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

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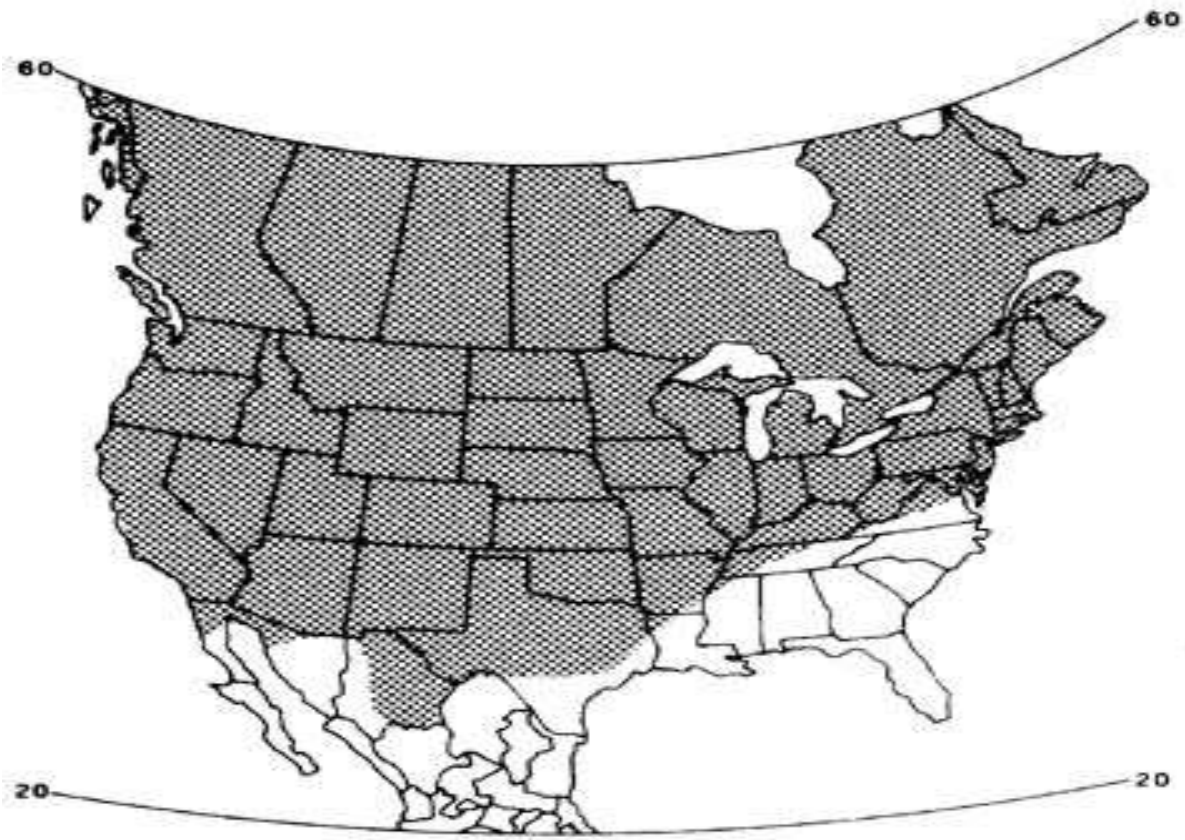
Cheatgrass

- 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

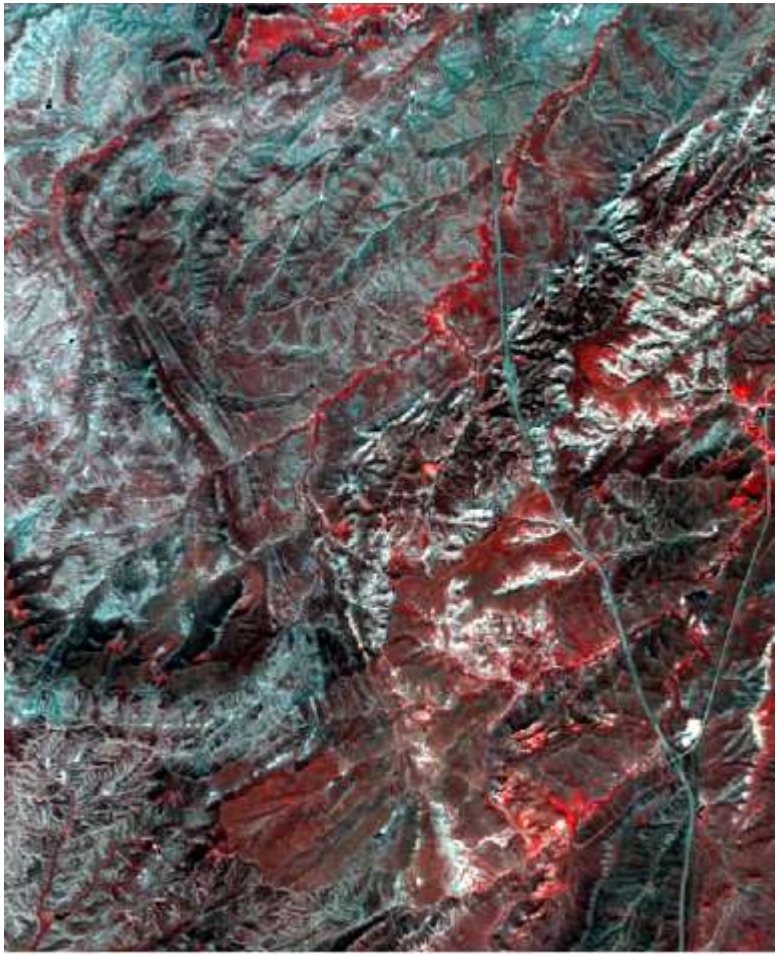
- Land managers employed by Government agencies like the Bureau of Land Management and the United States Forest Service are responsible for mapping Cheatgrass and finding ways to manage the invasion
  - Man power/ training
  - Cost (high)
  - Large geographic areas to cover
- Remote Sensing
  - The science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

My Research

- 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

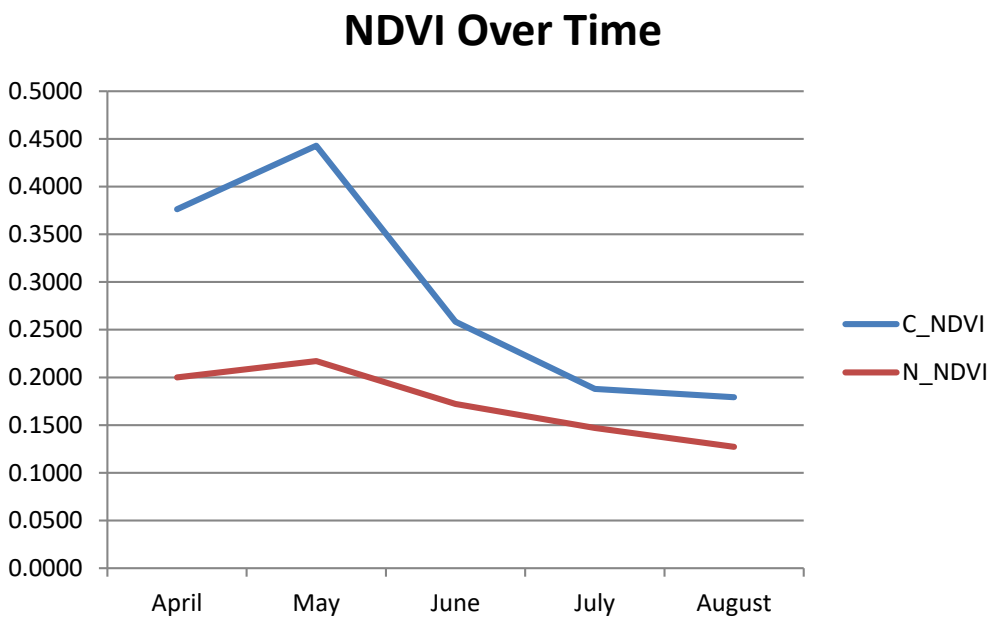
- Reflectance values at sites (units) that had cheatgrass and native vegetation
  - 4 sites that had cheatgrass present and another 4 with native vegetation were selected
  - Measured across six multispectral bands
  - Values were taken at each site for each month from April through August
  - NDVI,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

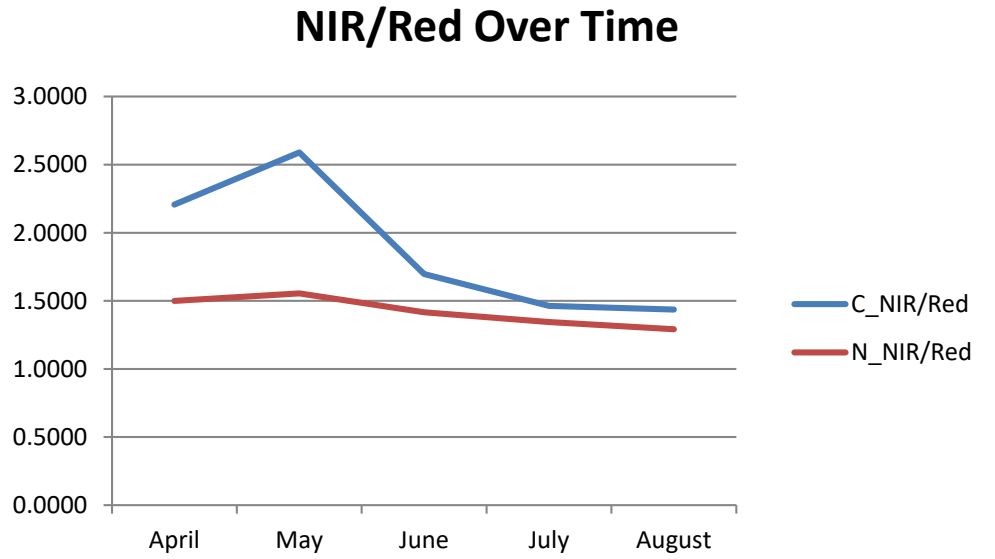
Vegetation Indices Comparison

- 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

T-Test	NDVI	NIR/Red
April	0.0004	0.0004
May	0.0002	0.0012
June	0.0157	0.0212
July	0.0706	0.0737
August	0.0346	0.0346





Results

- 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

What I learned…

- 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

Conclusion

- 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

- Ramesh Sivanpillai
- KS Ranch
- Department of Botany
- Photo Sources Cited
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