The Use of Remotely-Sensed Imagery to Analyze Vegetation Cover in Pinyon and Juniper Woodlands

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Land managers in the Great Basin need to rapidly assess vegetation structure and bare ground to effectively evaluate, manage, and restore shrub steppe communities that have been encroached by pinyon and juniper (P-J) trees. A major part of this process is to assess where to apply mechanical and prescribed fire treatments to reduce fuel loads and maintain or restore sagebrush steppe rangelands. Geospatial technologies like remote sensing offer an efficient option to 1) provide information to design and plan management practices; 2) complement and even replace some ground measurements for evaluating rangeland health; 3) evaluate the longevity of fuel reduction treatments and aid in prioritizing maintenance treatments; and 4) increase our understanding of the spatial distribution and cover of fuels. Our objective was to test the accuracy of remotely-sensed cover measurements relative to ground-based cover measurements utilizing two different aerial imagery sources: high-resolution imagery (6-cm pixel resolution) and imagery from the National Agriculture Imagery Program (NAIP, 1-m pixel resolution).

High Resolution Imagery

High-resolution imagery was acquired for sagebrush steppe communities invaded by P-J trees at five sites in Oregon, California, Nevada, and Utah (Fig. 1) in

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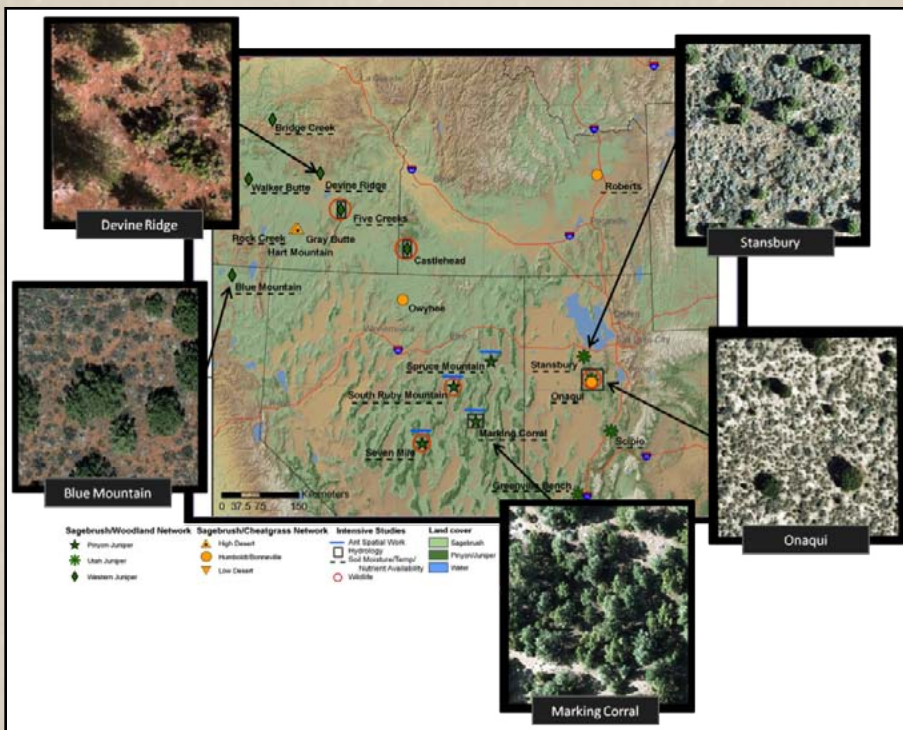
Fig. 1. Study site locations across the SageSTEP network. Subsets of high resolution imagery are examples of one untreated 30x33-m subplot found at each of the study site locations. Study sites includes two western juniper sites (Devine Ridge and Blue Mountain), one singleleaf pinyon and Utah juniper site (Marking Corral) and two Utah juniper sites (Stansbury and Onaqui). Imagery also represents the wide range of P-J woodland phases of encroachment found across the study sites, from phase III (closed canopy) woodlands at Marking Corral to phase I (open savanna) woodlands at Onaqui.
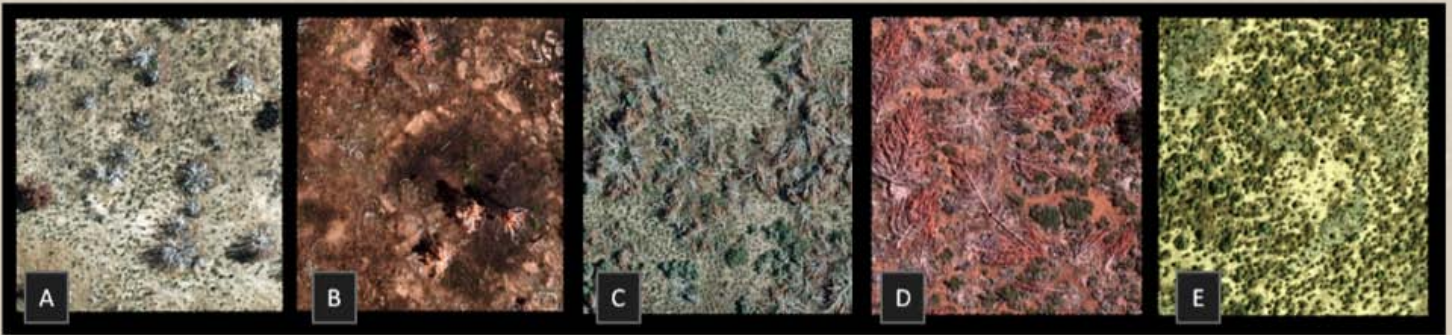
Fig. 2. Imagery of individual subplots (30x33–m) that represent the three fuel-reduction treatments implemented as part of the SageSTEP project. Images A (Onaqui) and B (Devine Ridge) represent two prescribed fire subplots. Between the two sites, variation exists in burn intensity, vegetation response, and soils. Images C (Stansbury) and D (Blue Mountain) represent subplots where trees were mechanically felled and left on site. Image E (Onaqui) represents the mastication treatment, which was only implemented on the Utah woodland sites. Masticated tree debris can be identified as the gray material scattered throughout shrubs and bunchgrasses.

June 2009. In addition to untreated P-J woodlands, imagery was acquired over P-J woodlands where fuels were reduced by prescribed fire, tree cutting, or mastication treatments (Fig. 2). Ground measurements (line-point intercept method) were simultaneously collected at each site in 2009 as part of the Sagebrush Steppe Treatment Evaluation Project (SageSTEP).
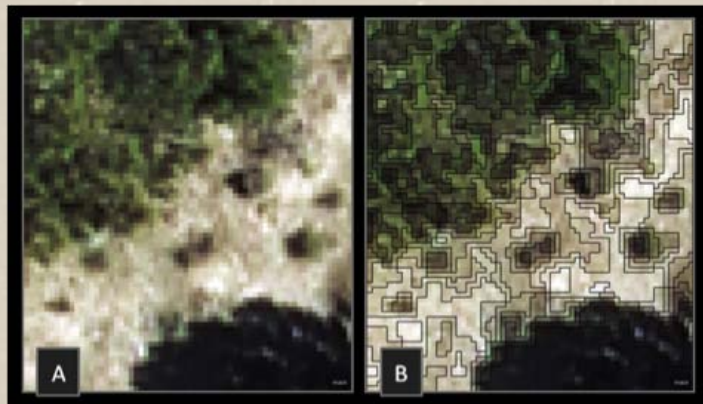

Fig. 3. Object-based image analysis (OBIA): (A) An image (zoomed to a 5x5–m scale) before segmentation, and (B) an example of a multiresolution segmentation that groups similar, neighboring pixels into distinct image objects within designated parameters. Rule-sets (models) were then created using spectral, contextual, and spatial features produced by the software to classify each image object.

For our study, we used eCognition Developer software to extract cover values from the imagery. We used an object-based image analysis (OBIA) technique (Fig. 3) to develop efficient methods to estimate land cover classes found in P-J woodlands for the following classes: trees (live, burned, cut, and masticated), shrubs, perennial herbaceous vegetation, litter (including annual species), and bare ground. Within this software, we used spectral, spatial, and contextual features to classify imagery. We then used statistical analyses (correlation analysis) to determine the relationship between

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ground measurements and the OBIA land cover measurements.

When comparing our estimates from the aerial images with ground measurements for untreated P-J woodlands (Fig. 4), our averages ranged from underestimating litter by 3% to overestimating trees by 1%. While these assessments varied slightly, they represent an accurate landscape-level assessment for use by land managers. Overall, our thematic maps showed an 84% agreement with ground-measured data. Correlations between OBIA and ground measurements were relatively high for live trees, bare ground, shrubs, and perennial herbaceous vegetation (Fig. 5).

Differences between the average cover estimates for our treated plots (Fig. 6) using OBIA and ground-measurements were not consistently higher or lower for any land cover classes and when evaluated for individual sites, were within ±5% of each other. Although cover assessments from OBIA differed somewhat from ground measurements, they are sufficiently accurate to evaluate treatment success and to evaluate the spatial distribution of fuel following fuel-reduction treatments. Correlation of cover between the two methods were high for most land cover classes, but were lower for cover of masticated debris, and shrub cover in the prescribed burn treatment. The overall accuracy for classified
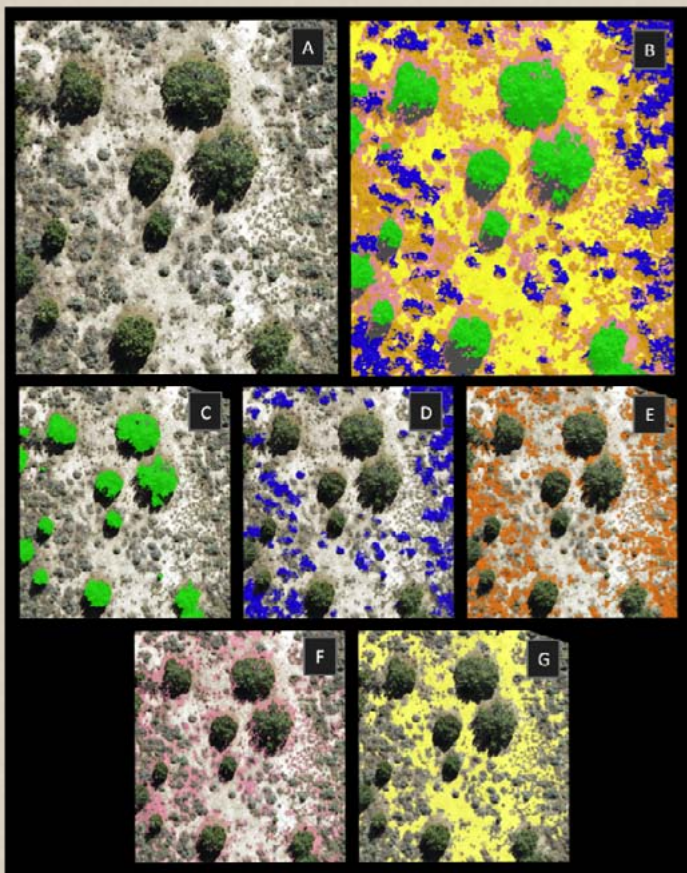
Fig. 4. (A) Example of a juniper subplot image at the Onaqui Utah site, and (B) the classification results using OBIA. Individual land cover classification colors are shown that represent live trees (C, green), shrubs (D, blue), perennial herbaceous vegetation (E, orange), litter including annuals (F, pink), and bare ground (G, yellow).
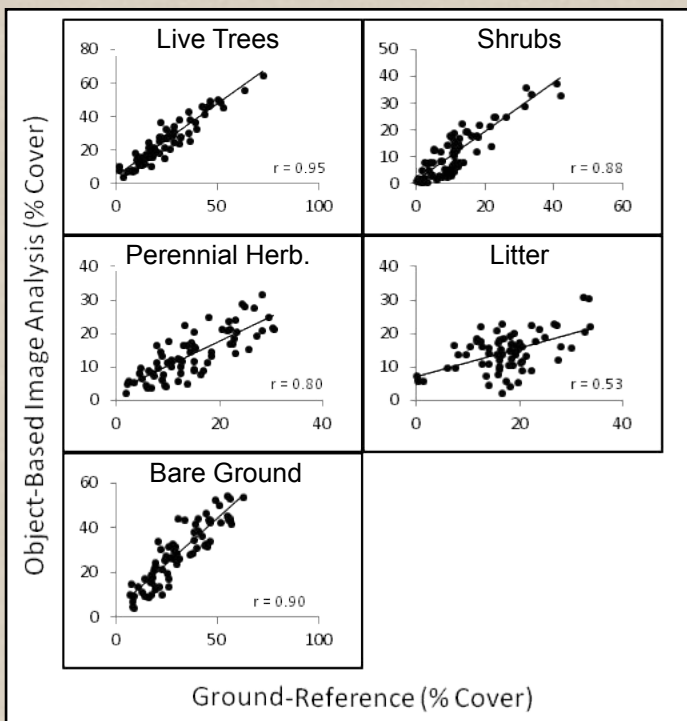

Fig. 5. Correlations of percent cover estimates from an OBIA (y-axis) with ground-reference cover (x-axis) using subplots for all study sites for each land cover class.
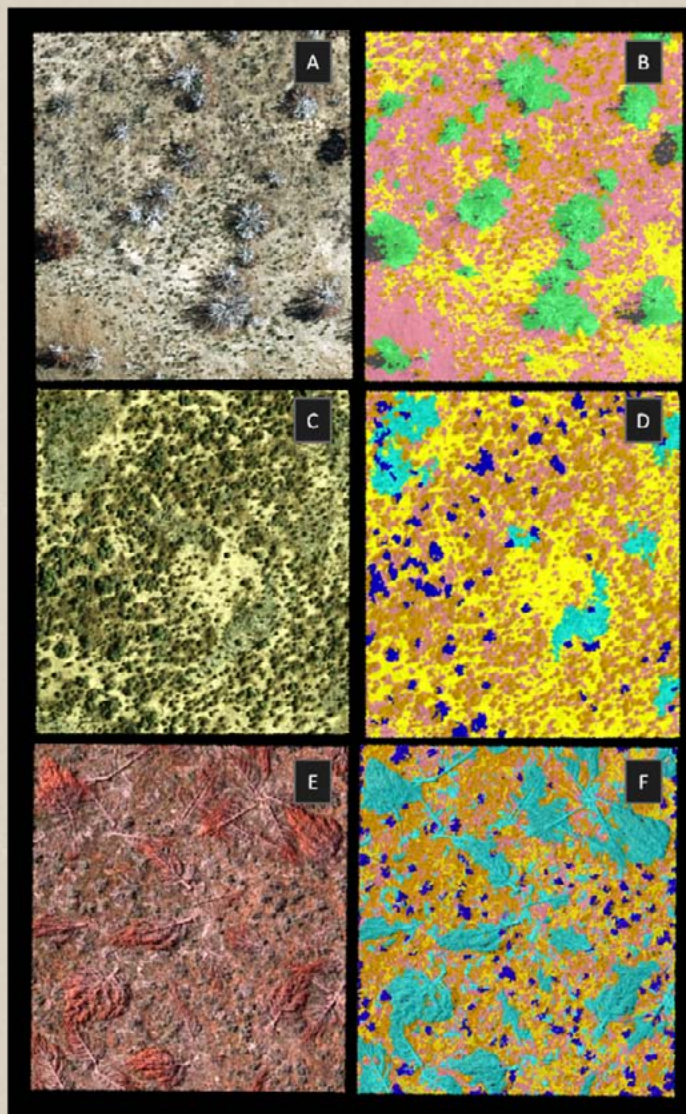

Fig 6. Example of juniper subplot imagery and classification results using OBIA for a prescribed burn at Stansbury (A, B), mastication at Onaqui (C, D), and cut and drop at Blue Mountain (E, F). Individual land cover classification colors represent burned trees (B, green), masticated debris (D, aqua), cut and felled trees (F, aqua), shrubs (blue), perennial herbaceous vegetation (orange), litter (pink), bare ground (yellow), and shadows (gray).

thematic maps for each treatment suggests a strong agreement between OBIA classification and ground-measured data.

Although aerial photography is limited to the overhead view of the various land cover classes, correctly classifying cover is a step toward better modeling and understanding fire behavior, planning future fuel-reduction treatments, gauging the success of treatments and prioritizing maintenance treatments. Additionally, our data suggest that remote sensing of land cover classes such as live trees, shrubs, and bare ground could reduce field data collection for monitoring and assessing rangeland health, therefore enabling land managers to evaluate a much larger scale than is currently practiced.

NAIP Imagery

For this study, we also wanted to test the accuracy of tree cover measurements extracted from NAIP imagery relative to ground-based measurements within P-J expansion woodlands. NAIP imagery is acquired by the federal government and made available to the public free of charge, usually within a year of acquisition. One of the primary goals of NAIP is to make aerial photographs available to government agencies, and information on how to utilize this resource can be a great benefit to public land managers, especially when working in sagebrush steppe communities where P-J trees are expanding.

We acquired 2006 NAIP imagery for four SageSTEP woodland sites in Utah (Stansbury, Onaqui, Scipio, and Greenville Bench). Tree cover was extracted from imagery using object-based image analysis (OBIA) techniques within eCognition Developer software (Fig. 7). Because we were only interested in tree cover, spectral features such as brightness levels were most often used in the classification. Ground measurements were collected during the summer of 2006 in 30x33-m subplots using the crown diameter method (Mueller-Dombois & Ellenberg 1974).

Fig. 7. (A) NAIP image of a 50 acre P-J woodland site (1-m pixel resolution; Onaqui), (B) Tree classification results (green) using object based image analysis techniques, (C) NAIP image of a 30x33-m subplot, and (D) example of tree classification at the subplot scale.
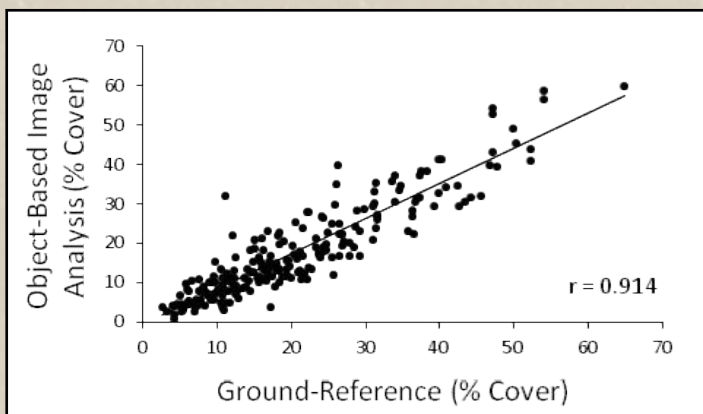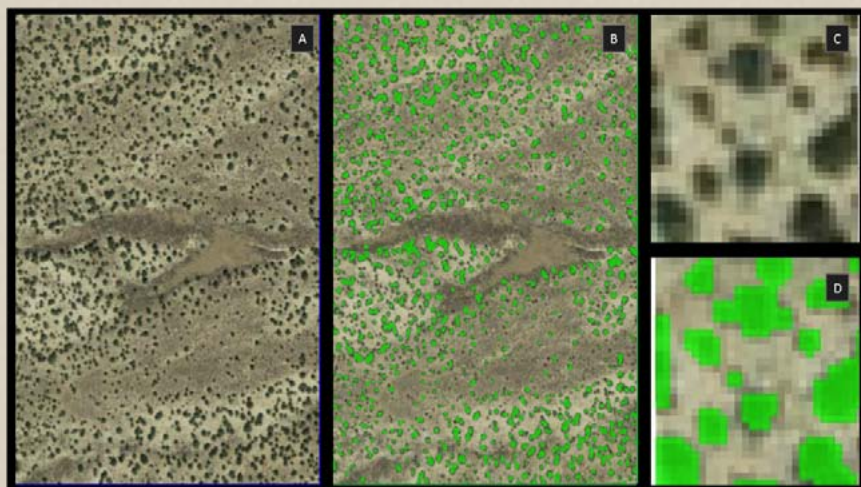

Fig. 8. Correlations of percent tree cover estimates from an OBIA (y-axis) with ground-reference tree cover (x-axis) using subplots for all Utah P-J woodland sites.

Differences in average tree cover estimates between ground measurements and aerial imagery were minimal. Averaged across all sites, OBIA cover estimates were approximately 2.5% less than ground-measured cover. Cover estimates from the two methods were highly correlated (Fig. 8), suggesting that NAIP imagery and OBIA techniques are a good method to rapidly identify areas threatened by P-J expansion. Further research evaluating NAIP imagery tree cover estimates will include all P-J woodland sites across the SageSTEP network.

Additional work is being conducted to evaluate the relationship between tree cover and biomass estimates across all SageSTEP P-J woodland sites using NAIP imagery. Biomass was estimated using structurally based analytic models developed by Tausch (2009) from ground-collected data. Preliminary correlation results between OBIA cover estimates and ground-measured biomass are highly correlated for Utah juniper trees ($r = 0.87$). However, for western juniper trees the correlation is less ($r = 0.57$), which may be due to structural differences between juniper species which impacts both our OBIA cover estimates and ground-measured biomass.

Because NAIP imagery is free and readily available, it offers a simple, efficient, and effective remote sensing tool for land management. Using NAIP imagery can reduce field data collection costs for monitoring and assessing P-J tree cover, evaluating encroachment patterns over time, and setting fuel-reduction priorities.

As these technologies continue to develop, they will become an increasingly important tool for land managers looking to rapidly and accurately assess large land areas. For additional information about this research, please contact april.hulet@oregonstate.edu. Related publications will be posted at http://www.sagestep.org/collaborative_projects/projects/hulet_gis.html as they become available.

References

Mueller-Dombois D. and H. Ellenberg. 1974. Aims and Methods of Vegetation Ecology. John Wiley and Sons, New York.

Tausch, R.J. 2009. A structurally based analytic model for estimation of biomass and fuel loads of woodland trees. *Natural Resource Modeling* 22:463-488.

2012 SageSTEP Field Days

If you haven't registered for our 2012 spring field days you still have time! We are planning two one-day field tours to provide opportunities for researchers and land managers to visit treated and untreated areas in sagebrush and juniper woodlands and to discuss the implications of wildfire fuels treatments. We will discuss research results and management tools for improved planning and decision-making. We hope you will join us! Field tours are planned in partnership with the Great Basin Science Delivery Project and the Great Basin Chapter of the Society for Ecological Restoration.

Woodlands & Fuels Treatments Field Day
May 30, 2012
9:00am – 3:30pm
Northeastern California

We will visit the SageSTEP Blue Mountain study site, a western juniper site on Forest Service land where prescribed fire and cut-and-leave treatments were implemented in fall 2007. We also plan to visit other sites, including sagebrush and juniper, where fuels treatments have been implemented.

We will discuss the impacts of treatments on a variety of ecosystem components and also look at untreated areas. Rick Miller will discuss the *Western Juniper Field Guide* and the decision-making process when planning management actions.

This area is just a short drive from Tulelake and Alturas, CA, and southern Oregon. We can accommodate participants travelling from various directions the morning of the tour. This is a great opportunity to get out in the field and discuss important issues in land management.

Sagebrush & Fire Field Day
June 7, 2012
7:30am – 4:30pm
Idaho Falls, Idaho

We will meet at the BLM Upper Snake River Field Office from which we will travel to the SageSTEP Roberts study site as well as a University of Idaho sagebrush study site.

The Roberts site was treated with prescribed fire, sagebrush mowing and herbicide treatments in fall 2007. In July 2010, the Jefferson wildfire burned through the prescribed burn plot, mow plot, and part of the herbicide plot (but not the control). This gave us an unanticipated opportunity to learn more about the effects of fuels treatments on wildfire behavior and subsequent recovery.

In the afternoon we will visit a BLM ES&R treatment area where we will look at post-fire site recovery and restoration. Speakers will include SageSTEP researchers, BLM managers with range and fuels experience, and USGS ecologist Matt Germino, an expert in fire ecology and cheatgrass invasion. There will be plenty of time for questions and discussion so plan on attending!

For more information about the field days and to register, visit
http://www.sagestep.org/events/2012-Field-Days.html.

Upcoming Events

17th Wildland Shrub Symposium: Humans in Changing Landscapes
May 22-24, 2012
Las Cruces, New Mexico
http://jornada.nmsu.edu/wildland-shrub-symposium

SageSTEP 2012 Field Days
http://www.sagestep.org/events/2012-Field-Days.html

Woodlands & Fuels Treatments Field Day
May 30, 2012
Tulelake, California

Sagebrush & Fire Field Day
June 7, 2012
Idaho Falls, Idaho

Eastern Nevada Landscape Coalition Annual Meeting
June 7-8, 2012
Ely, Nevada
http://www.envlc.org

Restoring the West Conference 2012 Balancing Energy Development and Biodiversity
October 30-31, 2012
Logan, Utah
http://www.restoringthewest.org

SageSTEP is a collaborative effort among the following organizations:

- Brigham Young University
- Bureau of Land Management
- Bureau of Reclamation
- Joint Fire Science Program
- National Interagency Fire Center
- Oregon State University
- The Nature Conservancy
- University of Idaho
- University of Nevada, Reno
- US Geological Survey
- US Fish & Wildlife Service
- USDA Forest Service
- USDA Agricultural Research Service
- Utah State University

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