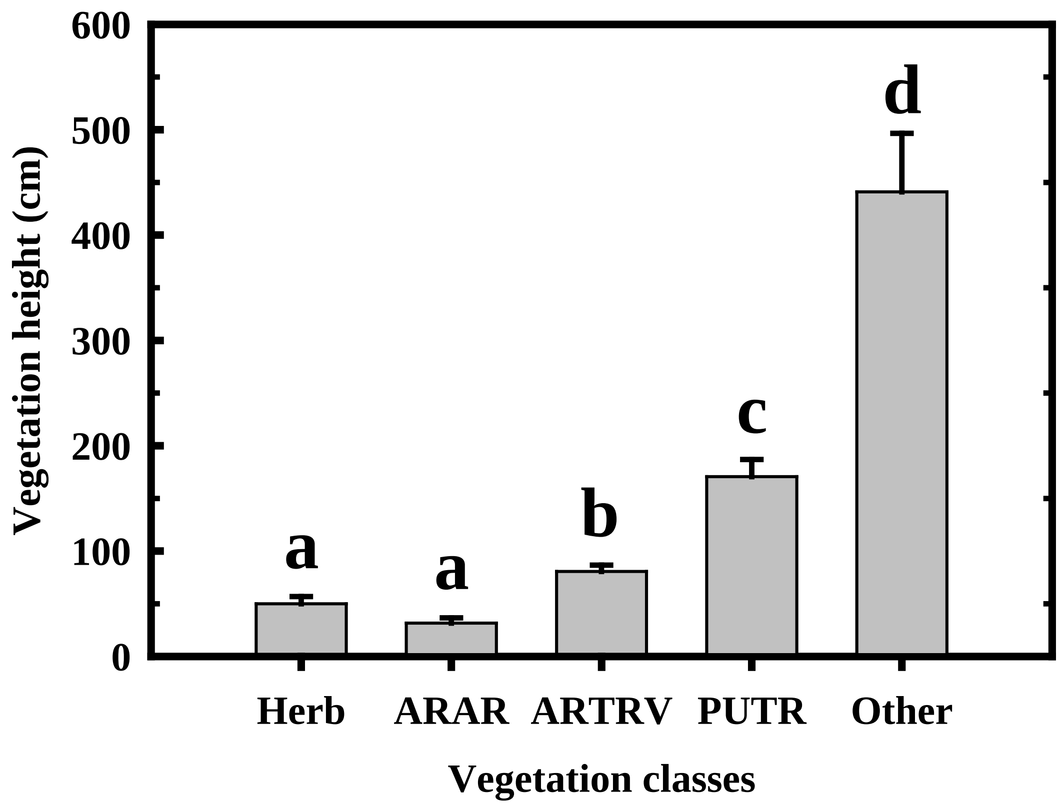
Streutker, D.R., Glenn, N.F, 2006. LiDAR measurement of sagebrush steppe vegetation heights. Remote Sensing of Environment, 102, 135-145.

Bare Earth Validation



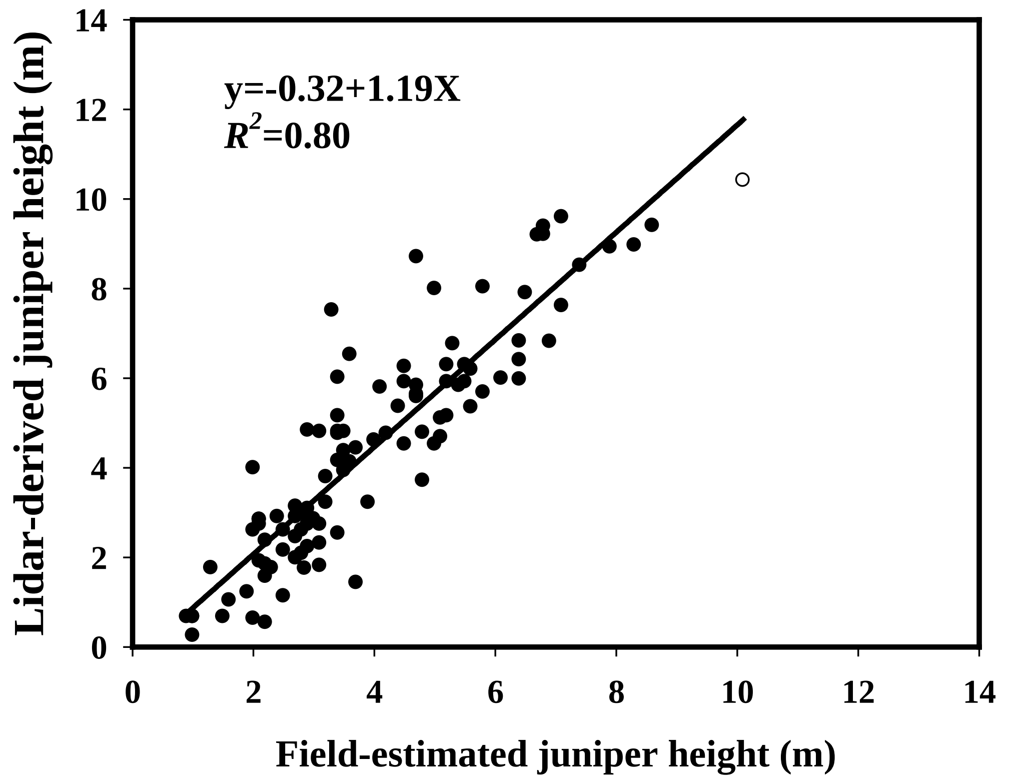
Spaete et al., Vegetation and slope effects on accuracy of a LiDAR-derived DEM in the sagebrush steppe (in review).

LiDAR Height Classes – 3 m pixels



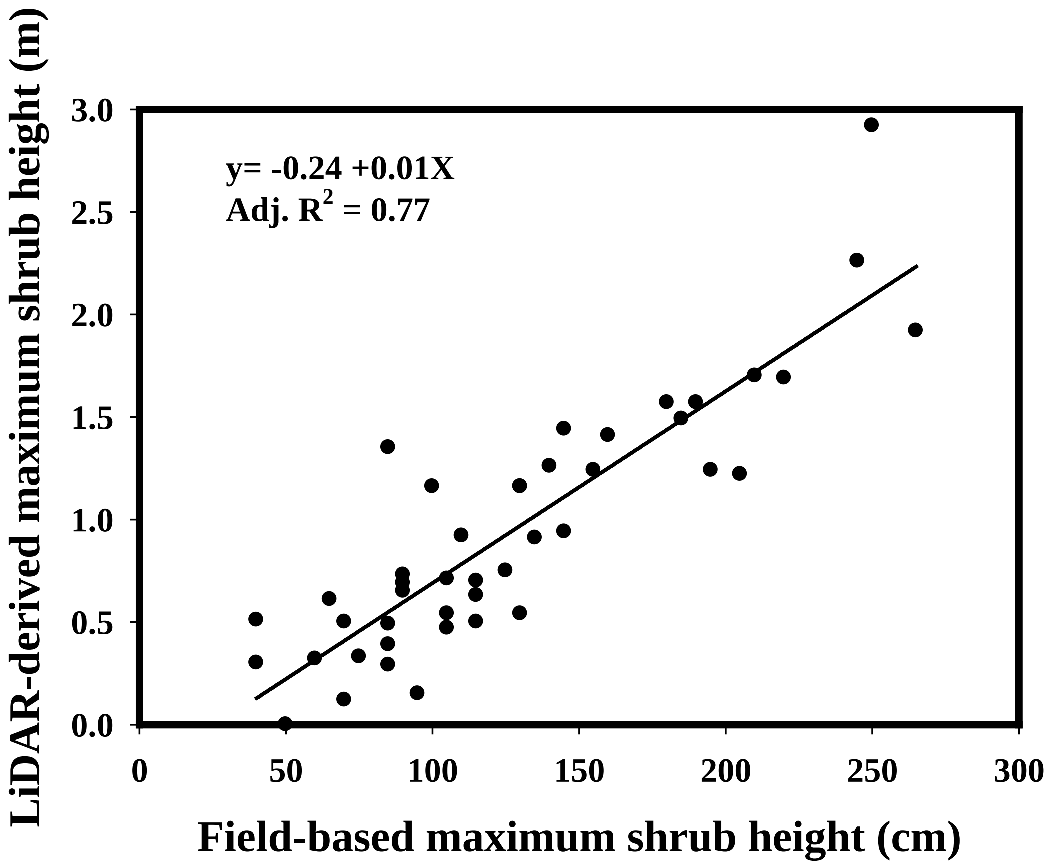
Sankey, T.T., Bond, P., LiDAR classifications of sagebrush communities. Rangeland Ecology and Management (in review).

Juniper – 3 m pixels



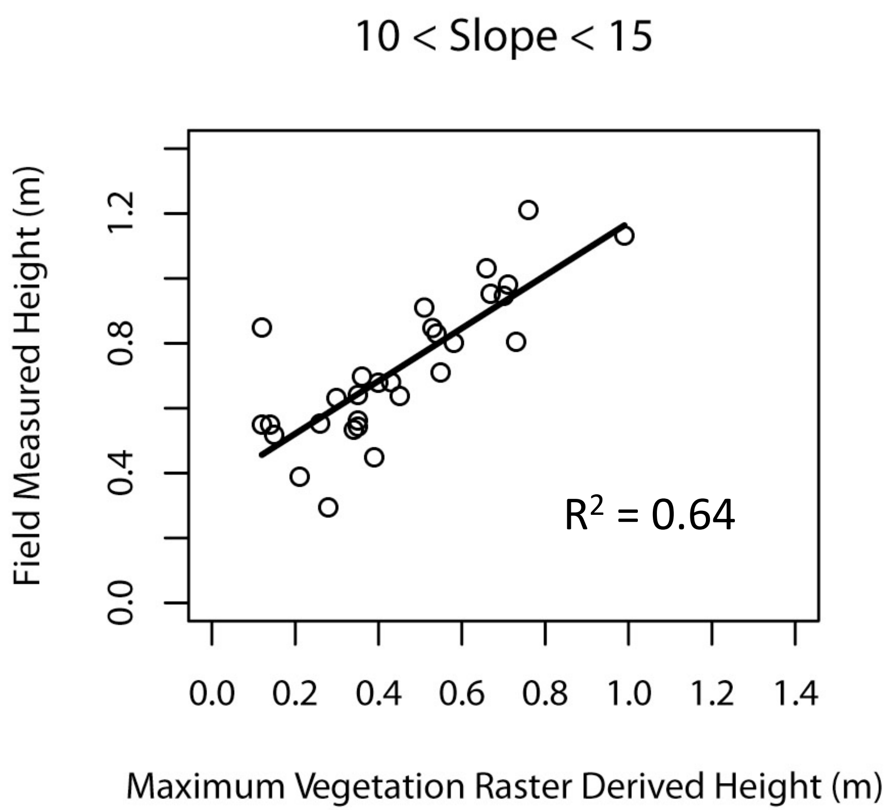
Sankey, T.T., Glenn, N., Ehinger, S., Boehm, A., Hardegree, S., Characterizing western juniper (Juniperus occidentalis) expansion via a fusion of Landsat TM5 and LiDAR data. Rangeland Ecology and Management (in press).

Sagebrush – 3 m pixels



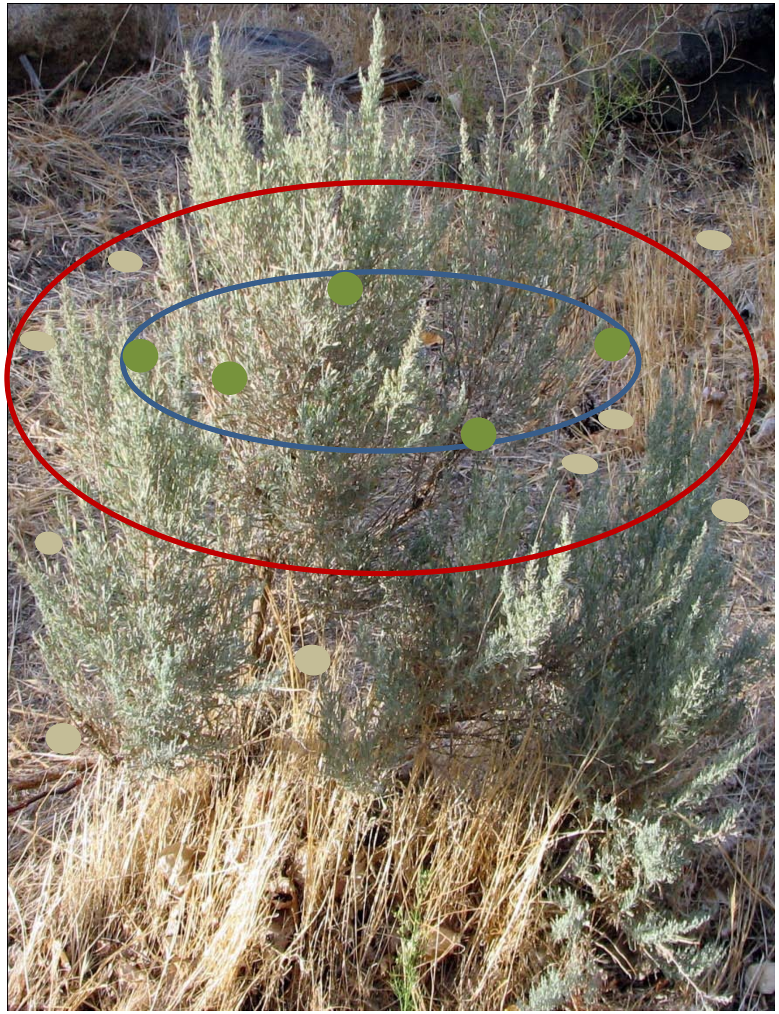
Sankey, T.T., Bond, P., LiDAR classifications of sagebrush communities. Rangeland Ecology and Management (in review).

Individual Sagebrush on Slopes



Glenn, N.F., Spaete, L.P., Sankey, T.T., Derryberry, D.R. and Hardegree, S.P., LiDAR-derived shrub height and crown area: development of methods and the lack of influence from sloped terrain (in review).

Shrub Crown Area

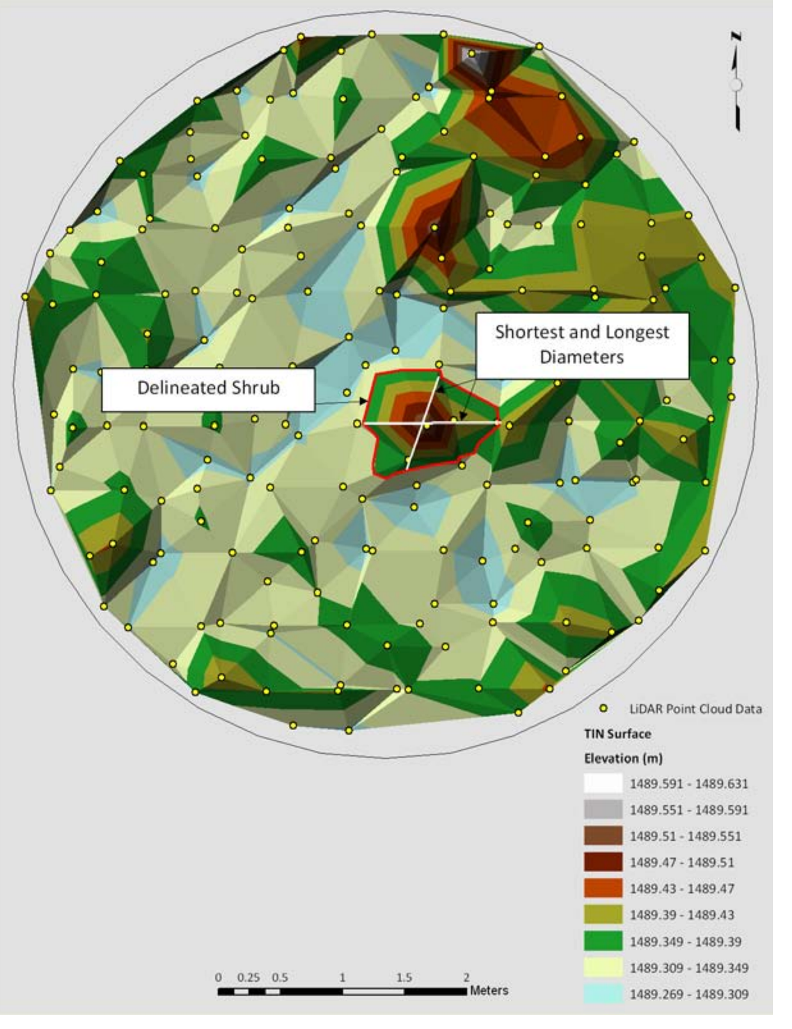


- Point cloud – elliptical area
- Field area underestimated by 49%

Glenn, N.F., Spaete, L.P., Sankey, T.T., Derryberry, D.R. and Hardegree, S.P., LiDAR-derived shrub
height and crown area: development of methods and the lack of influence from sloped terrain (in review).

Shrub Crown Area

- Point cloud data – TIN
- Underestimated by 33%



Mitchell, J., Glenn, N.F., Sankey, T., Derryberry, D. R., Hruska, R. and Anderson, M. O. Small-footprint LiDAR estimations of sagebrush canopy characteristics (in review).

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)

$$\text{RdNBR} = \frac{\text{dNBR}}{\sqrt{|\text{NBR}_{\text{pre-fire}}|}}$$

Accuracy type	dNBR	RdNBR	NDSWIR	MSAVI	SAVI
Overall accuracy	66%	73%	58%	66%	67%
Producer's unburned	96%	98%	90%	94%	94%
Producer's moderate	50%	61%	37%	50%	52%
Producer's high	55%	63%	52%	55%	57%
User unburned	86%	86%	74%	90%	90%
User moderate	38%	56%	34%	42%	44%
User high	74%	76%	66%	66%	68%
KHAT	0.49	0.59	0.37	0.49	0.51
Z	8.43	10.77	6.04	8.45	8.89

Norton, J., Glenn, N., Germino, M., Weber, K., Seefeldt, S., 2009, Relative suitability of indices derived from Landsat ETM+ and SPOT 5 for detecting fire severity in sagebrush steppe, *International Journal of Applied Earth Observation and Geoinformation*, 11(5): 360-367, 10.1016/j.jag.2009.06.005.

Leafy Spurge

Classification	Medicine Lodge HyMap using MTMF	Medicine Lodge area Landsat 5 TM using MTMF	Spencer HyMap using MTMF	Spencer area Landsat 5 TM using MTMF	Entire Landsat 5 TM image using SAM and transformed input bands
User's accuracy (present)	100%	89%	64%	31%	96%
User's accuracy (absent)	60%	35%	77%	62%	30%
Producer's accuracy (present)	80%	59%	90%	72%	30%
Producer's accuracy (absent)	100%	75%	40%	22%	96%
Overall accuracy	85%	62%	67%	38%	46%
Kappa	0.65	0.38	0.31	−0.05	0.15

Sample size	53	51	49	44	41	37	34	29	24	15
Leafy spurge % canopy cover classes	>0%	>10%	>20%	>30%	>40%	>50%	>60%	>70%	>80%	90%
HyMap (121 bands, 3.2-m pixels)										
Producer's accuracy	80%	85%	89%	88%	93%	96%	100%	100%	100%	100%
Overall accuracy	85%	88%	92%	91%	95%	97%	100%	100%	100%	100%
Kappa	0.65	0.72	0.80	0.79	0.89	0.94	1.00	1.00	1.00	1.00
HyMap: spectrally degraded (6 bands, 3.2-m pixels)										
Producer's accuracy	88%	92%	95%	97%	100%	100%	100%	100%	100%	100%
Overall accuracy	91%	94%	96%	98%	100%	100%	100%	100%	100%	100%
Kappa	0.77	0.85	0.90	0.94	1.00	1.00	1.00	1.00	1.00	1.00
HyMap: spatially degraded (121 bands, 30-m pixels)										
Producer's accuracy	59%	62%	65%	69%	72%	76%	77%	82%	83%	100%
Overall accuracy	68%	71%	73%	77%	80%	84%	85%	90%	92%	100%
Kappa	0.39	0.43	0.47	0.55	0.61	0.67	0.71	0.79	0.83	1.00
HyMap TM simulation (6 bands, 30-m pixels)										
Producer's accuracy	63%	67%	70%	72%	72%	72%	82%	82%	83%	67%
Overall accuracy	72%	75%	78%	80%	80%	81%	88%	90%	92%	93%
Kappa	0.44	0.48	0.54	0.58	0.61	0.63	0.76	0.79	0.83	0.76
Landsat 5 TM: Medicine Lodge Area										
Producer's accuracy	59%	56%	57%	53%	55%	64%	68%	71%	67%	33%
Overall accuracy	62%	61%	61%	59%	61%	68%	71%	72%	71%	67%
Kappa	0.38	0.37	0.38	0.39	0.42	0.50	0.55	0.60	0.62	0.65