Using landscape-level assessments of similarity to improve state-and-transition model development

Presented @ the ESD Development Technical Workshop
SRM Conference 2011

Alexander Hernandez
R. Douglas Ramsey
RS/GIS Lab
Utah State University
The three landmarks of rangeland evaluation

- **Similarity Index**: compares the present plant community to the historic climax plant community for that site or to a desired plant community that is one of the site’s potential vegetation states.

- **Trend**: direction of change in an existing plant community relative to the historic climax plant community. It is only applicable on rangelands that have ecological site descriptions identifying the historic climax plant community.

- **Rangeland Health**: qualitative assessments of rangeland health provide land managers and technical specialist with a good communication tool for evaluating ecological processes and can assist to identify potential areas at risk of degradation.

USDA, 2006
Our proposal: Assess landscapes

-Utilize multi-temporal remotely-sensed data sets to: develop a protocol that measures the similarity of ecological site units to undesired conditions and identifies the direction of change (trend) to those negative states

In order to detect change for a landscape of interest it is necessary to define units to be used as benchmarks. Benchmarks are standards against which the values of indicators can be compared and judged

West, 1991
Measuring similarity, a shift... from this...

To this...


http://www.sagestep.org/educational_resources/ethnobotany/ethnobotany.html
Ecological site units in the pilot area: Emphasis in Big Sagebrush Ecosites
Study site name: Sheep Range Spring
Vegetation type: Big Sagebrush

Compass bearing: Frequency baseline 84 degrees magnetic.

Frequency belt placement: line 1 (11ft), line 2 (34ft), line 3 (59ft), line 4 (71ft), line 5 (95ft). Rebar: belt 4 on 21 ft.

LOCATION DESCRIPTION

From Grouse Creek Junction, travel south for 5.4 miles to the railroad tracks. Continue straight for 0.6 miles to the TL Bar Beefmaster Ranch. Take the left fork and travel 5 miles to a fork in the road. Take a right turn and travel 2.1 miles to a four way intersection. Continue straight (stay right) for 2.7 miles to Governors Spring. Take a left at Governors Spring and drive 1.0 mile. Take a right and travel down hill for 1.0 mile. Take the left fork and continue for 1.6 miles to an intersection. From the intersection take the left and continue 1.1 miles where there will be a road going up a steep hill to the right. Stay left and travel 0.1 miles to the end of the road. From the PIMO walk 120 paces at 3 degrees magnetic to the 0-foot baseline stake (near a PIMO). The baseline runs 84 degrees magnetic.

Map Name: Patterson Pass
Diagrammatic Sketch
Remote Sensing + Topography + Climate

1984-2010

SAVI
BGW

Mean and Variance

Acquiring Remote Sensing Phenology Data from USGS/EROS

Historical remote sensing phenology (RSP) image data and graphics for the conterminous U.S. are made freely available from the USGS/EROS Center through its table. Click on the drop down list to the right of the icon for image data (top) or graphics (bottom) and select the year for the RSP data set or graphic. Metadata, providing processing details, are bundled with the image data.

As a courtesy, please give credit to the USGS EROS Center as the source for this RSP data in some manner. Our suggestion: The source for this data was the USGS EROS Center (http://phenology.cr.usgs.gov/).

<table>
<thead>
<tr>
<th>RSP Data Set</th>
<th>Acronym</th>
<th>Phenological Interpretation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of Season – Time</td>
<td>SOST</td>
<td>Beginning of measurable photosynthesis in the vegetation canopy</td>
<td>Day of year identified as having a consistent upward trend in time series NDVI</td>
</tr>
<tr>
<td>Start of Season – NDVI</td>
<td>SOSN</td>
<td>Level of photosynthetic activity at the beginning of measurable photosynthesis</td>
<td>NDVI value (or baseline) identified at the day of year identified as having a consistent upward trend in time series NDVI</td>
</tr>
<tr>
<td>End of Season – Time</td>
<td>EOST</td>
<td>End of measurable photosynthesis in the season</td>
<td>Day of year identified at the end of a season</td>
</tr>
</tbody>
</table>

1989-2008

PRISM CLIMATE GROUP

Latest PRISM Data - Dec 2010

Quick Links
Data Alert
Monthly Data
800m Normals (1971-2000)
Internet Map Server

The data sets available on this website were created using the PRISM (Parameter-elevation Regressions on Independent Slopes Model) climate mapping system, developed by Dr. Christopher Daly, PRISM Climate Group director. PRISM is a unique knowledge-based system that uses point measurements of precipitation, temperature, and other climatic factors to produce continuous, digital grid estimates of monthly, yearly, and event-based climatic parameters. Continuously updated, this unique analytical tool incorporates point data, a digital elevation model, and expert knowledge of complex climatic extremes, including rain shadows, coastal effects, and temperature inversions. PRISM data sets are recognized world-wide as the highest-quality spatial climate data sets currently available. PRISM is the USDA's official climatological data.
## Data sets

<table>
<thead>
<tr>
<th>Code</th>
<th>ID</th>
<th>Code</th>
<th>ID</th>
<th>Code</th>
<th>ID</th>
<th>Code</th>
<th>ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>001</td>
<td>014</td>
<td>002</td>
<td>030</td>
<td>003</td>
<td>047</td>
<td>004</td>
<td>064</td>
</tr>
<tr>
<td>005</td>
<td>081</td>
<td>006</td>
<td>108</td>
<td>007</td>
<td>135</td>
<td>008</td>
<td>162</td>
</tr>
<tr>
<td>009</td>
<td>190</td>
<td>010</td>
<td>217</td>
<td>011</td>
<td>244</td>
<td>012</td>
<td>271</td>
</tr>
<tr>
<td>013</td>
<td>298</td>
<td>014</td>
<td>325</td>
<td>015</td>
<td>352</td>
<td>016</td>
<td>379</td>
</tr>
<tr>
<td>017</td>
<td>406</td>
<td>018</td>
<td>433</td>
<td>019</td>
<td>460</td>
<td>020</td>
<td>487</td>
</tr>
</tbody>
</table>

## Benchmarks

<table>
<thead>
<tr>
<th>Area</th>
<th>Symbol</th>
<th>Spatial Layer</th>
<th>MUSYM</th>
<th>HKey</th>
<th>Compete</th>
<th>Splied</th>
<th>EcoSite</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTG01</td>
<td>1288</td>
<td>276</td>
<td>512</td>
<td>510</td>
<td>0.474</td>
<td>0.734</td>
<td>0.183</td>
<td>1001</td>
</tr>
<tr>
<td>UTG02</td>
<td>1288</td>
<td>276</td>
<td>512</td>
<td>510</td>
<td>0.474</td>
<td>0.734</td>
<td>0.183</td>
<td>1002</td>
</tr>
<tr>
<td>UTG03</td>
<td>1288</td>
<td>276</td>
<td>512</td>
<td>510</td>
<td>0.474</td>
<td>0.734</td>
<td>0.183</td>
<td>1003</td>
</tr>
<tr>
<td>UTG04</td>
<td>1288</td>
<td>276</td>
<td>512</td>
<td>510</td>
<td>0.474</td>
<td>0.734</td>
<td>0.183</td>
<td>1004</td>
</tr>
<tr>
<td>UTG05</td>
<td>1288</td>
<td>276</td>
<td>512</td>
<td>510</td>
<td>0.474</td>
<td>0.734</td>
<td>0.183</td>
<td>1005</td>
</tr>
<tr>
<td>UTG06</td>
<td>1288</td>
<td>276</td>
<td>512</td>
<td>510</td>
<td>0.474</td>
<td>0.734</td>
<td>0.183</td>
<td>1006</td>
</tr>
</tbody>
</table>

## SMU

- EcoSite
- RS + Topos + Climate

- Data sets
- Benchmarks
- RS + Topos + Climate
Interested in Similarity and Trend...

Need to find an integrated (synthesized) response for benchmarks and ecological site units (SMUs) that allows comparison in order to detect change.

Decided to handle as a problem of **ordination**: allows to reduce the multidimensional spectral-topographic-climatic space by estimation of spatiotemporal dissimilarities among units of interest (Benchmarks + EcoSites units)
MultiDimensional Scaling MDS for two periods
MultiDimensional Scaling MDS: Similarity to undesired states
MDS: Similarity to undesired states: Applications for STM

Follow changes in ordination space for a given sphere or cluster of observations for the different periods, and interpret whether the trajectories are suggesting changes or stability.
MDS : Similarity to undesired states: Applications for STM

Narratives in DWR-RTS may be used to interpret states and transitions for benchmarks and Ecosites Units

2006 TREND ASSESSMENT
The browse trend is down. Wyoming big sagebrush continued to decline. Density was down by 19%, while decadence increased again, from 35% to 41%. A quarter of the population was classified as dying and young plants were less numerous. Drought and winter injury have likely caused the decline of this sagebrush population. Shadetree was also less abundant in 2006. The grass trend is stable. The abundance of both perennial species and cheatgrass changed very little, although cheatgrass cover was higher. The forb trend is also stable. The DCI score declined due to increased decadence and cheatgrass cover.

HERBACEOUS TRENDS –
Management unit 01, Study no. 18

<table>
<thead>
<tr>
<th>Species</th>
<th>Nested Frequency</th>
<th>Average Cover %</th>
<th>96</th>
<th>97</th>
<th>98</th>
<th>01</th>
<th>06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agropyron cristatum</td>
<td>0.30</td>
<td>0.10</td>
<td>0.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agropyron smithii</td>
<td>0.30</td>
<td>0.12</td>
<td>0.82</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agropyron spicatum</td>
<td>0.72</td>
<td>1.11</td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bromus tectorum (a)</td>
<td>0.30</td>
<td>3.50</td>
<td>7.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elymus sp.</td>
<td>0.12</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Festuca sp.</td>
<td>0.03</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poa fendleriana</td>
<td>0.03</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poa secunda</td>
<td>2.92</td>
<td>4.32</td>
<td>5.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitanion hystrix</td>
<td>1.19</td>
<td>0.89</td>
<td>1.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total for Annual Grasses</td>
<td>0.30</td>
<td>3.50</td>
<td>7.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total for Perennial Grasses</td>
<td>5.51</td>
<td>6.55</td>
<td>8.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total for Grasses</td>
<td>5.18</td>
<td>10.05</td>
<td>15.73</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agoseris glansa</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allium acuminatum</td>
<td>0.00</td>
<td>0.03</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
If sufficient benchmarks are available to characterize the phases of a stable state then the Ecosites units may be assessed in terms of ecological thresholds.
MDS: Similarity to undesired states: Applications for STM

Refine the spatial detail of ecological site units (i.e. without a major component)
MDS: Similarity to undesired states: Applications for STM

Predict the distribution of ESD on a pixel basis
MDS: Similarity to undesired states:

Similarity to TS-13 – 1984 - 1996

Similarity to TS-13 – 1997 - 2008
MDS: Similarity to undesired states: EcoSites Units’ trend to a specific benchmark
MDS: Similarity to undesired states:

Limitations:

* Thematic (no distinction of grasses, forbs, etc) resolution

* Spatial resolution of the geospatial data sets

* Accounting for changes in vegetation composition only

* Detail of soil mapping units for different soil surveys

New benchmarks may include a suite of conditions (communities) within a state but may lack the information to characterize transitions.
MDS: Similarity to undesired states: Conclusions

The spatiotemporal spectral signature captured with the multivariate data set clearly discriminates different conditions of the land considered negative for big sagebrush ecological sites as well as EcoSites units.

A protocol based on the concept of benchmarks of undesired conditions to assess similarity has been developed. High-quality remotely-sensed data sets are available online at no cost and may be processed easily.

Ordination seems to be an appropriate technique to reduce the dimensionality of the data set and may provide insight about current states and potential transition that ecological site units have experienced on the landscape.

Statistical uncertainty of results directly associated with % component attribute of ecological site unit as well as size of the SMU.