Assessing the Suitability of Landsat Satellite Data for Distinguishing Cheatgrass Infested Sites Near Midwest, Wyoming

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An invasive annual grass species introduced from Europe, but is also native to the northern rim of Africa, and southwestern Asia.

- *Bromus tectorum*
- Prolific seed production
- Capable of adaption to fill many niches
- Greens up early in the season (as early as March and April in Wyoming)
  - Has a competitive advantage over other plants by claiming early levels of soil moisture and nutrients
Now present in most of the 50 states, parts of Mexico and Canada.

- Especially prevalent in the more arid and semi-arid climates of the west
  - Average annual precipitation of 12–22 inches.
Negative Impacts

- Increases the fire cycle to every 2–3 years
  - Increase in fine fuel load
- Uses up reserves of nutrients in the top soil layers
- Outcompetes the native vegetation
- Increases chances of degradation and damage to the land
- Reduces recreation value
- Injuries to livestock and pets
- Lower quality vegetation
  - less nutrients for domestic livestock and wildlife
Management

- Land managers employed by Government agencies like the Bureau of Land Management and the United States Forest Service are responsible for mapping Cheatgrass and finding ways to manage the invasion
  - Man power/ training
  - Cost (high)
  - Large geographic areas to cover

- Remote Sensing
  - The science and art of gathering information about an area from a device that is NOT in contact with that area
  - Have used RS to map vegetation
    - Map large areas with fewer people, repeat observations – updated information
  - Trained personnel, cost of hardware and software, etc.
Remote Sensing Data Sources

Platforms: balloons, kites, airplanes, satellites
- Balloons and kites
- Airplane
  - Finer resolution (more detailed), mostly expensive, flying conditions, not suitable for large areas
- Satellite
  - Approximately 20+ countries operating 30+ RS satellites
  - Different data characteristics
  - Landsat Program (1–7)
    - Oldest civilian remote sensing satellite program by US
    - Thematic Mapper (Landsat 5 and 7) – 30 m x 30 m footprint
    - Acquired once every 16 days, in six multispectral bands
    - Images (1972 – present) are FREE to the public since 2009
Image Comparison

Image acquired from Google Earth

Landsat 5 TM Image of approximately the same area
Challenges for Using Satellite Imagery

- **Image characteristics**
  - Cloud, shadow, snow–free imagery
  - Acquired during March through mid–May

- **Test its suitability for mapping cheatgrass in WY**
  - Fewer studies in the upper latitudes

- **Cheatgrass grows with native species**
  - Finding monoculture or mostly cheatgrass site is difficult
  - May not be a monoculture of the invasive species (mixture of native species, invasive species, different growth forms)
  - Size of the plot must be large enough for the remote sensing tools to pick it up (Landsat 30m x 30m squares)
Objective 1:
- Can Landsat 5 TM data distinguish sites that had cheatgrass present from sites that had native vegetation in early growing season?
  - Hypothesis: Based on high reflectance in infrared bands during early growing season.

Objective 2:
- How does the reflectance pattern between these two sites change over the growing season?
  - Hypothesis: Cheatgrass will start to cure at approximately the same time that native vegetation greens up
  - Caveat being – if we can find monoculture sites of cheatgrass
• **Study Area**
  – KS Ranch and Teapot Ranch 27.5 miles north of Casper, WY
  – Images from the year 2006
    – 5 months clear of cloud and snow cover
  – Eight sites were sampled in the study
    • Four cheatgrass sites
      – A historical sheep bed ground
      – Two sites of past fires in 2000 and 2003
      – Disturbed construction site
    • Four sites of native vegetation in relatively close proximity to the cheatgrass sites

• **Method for choosing sites**
  – Personal knowledge and experience of both ranches
    – Areas with high reflectivity in April image
    – Areas of degradation (fire, construction, overgrazing, etc.)
Images of the Sites
Method

- Satellite imagery acquired from USGS website
  - Landsat 5 Thematic Mapper images
- Images were chosen based on
  - No snow or cloud cover
  - Being from the same year to maintain consistency in sampling sites

- 2006 was the year chosen for this study
- Every month from April to August had an acceptable image
Images subset to the approximate size of the study area

Images were then normalized
- To take into account differences in sun angle
- Method used was described by Chavez (1992)
- Output was a normalized reflectance

Reflectance values at sites (units) that had cheatgrass and native vegetation
- 4 sites that had cheatgrass present and another 4 with native vegetation were selected
- Measured across six multispectral bands
- Values were taken at each site for each month from April through August
- NDVI, NIR/Red ratio
- Compared the reflectance from the two sets of sites
Vegetation Indices Comparison

• The difference between the cheatgrass infested sites and the native sites is most pronounced in early spring, April and May

• T-test to measure significance (has to be under 0.05 to be significantly different)
  • May shows the most significant difference
  • July shows no significant difference

<table>
<thead>
<tr>
<th>T-Test</th>
<th>NDVI</th>
<th>NIR/Red</th>
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<tr>
<td>April</td>
<td>0.0004</td>
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<tr>
<td>May</td>
<td>0.0002</td>
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<td>June</td>
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<td>July</td>
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<td>August</td>
<td>0.0346</td>
<td>0.0346</td>
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</table>
April and May are the best months to use Landsat 5 TM data to map cheatgrass invasion North of Casper, WY because the difference is most pronounced.

The significant difference between sites containing cheatgrass and native vegetation sites gradually lessens from May until July when there is NO significant difference.

Difference is significant again in August.

Having no sites with a monoculture of cheatgrass made it difficult to accurately map the change in these two sites over the growing season.
Need to complete ground work (transects) in the study area to actually quantify the percentage of the sites occupied by cheatgrass versus native vegetation to get more accurate results
  - A monoculture of cheatgrass (100%) all the way down to 25% cheatgrass to assess which percentage produces reflectance differences capable of being separated from native vegetation by Landsat 5 TM

A more recent year would be preferable to increase accuracy of records

More specific records kept of the specific green up days and when the species cures
  - for cheatgrass infested sites and native vegetation (operating from memory on this project)

Riparian areas need to be separated from the higher reflectance values of cheatgrass using linear mapping techniques

Will have to sample months in the fall to verify that native species do actually overcome cheatgrass
  - Sampling earlier in the spring would also be better, provided adequate images can be found
The Landsat 5 TM imagery can be used to map the reflectivity differences between cheatgrass and native species on rangeland near Midwest, WY

- Timing is crucial
- Ground work needs to be completed to verify sites with cheatgrass and their percentage composition

Cheatgrass reflectance values were higher in the spring months than the native grass species, however a monoculture of cheatgrass needs to be established to accurately map differences over the growing season
Acknowledgements

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- KS Ranch
- Department of Botany

Photo Sources Cited