Influence of Sun Angle differences in Extracting Surface Area of Water Bodies

By: Gregory F Galli, with Dr. Ramesh Sivanpillai

Undergraduate Research Day

May 2, 2015

Laramie, WY

Remote Sensing Data & Its Applications

- Remote sensing is:
- Used for mapping and monitoring
  - Forestry
  - Agriculture
  - Rangeland
  - Urban growth and change
  - Geology and soil types

Landsat

- First satellite was launched in 1972 (renamed as Landsat 1)
- Since then
  - Landsat 2 (1975), Landsat 3 (1978), Landsat 4 (1982), Landsat 5 (1984), Landsat 7 (1999), and Landsat 8 (2013)
- Longest running civilian remote sensing program
- Its data are used for mapping and monitoring Earth surface features

http://landsat.usgs.gov

Landsat Data & Project Scope

- Collected in visible (BGR) and invisible (3 infra red) regions
- Several techniques exist to convert raw Landsat data to information about Earth surfaces
- Map waterbodies (i.e., surface areas) using Landsat data

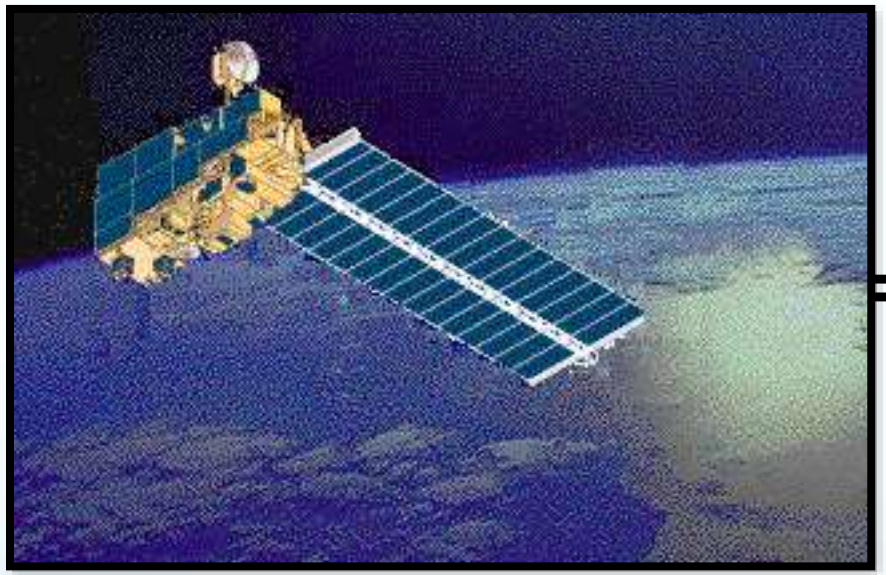
Normalized Difference Wetness Index

- Normalized Difference Wetness Index (NDWI)
  - Used to map water bodies (lakes, reservoirs, ponds etc.)
  - Computed from Green (visible) and NIR (invisible) portions
  - *NDWI = (Green – NIR) / (Green + NIR)*
  - Is an index ranging between -1 and +1
  - Water usually has NDWI value > 0

Several Factors Affect NDWI

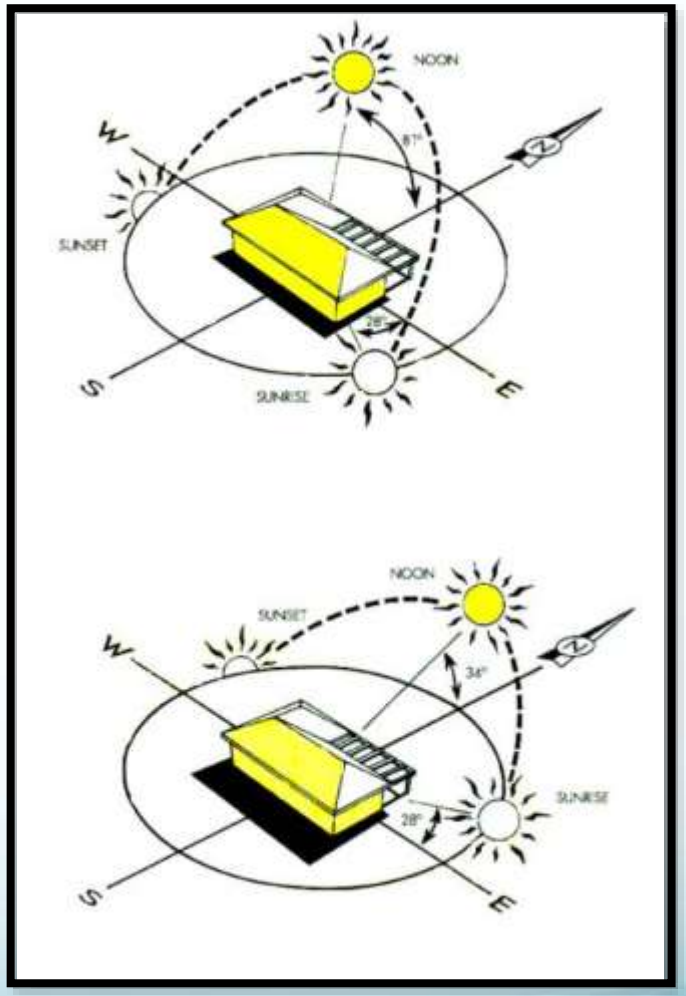
- Materials present in water
  - Algae
  - Turbidity
  - Others
- Physical characteristics of the water body
  - Depth of the water
  - Shape
- External factors
  - Shade (due to sun angle)

Overview



Middle Summer

Middle Winter



http://www.see.murdoch.edu.au/resources/info/Tech/house/
http://novaonline.nvcc.edu/eli/evans/his135/events/landsat/chronology.html

Hypothesis

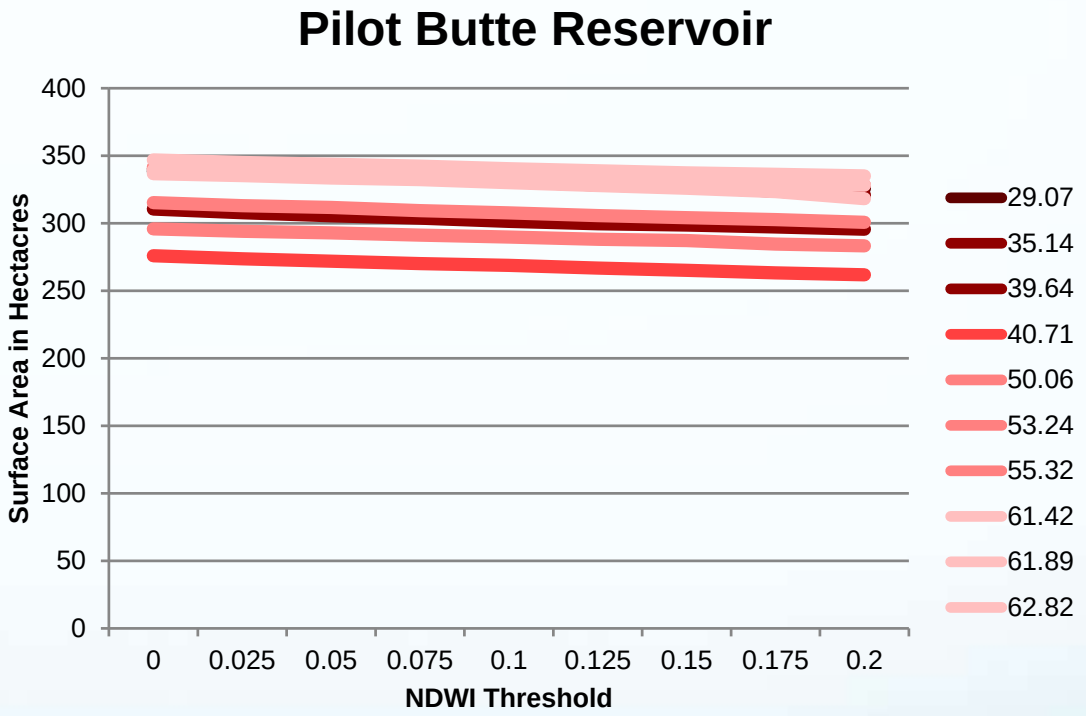
- Sun Angle will affect NDWI estimates
  - Presence of tall features (steep cliffs for example) will increase the shadow length at low sun angles
- The water bodies analyzed include:
  - Bull Lake Reservoir (tall, steep cliffs)
  - Keyhole Reservoir (relief at certain locations)
  - Fontenelle Reservoir (relatively flat)
  - Pilot Butte Reservoir (very flat)

Sensitivity of NDWI Values

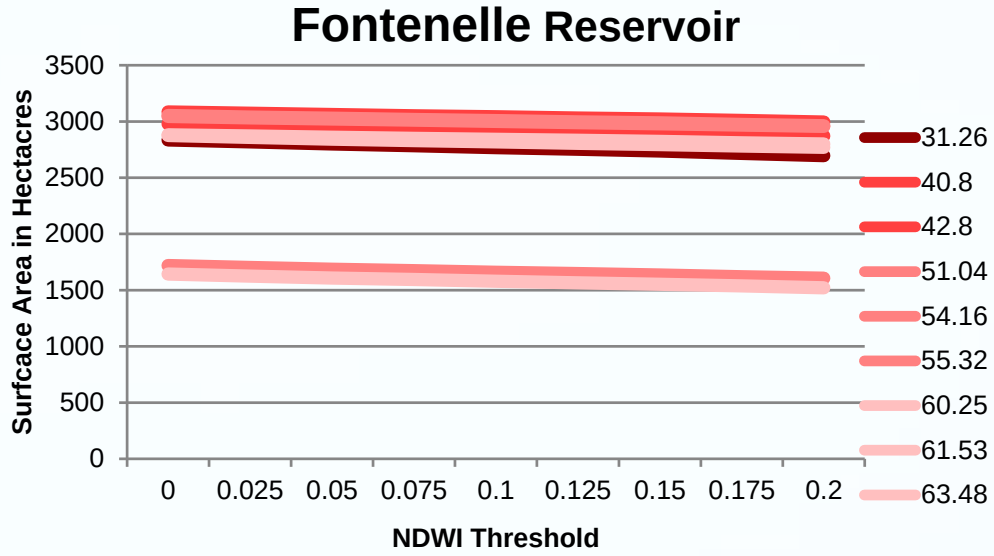
- Universal threshold
  - IF NDWI > 0 then WATER
- Tested the sensitivity by increasing the threshold value from 0.00 to 0.20 at 0.025 increments
  - IF NDWI > 0.025 then WATER (iteration 1)
  - IF NDWI > 0.050 then WATER (iteration 2)

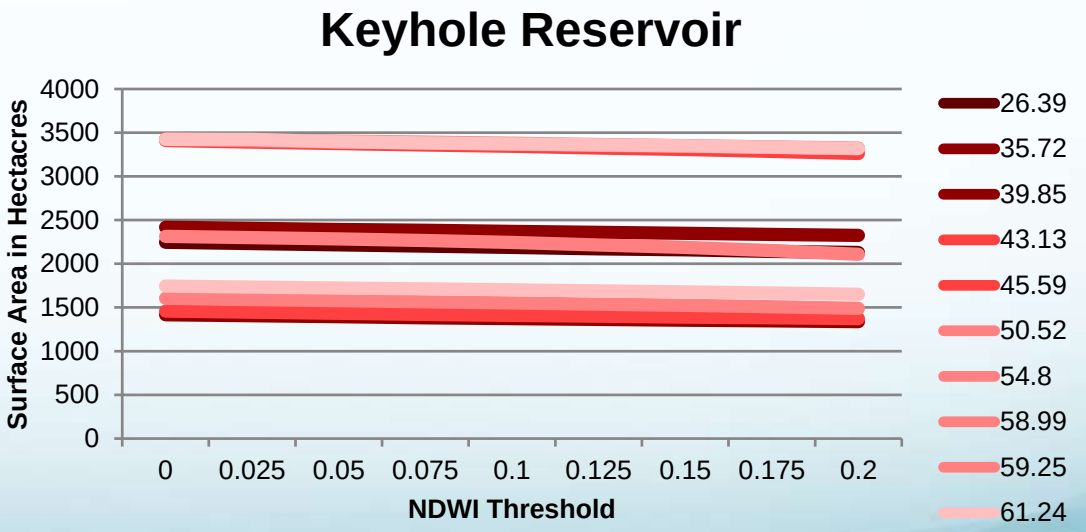
  - IF NDWI > 0.200 then WATER (iteration 8)
- If shadows influence NDWI sensitivity

Results

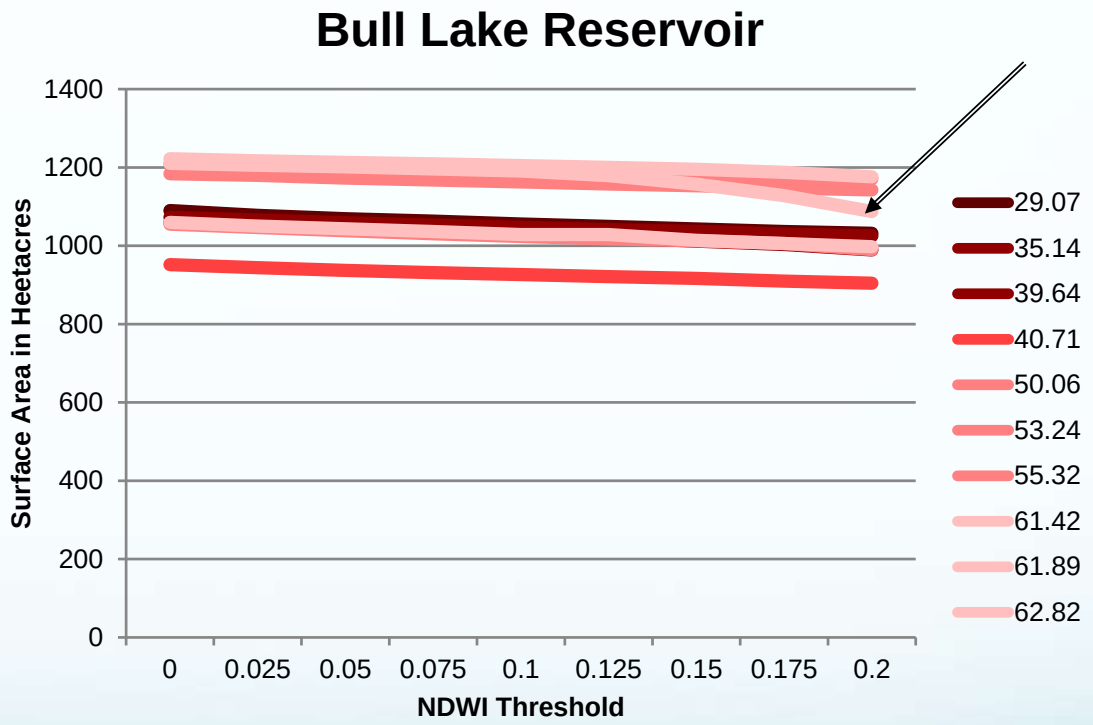


Recreation.gov
http://www.recreation.gov/unifSearchResults.do





http://www.usbr.gov/projects/Project.jsp?proj_Name=Keyhole+Unit
http://www.usbr.gov/projects/Powerplant.jsp?fac_Name=Fontenelle+Powerplant

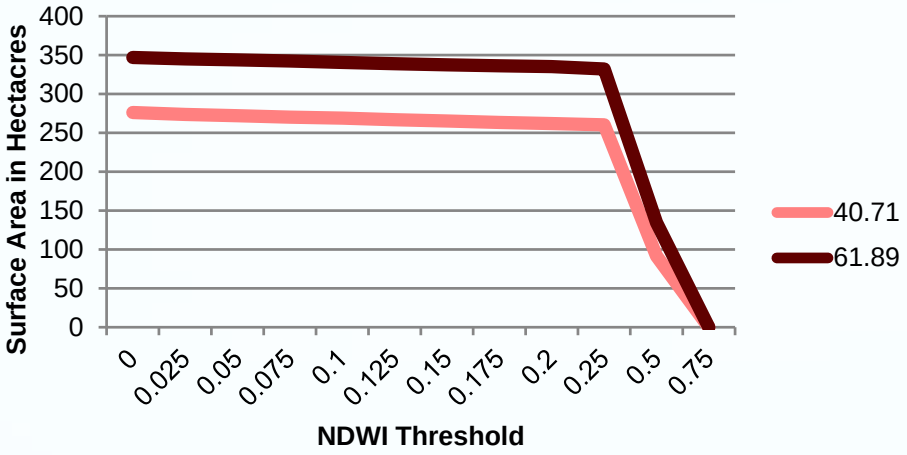


http://www.usbr.gov/projects/Facility.jsp?fac_Name=Bull+Lake+Dam

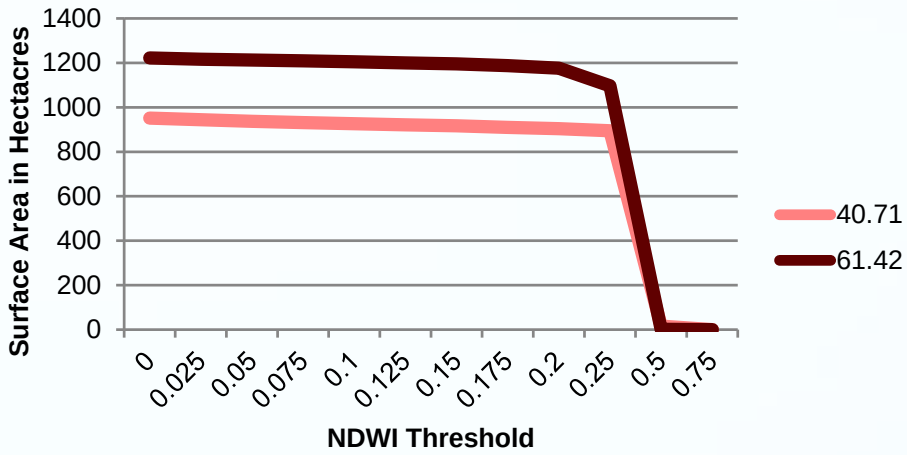
Extending the Range of Sensitivity

- Since no major change was noticed for 0 – 0.2
- Extended the threshold range:
  - Threshold values were changed from 0.25, 0.5, to 0.75
  - For the highest and lowest sun-angles for each reservoir

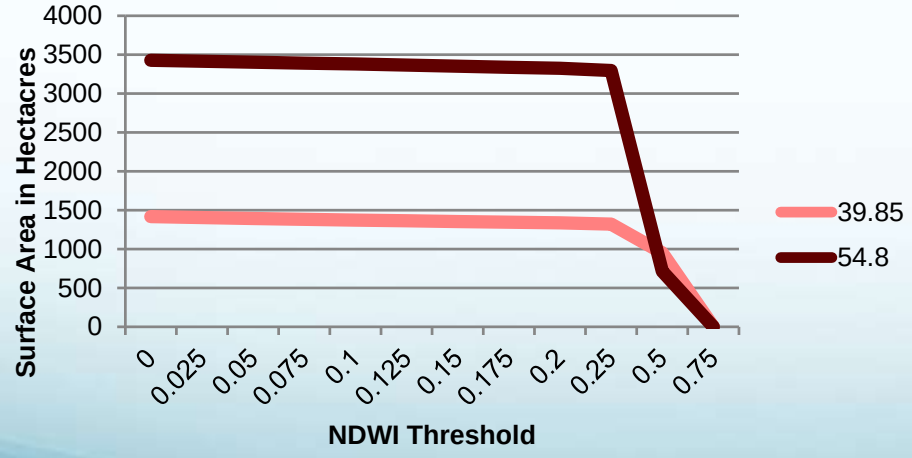
Pilot Butte Reservoir



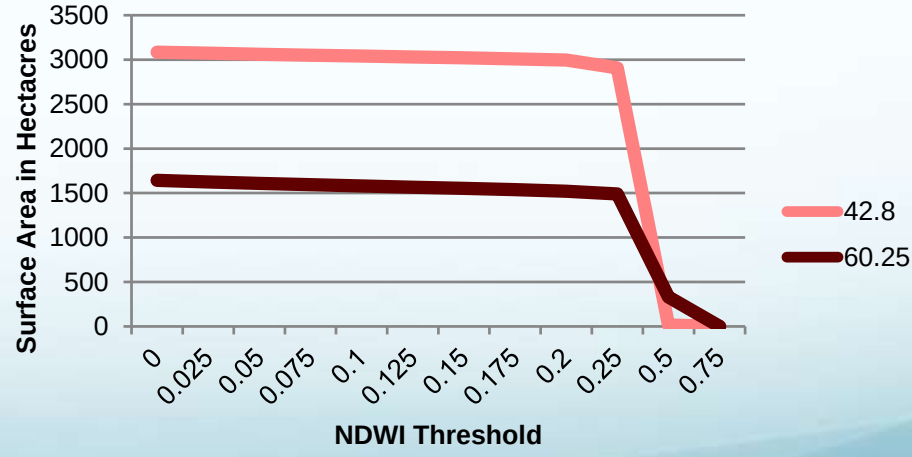
Bull Lake Reservoir



Keyhole Reservoir



Fontenelle Reservoir



Discussion

- Issues with Landsat include that they are hindered by external factors such as
  - Shadow
    - Similar patterns were noticed in Bull Lake, Pilot Butte and Fontenelle
    - Keyhole was more or less similar
  - Drought/wet years could have influenced
- Other factors that could:
  - Turbidity/Clarity
  - Eutrophication

Conclusion

- Sun angle does not influence area estimates derived from NDWI
  - Between 0.00 thru 0.20 threshold values
  - There is some decrease but very minimal
- Sun angle seem to influence at high NDWI threshold values
  - Future research must focus on 0.2 – 0.5 at 0.025 increments
- Do not combine drought and wet years
- Include more reservoirs with different external characteristics

Acknowledgement

- WyomingView (AmericaView/USGS) for this opportunity

- http://www.usbr.gov/projects/Powerplant.jsp?fac_Name=Fontenelle+Powerplant
- http://www.usbr.gov/projects/Facility.jsp?fac_Name=Bull+Lake+Dam
- http://www.usbr.gov/projects/Project.jsp?proj_Name=Keyhole+Unit
- http://www.usbr.gov/projects/Powerplant.jsp?fac_Name=Fontenelle+Powerplant
- http://novaonline.nvcc.edu/eli/evans/his135/events/landsat/chronology.html
- http://www.see.murdoch.edu.au/resources/info/Tech/house/
- http://landsat.usgs.gov