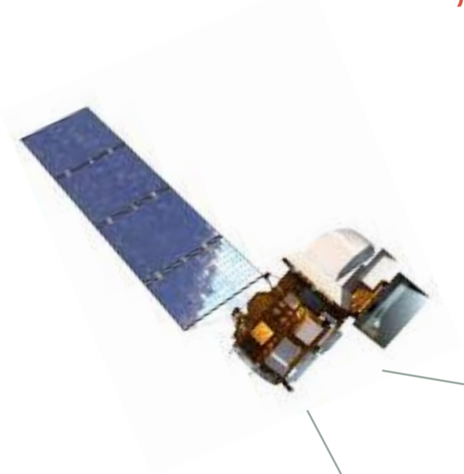
SNWA_EXH_614
Huntington Slideshow

REMOTE SENSING OF PHREATOPHYTIC SHRUBLAND: BACKGROUND, PROCESSING, AND APPLICATION



Justin Huntington, PhD

Phreatophyte Shrubland, Spring Valley

Introduction

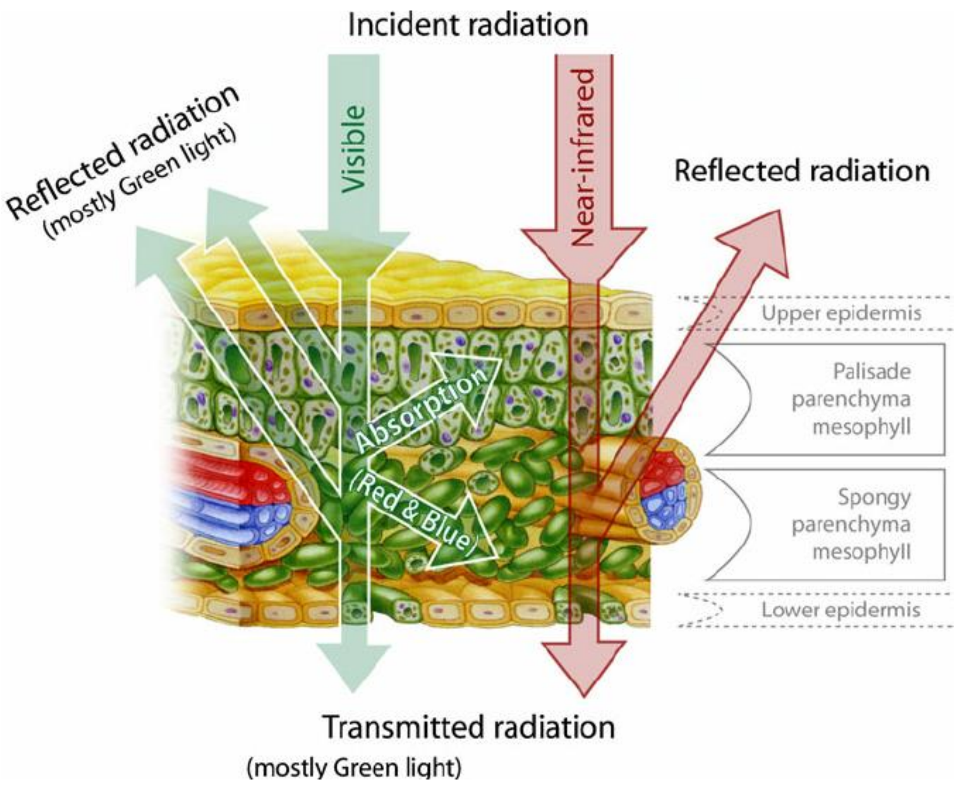
Phreatophytic Shrubland, Spring Valley

- Assessing long-term (i.e. ~30 years) variability is needed for establishing baseline conditions, and for assessing changes with respect to climate, hydrology, and resource management

- However, long-term monitoring of vegetation (i.e. greenness and cover) in time and space is generally lacking, especially phreatophytic shrublands of the Great Basin

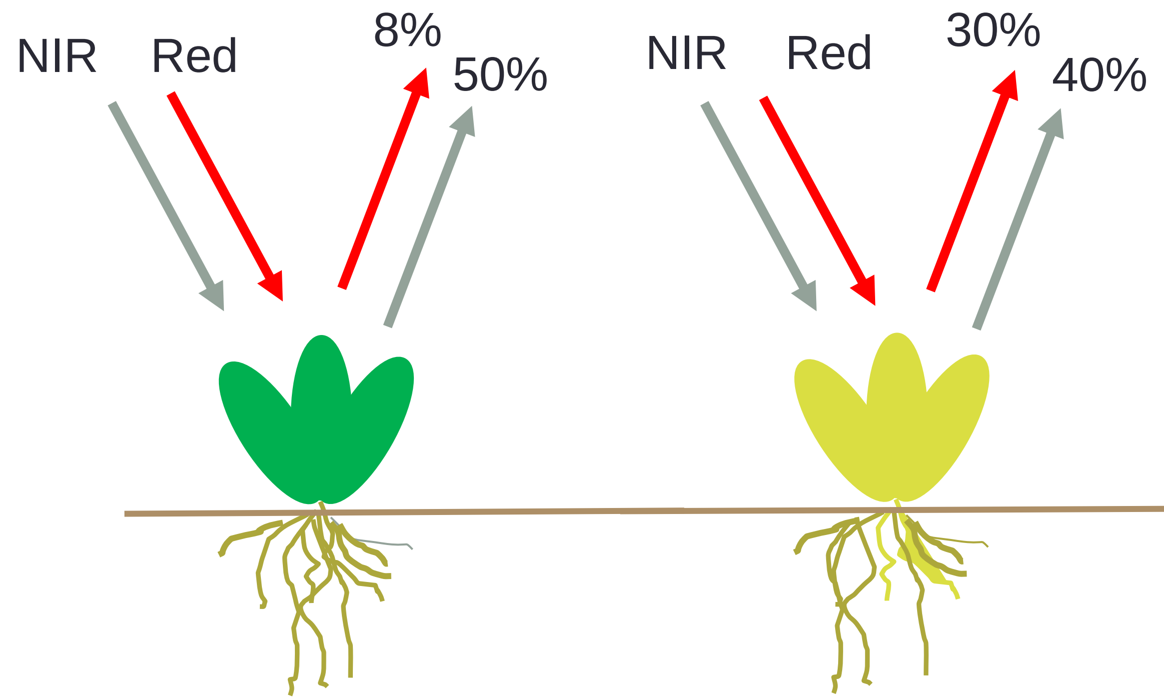
Introduction: Remote Sensing of Vegetation

- Chlorophyll is a pigment found in plants, and allows plants to absorb energy from light
- Chlorophyll is primarily responsible for absorption of the light in visible region of the electromagnetic spectrum (e.g. blue and red)
- Mesophyll tissues reflects near-infrared (NIR)



Introduction: Remote Sensing of Vegetation

- A simple example of how NDVI responds to differences in vegetation vigor
- Because it is physically based and simple, NDVI is the most widely used vegetation index



NDVI = (NIR – Red) / (NIR + Red)

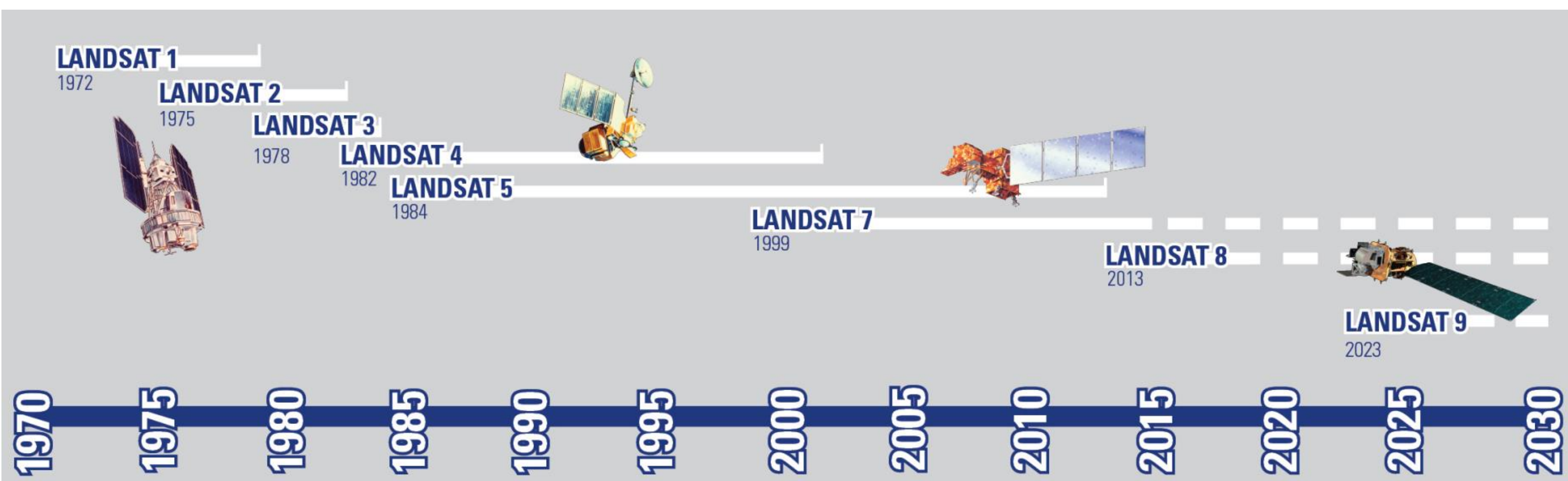
(0.50 – 0.08) / (0.50 + 0.08) = 0.72

(0.40 – 0.30) / (0.40 + 0.30) = 0.14

Landsat

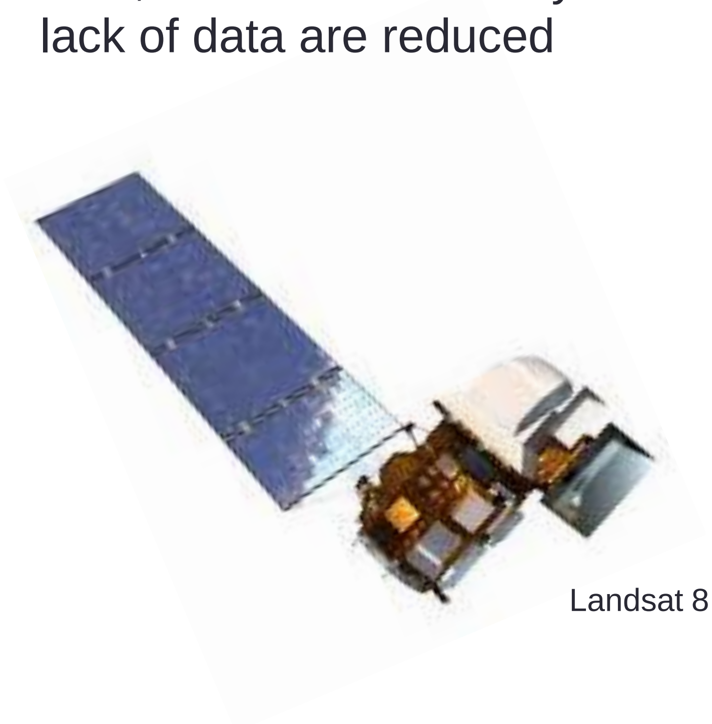
Landsat 8

- This joint NASA/USGS Landsat program provides the longest continuous space-based record of Earth's land in existence
- Every day, Landsat satellites provide essential information to help land managers and policy makers make wise decisions about our resources and our environment
- Due to differences in image quality and sensor compatibility, most studies of vegetation and vegetation change focus on the use of the Landsat 5, 7, and 8 archives (1984 to pres.)
- Planned launch for Landsat 9 is 2020 (moved up from 2023)
- Planning for Landsat 10 design for continued Earth observations is ongoing
- European Space Agency recently launched 2 Landsat-like satellites (Sentinel 2a,b) that can also be used for vegetation monitoring



Why Remote Sensing with Landsat?

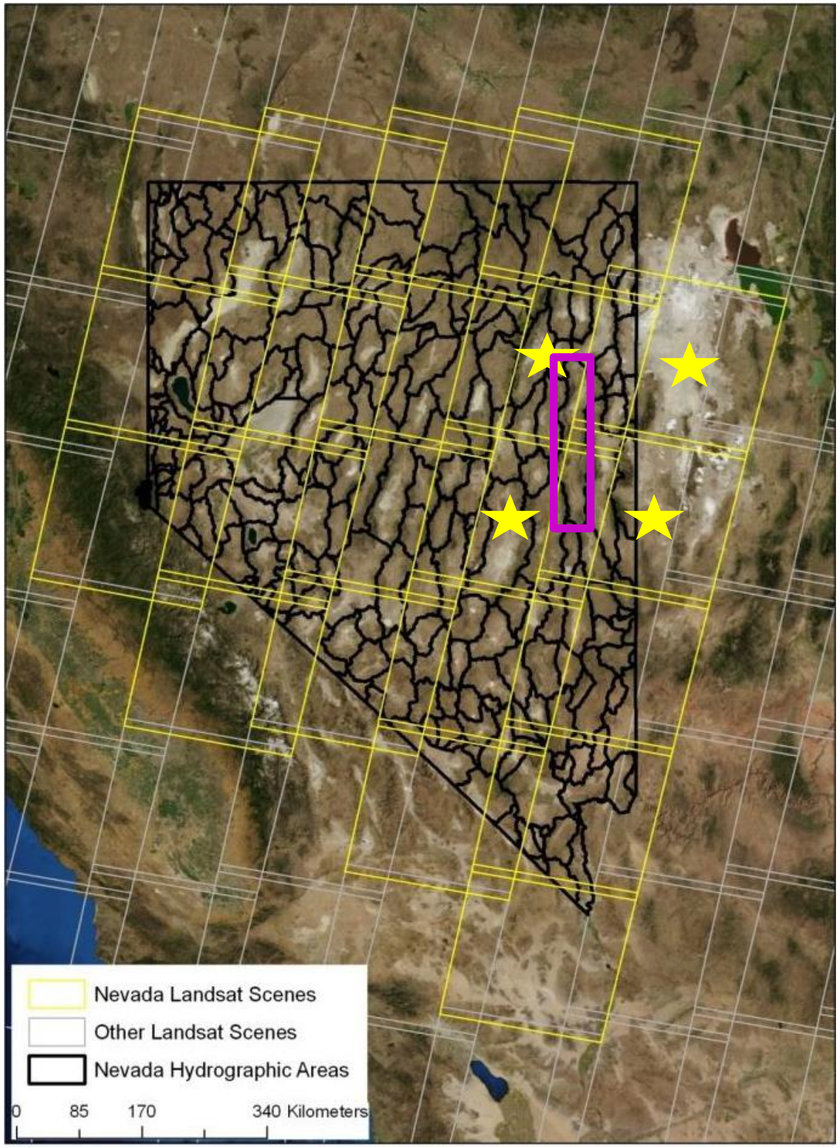
- Can provide vegetation cover information over the last 30+ years at relatively high resolution (i.e. 30m pixels)
- Optimal spatial resolution for mapping vegetation over space and time and resource management scales (i.e. field scale)
- Can complement field measurements of vegetation cover
- Can provide estimates where field measurement do not exist
- Also, with free availability of Landsat data for everyone, disputes over data or lack of data are reduced



Landsat 8

Landsat Path and Rows

- Landsat data are broken out by path and row, or “scenes”
- Spring Valley contains 4 different paths and rows (39:32, 39:33, 40:32, 40:33)
- ~1000+ Landsat images per path/row since 1985
- Equates to ~4,000 possible images to process for Spring Valley
- Equal to ~$ 2.5 million in imagery prior to 2009 ($600/image)
- Now it is all freely available via USGS, and in Google and Amazon clouds



Approach

General Approach:

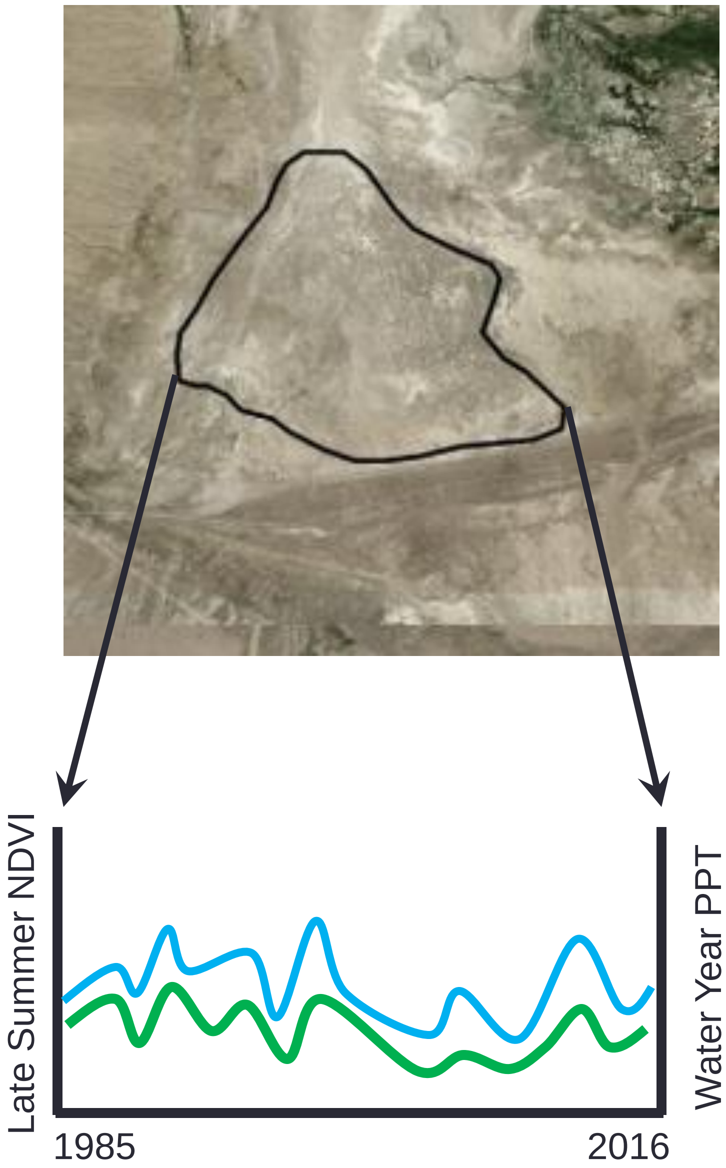
1) Define analysis areas

2) Derive time series of Landsat NDVI from 1985-2015

   - Focus on mid to late-summer period to minimize the signal from vegetation that can be highly variable due to seasonal precipitation, and maximize the relevant signal for tracking annual changes in vegetation in relation to groundwater availability

3) Derive time series of gridded weather data: water year precipitation (PPT) from 1985-2015

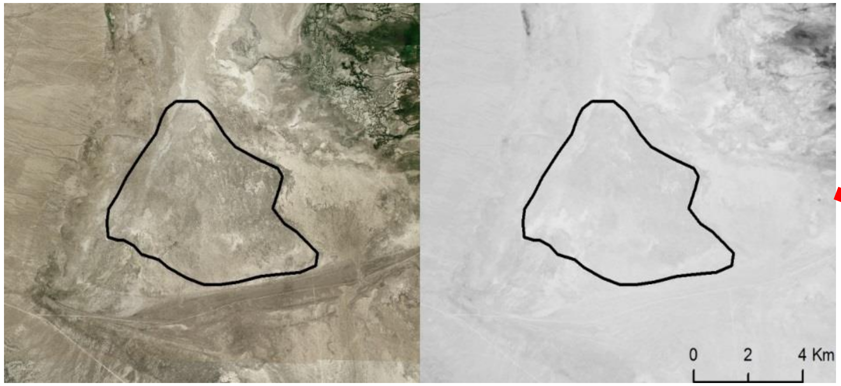
4) Develop useful graphical and statistical characterizations of baseline conditions for understanding temporal and spatial relationships between vegetation cover and climate, hydrology, and management



Approach – Follows Recent Work in NV

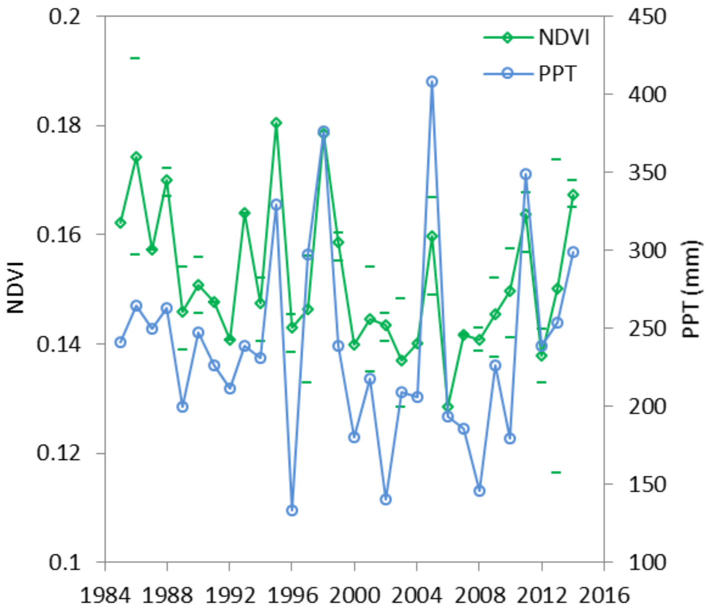
- Natural Background Variability
  - Spring Valley phreatophyic shrub area
- Groundwater level changes
  - Fish Lake Valley
- Riparian Restoration
  - Maggie Creek and Susie Creek – Middle Humboldt River

Spring Valley, NV

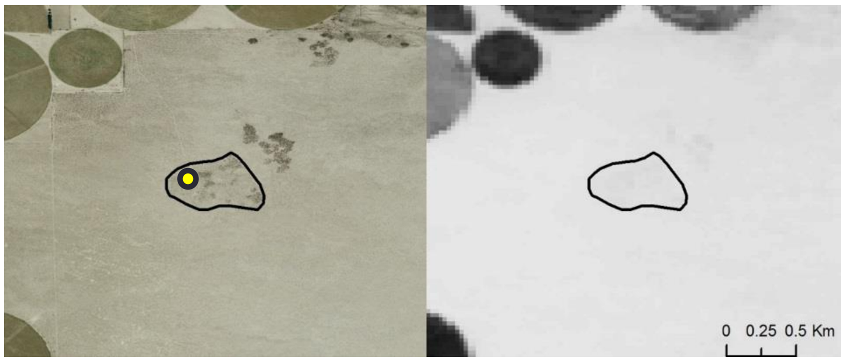


NDVI; Black = High, White = Low

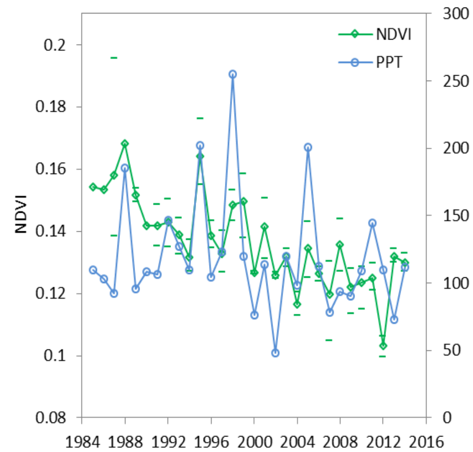
- Water year precipitation (derived from gridMET data) and Landsat NDVI generally track well over time
- Primary factors limiting the correspondence between water year precipitation ("PPT") and summer average NDVI are likely antecedent soil moisture conditions, and shallow groundwater stabilizing minimum vegetation vigor and NDVI
- The use of Landsat NDVI along with PPT estimates allows for baseline variability of vegetation and climate to be established at local to regional scales

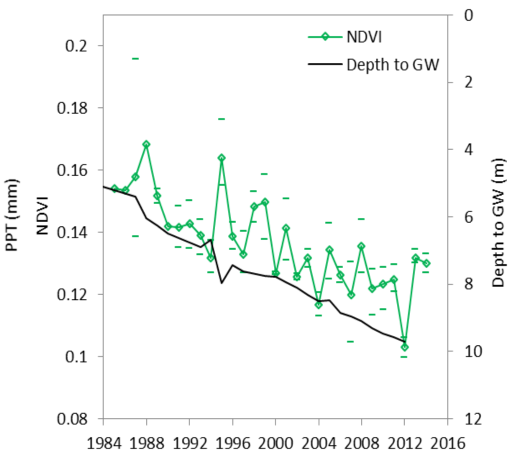


Fish Lake Valley, NV – Shallow Groundwater Level Changes



NDVI; Black = High, White = Low





- Inter-annual variability of Landsat NDVI generally corresponds with water year PPT variability
- Groundwater levels at the Arlemont Ranch well have steadily decreased since at least 1979 due to groundwater pumping for irrigation
  - Depth to groundwater was shallow prior to pumping
  - Approximately 5 m in 1985 and was 10m in 2014
- NDVI has also declined during the period of groundwater level decline, with intermittent NDVI increases that correspond to anomalously high annual PPT
- NDVI following groundwater decline never reaches early year values, even in wet years
- The trends of summer average, maximum, and minimum Landsat NDVI from 1985-2014 are statistically significant at the 95% confidence level
- Inter-annual Landsat NDVI time series can effectively be used to assess vegetation impacts due to lowering of shallow groundwater levels

Methods

- SNWA requested data derived from Landsat satellite imagery to quantify changes in shrubland habitat vegetation for the purpose of establishing baseline conditions and conducting long-term monitoring its Spring Valley monitoring, management, and mitigation (3M) program

- Landsat composite images, cloud masks and cloud score datasets, cross-sensor calibrated at-surface reflectance NDVI datasets, and gridMET PPT datasets from 1985-2015 were provided to SNWA for the Spring Valley Hydrographic Area

- Process
  - Accessed the Landsat Archive in the Google cloud
  - Applied atmospheric corrections
  - Applied Landsat cross-sensor corrections
  - Extracted cloud masks
  - Performed calculations in the Google cloud and downloaded image products
  - Provided image products to SNWA

Precipitation Data

- Monthly and annual PPT data were derived from University of Idaho's gridMET dataset
- gridMET is a hybrid 4 km spatial resolution daily PPT dataset based on the Parameter Regression on Independent Slopes Model (PRISM) (Daly et al., 1994) and NLDAS (Mitchell et al., 2004)
- gridMET has been shown to outperform or be similar to other gridded PPT products when comparing to independent valley floor PPT measurements in Spring and Snake valleys, Nevada (McEvoy et al., 2014)
- gridMET is ideal for ecohydrological applications and for pairing with Landsat data
- gridMET PPT data were processed, clipped, downloaded, and delivered to SNWA from 1985-2015

INTERNATIONAL JOURNAL OF CLIMATOLOGY
Int. J. Climatol. **33**: 121–131 (2013)
Published online 21 December 2011 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/joc.3413

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Development of gridded surface meteorological data for ecological applications and modelling

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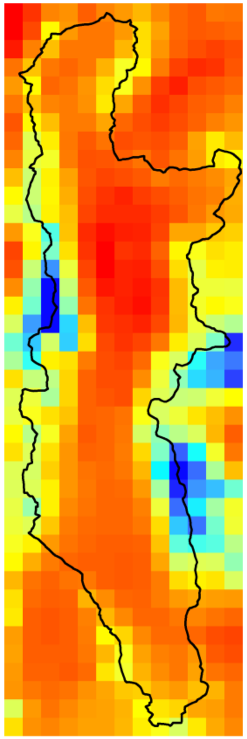
ABSTRACT: Landscape-scale ecological modelling has been hindered by suitable high-resolution surface meteorological datasets. To overcome these limitations, desirable spatial attributes of gridded climate data are combined with desirable temporal attributes of regional-scale reanalysis and daily gauge-based precipitation to derive a spatially and temporally complete, high-resolution (4-km) gridded dataset of surface meteorological variables required in ecological modelling for the contiguous United States from 1979 to 2010. Validation of the resulting gridded surface meteorological data, using an extensive network of automated weather stations across the western United States, showed skill comparable to that derived from interpolation using station observations, suggesting it can serve as suitable surrogate for landscape-scale ecological modelling across vast unmonitored areas of the United States. Copyright © 2011 Royal Meteorological Society

Additional Supporting information may be found in the online version of this article.

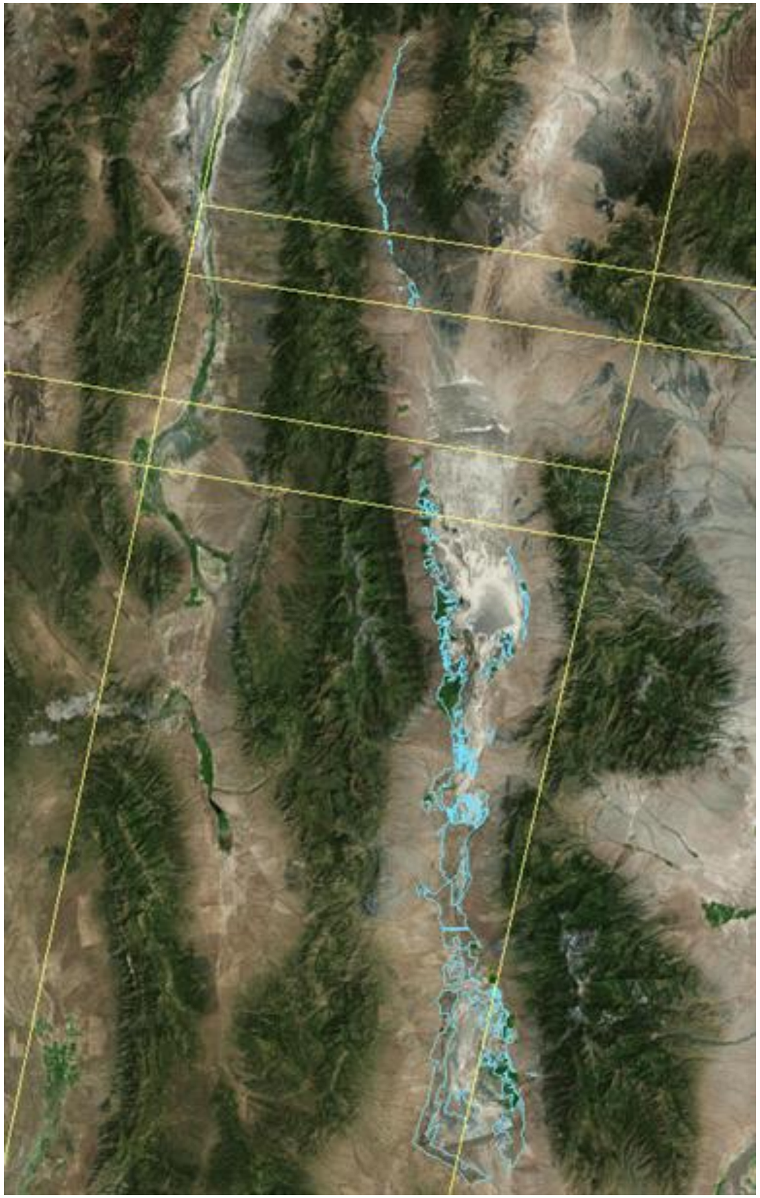
KEY WORDS weather data; humidity; agriculture; wildfire

Received 6 July 2011; Revised 13 November 2011; Accepted 15 November 2011



Spatial Averaging

- Python software scripts were developed and provided to SNWA for the purpose of producing NDVI and PPT zonal statistics for analysis areas
- SNWA applied the Python scripts and zonal statistic procedures correctly to produce spatially averaged NDVI and PPT datasets for analysis
- SNWA used the cloud mask and cloud score datasets appropriately to omit cloud cover data



Summary

- SNWA is utilizing data derived from satellite imagery to quantify changes in vegetation over time in order to establish baseline conditions and conduct long-term monitoring
- The Normalized Difference Vegetation Index (NDVI) is one of the most widely-used remote sensing indices for monitoring vegetation, and is commonly used as a proxy for vegetation cover
- Landsat satellite imagery was used to compute at-surface reflectance NDVI, and gridMet was used to estimate precipitation, for the Spring Valley HA from 1985-2015
- Methods used for processing
    - Atmospheric corrections
    - Cross-sensor corrections
    - Computation of at-surface reflectance and NDVI
    - Development of cloud mask and cloud score images
    - Clipping and extraction of Landsat and gridMET PPT datasets for the Spring Valley HA
- Spatial averaging scripts for post-processing Landsat and PPT data to shrubland habitat areas were provided to SNWA and used appropriately
- SNWA’s final NDVI and PPT datasets used in their shrubland habitat remote sensing analysis adhere to scientifically accepted standards
- The use of NDVI and PPT data is an appropriate method for monitoring shrubland habitat cover in the Great Basin