CLOUD COMPUTING OF LANDSAT IMAGERY AND GRIDDED WEATHER DATA FOR EVALUATING GROUNDWATER DEPENDENT ECOSYSTEMS IN NEVADA

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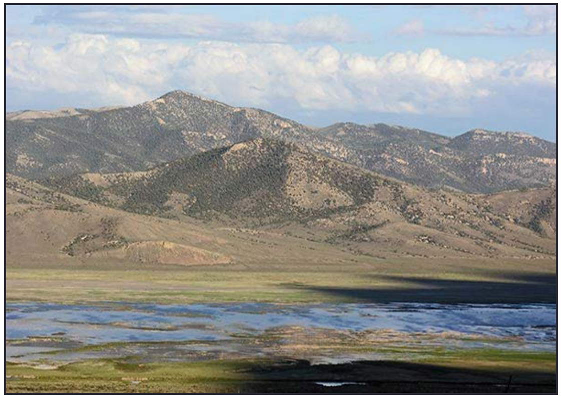
Introduction

- Many sensitive species rely on habitat areas that are groundwater dependent, such as meadows, spring complexes, and riparian corridors

- Management and restoration, and changes in precipitation and air temperature cause significant changes in vegetation vigor within these areas



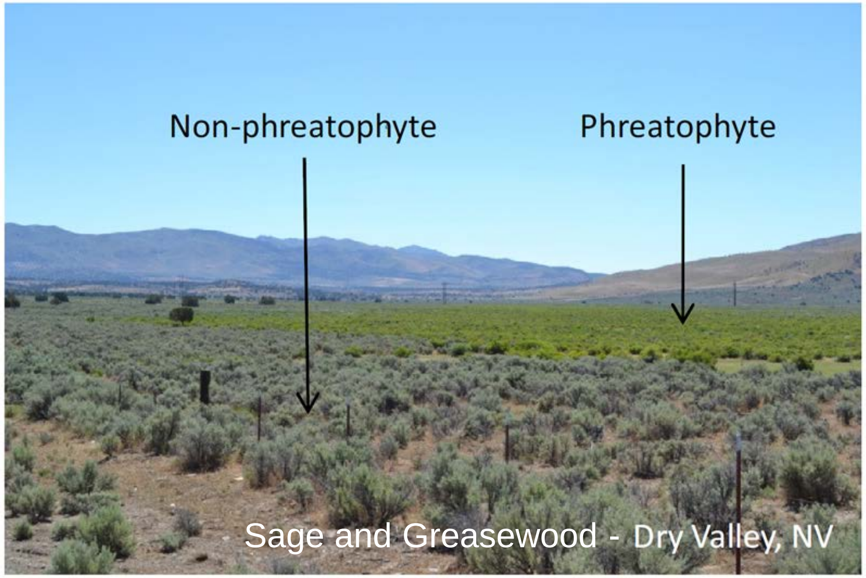
Ruby Lake,
Ruby Valley

Bog Hot Springs,
Continental Lake Valley

Big Springs, Snake Valley

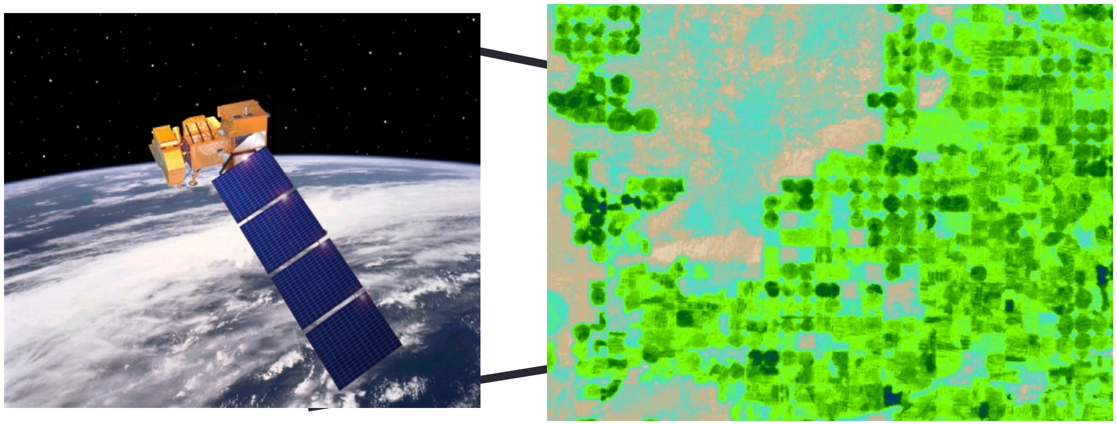
Introduction

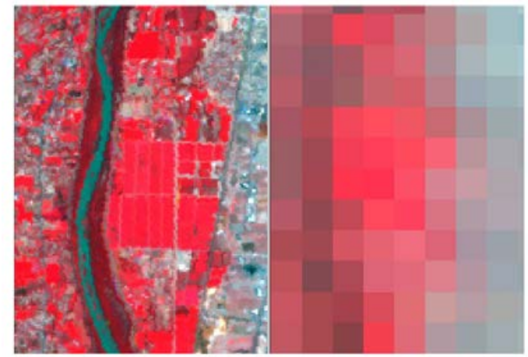
- In addition, groundwater pumping and water development can cause changes in vegetation vigor
  - Many times designed to reduce ET/vigor.. is the basis of ‘perennial yield’ : capture natural discharge for beneficial use
- To better understand if vegetation changes are natural or anthropogenic, natural background variability must be well understood
- Analyzing background variability will increase the effectiveness of sensitive species management plans, and monitoring plans associated with water development projects (i.e. 3M)



Remote Sensing for Vegetation and Water Use Monitoring

- Remote sensing using Landsat is arguably the only way to estimate vegetation condition and water use at field scales over large areas





Landsat MODIS

- Landsat pixel size (30m x 30m) is optimal for evaluating individual fields and riparian zones

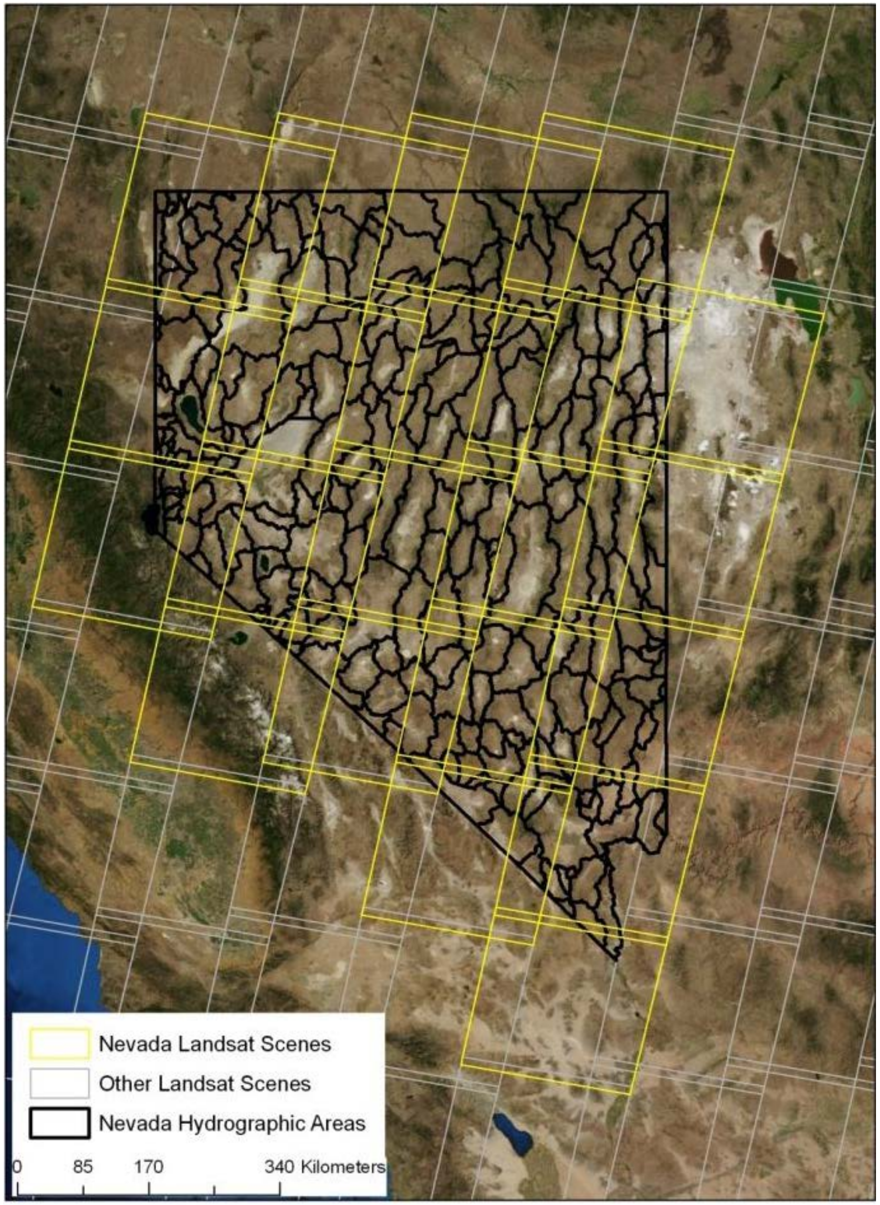
- Recent USGS/NASA Landsat Science News Clip - *Landsat can be an Impartial Arbitrator in Water Conflict Issues* – Article highlights our remote sensing work in Nevada

  "Access to accurate ET maps produced using a widely accepted approach allows us to assess water use on a field by field basis in an <u>objective</u> way where everyone is treated equally."

  "With <u>equality</u> of data for everyone, disputes over data or lack of data are reduced, which is a big change in how water conflicts have been dealt with in the past."

Objectives

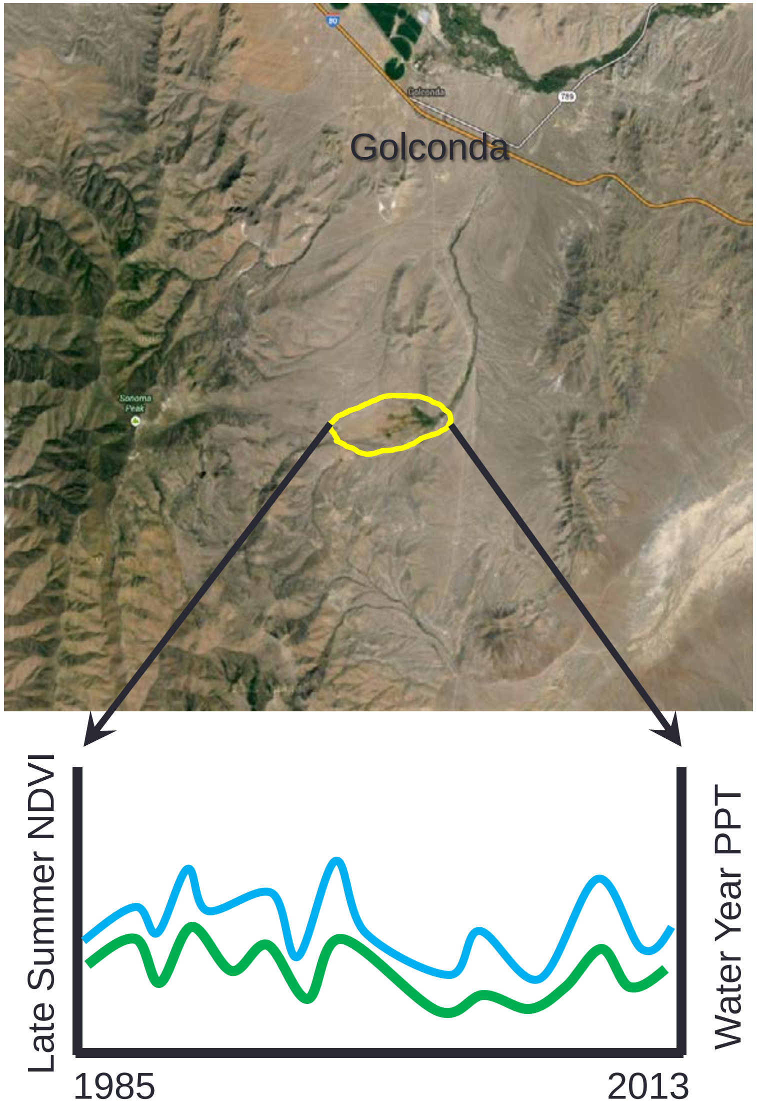
- Develop a tool to better understand the long term spatial and temporal variability of groundwater dependent vegetation and water use
- Rely on Landsat satellite imagery (8-16 day return intervals) to compute vegetation indices
- Rely on gridded weather data to estimate PPT and ET_o
- Problem – lots and lots of data and processing..
  - 21 scenes for NV
  - 1000+ Landsat images per path/row since 1982
  - Equates to >20,000 images to process..



Approach – Feature Driven Analysis and Cloud Computing

General Approach:

1) Define target vegetation features on landscape



2) Derive time series of satellite-based measures of vegetation abundance/vigor (i.e. NDVI, EVI, MSAVI, etc..) for late summer

3) Derive time series of gridded weather data: water year PPT

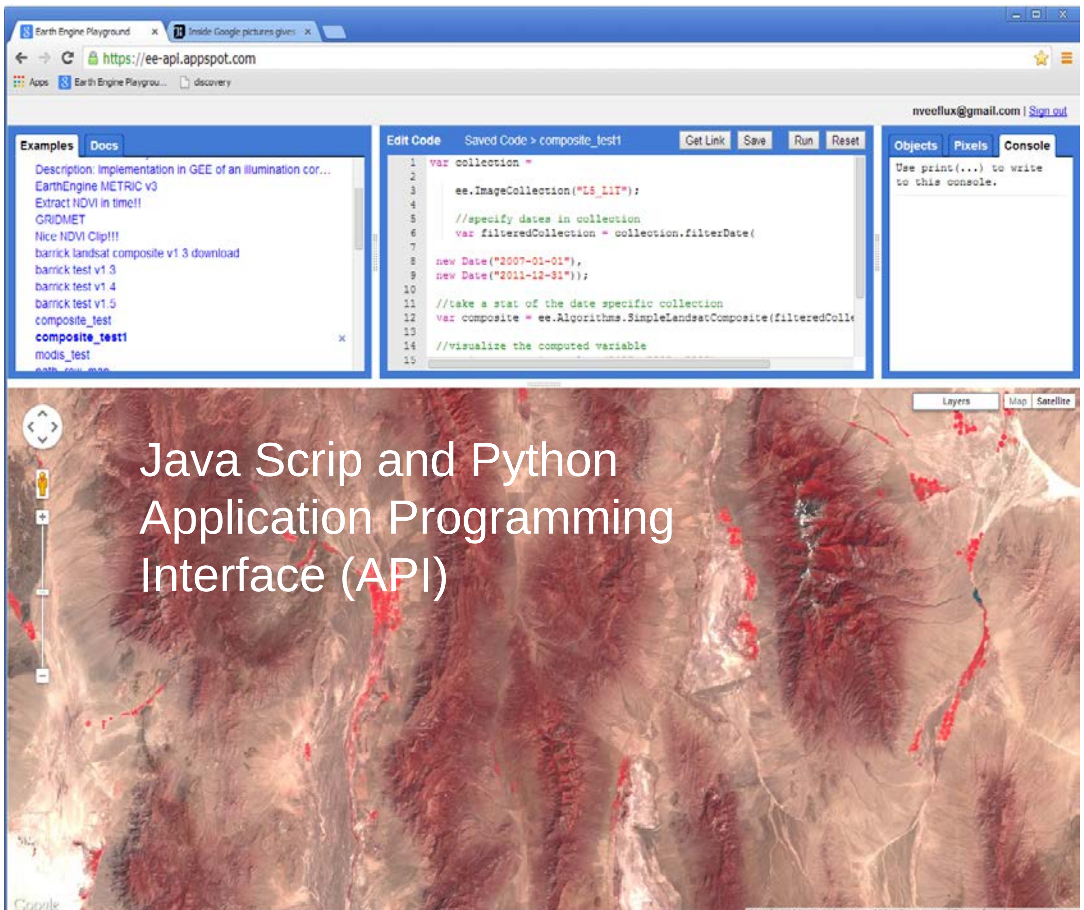
4) Develop useful graphical and statistical characterizations for better understanding temporal relationships

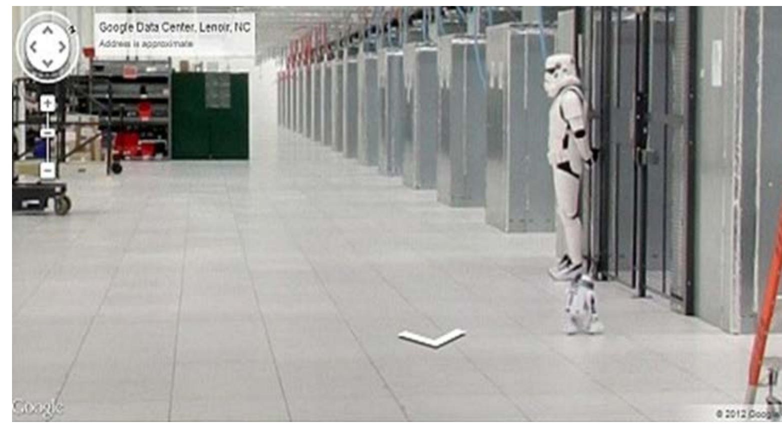
Example of Vegetation Change Using Google Earth Engine (exists for anywhere…)

Earth Engine › Landsat Annual Timelapse 1984-2012

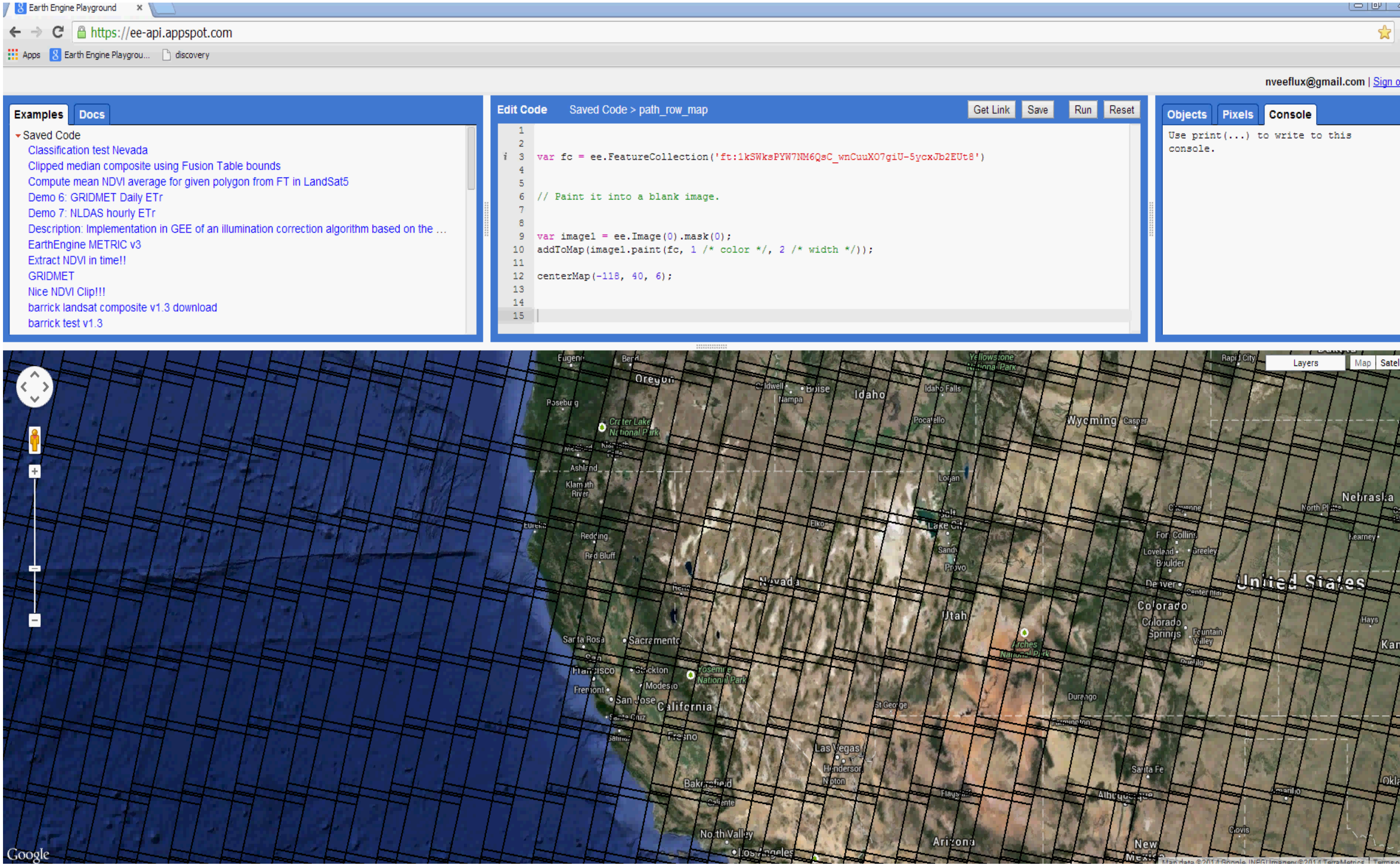
Approach – Google Cloud Computing Farm

- Rely on Google Earth Engine cloud computing and environmental monitoring platform
- Google has the entire archive of Landsat archive and downscaled Land Data Assimilation System (NLDAS) gridded weather data available for massive parallel processing in the cloud
- This technology has changed the paradigm of how we process and analyze Landsat imagery



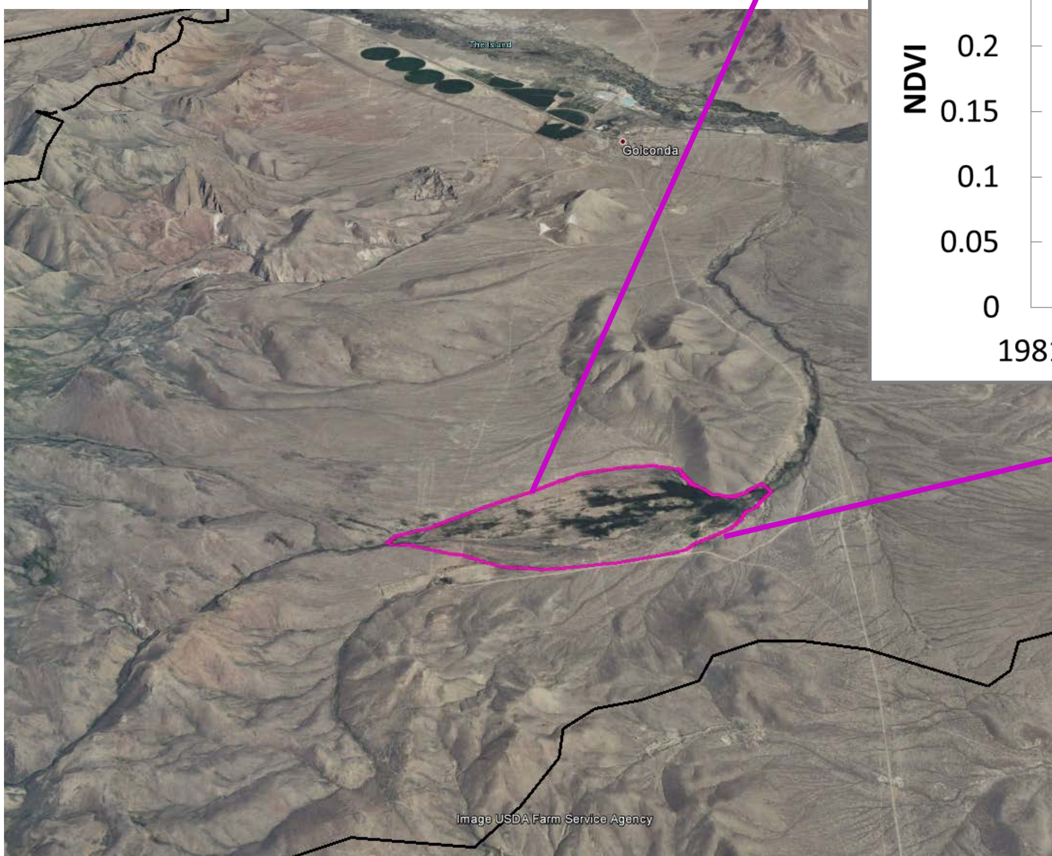


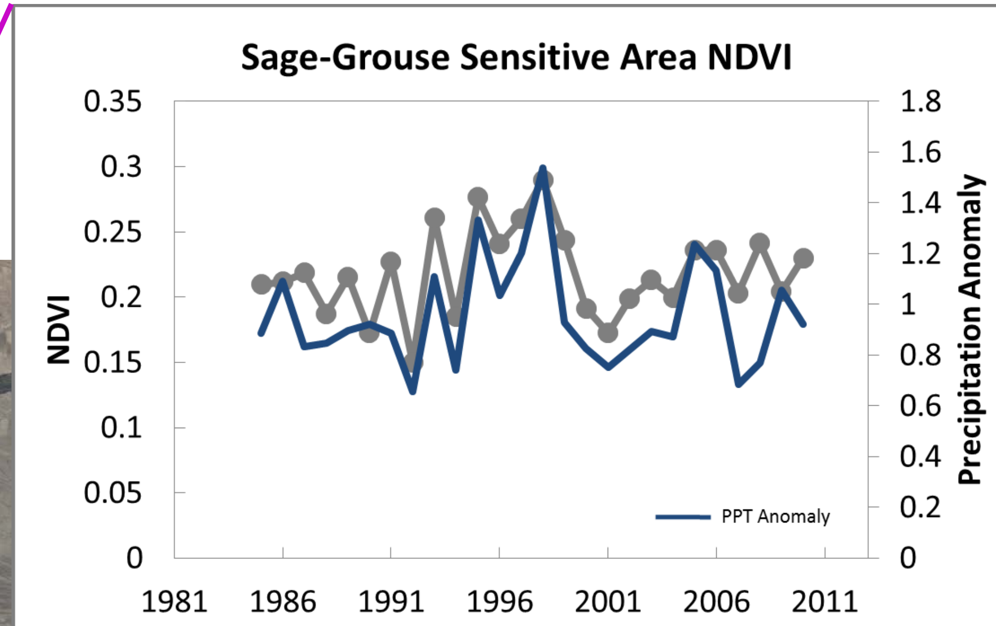
Demo of Google EE Playground – Clip and Compute NDVI



Preliminary Tests – Sage-grouse Sensitive Area

- Natural variability for wet patch near Golconda



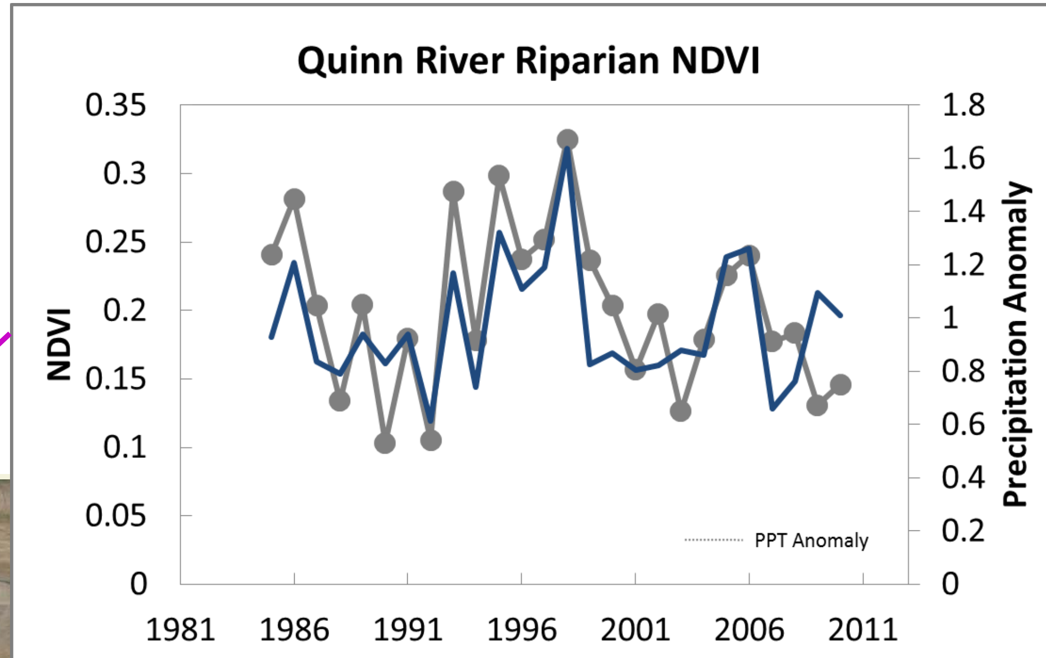


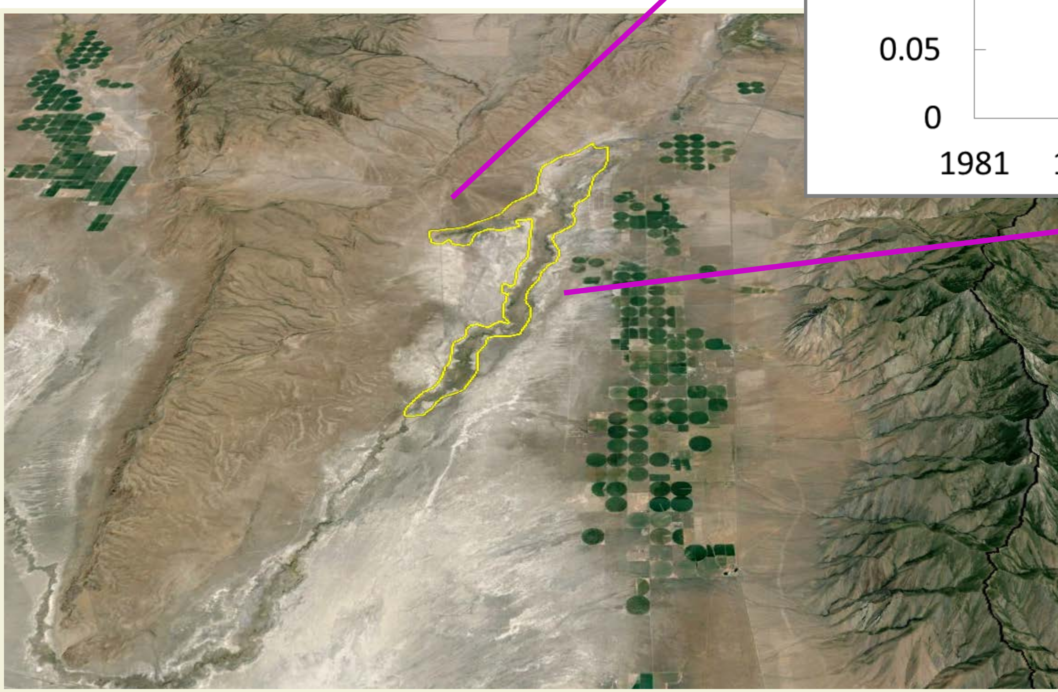
Aug-Sept Avg. NDVI (Grey)

Water Year PPT Anomaly:
WY PPT / Mean WY PPT (Blue)

Preliminary Tests – Quinn River Riparian

- Natural variability for riparian area near Orovada
- Pumping up gradient, but cant obviously detect any decline in riparian vigor..



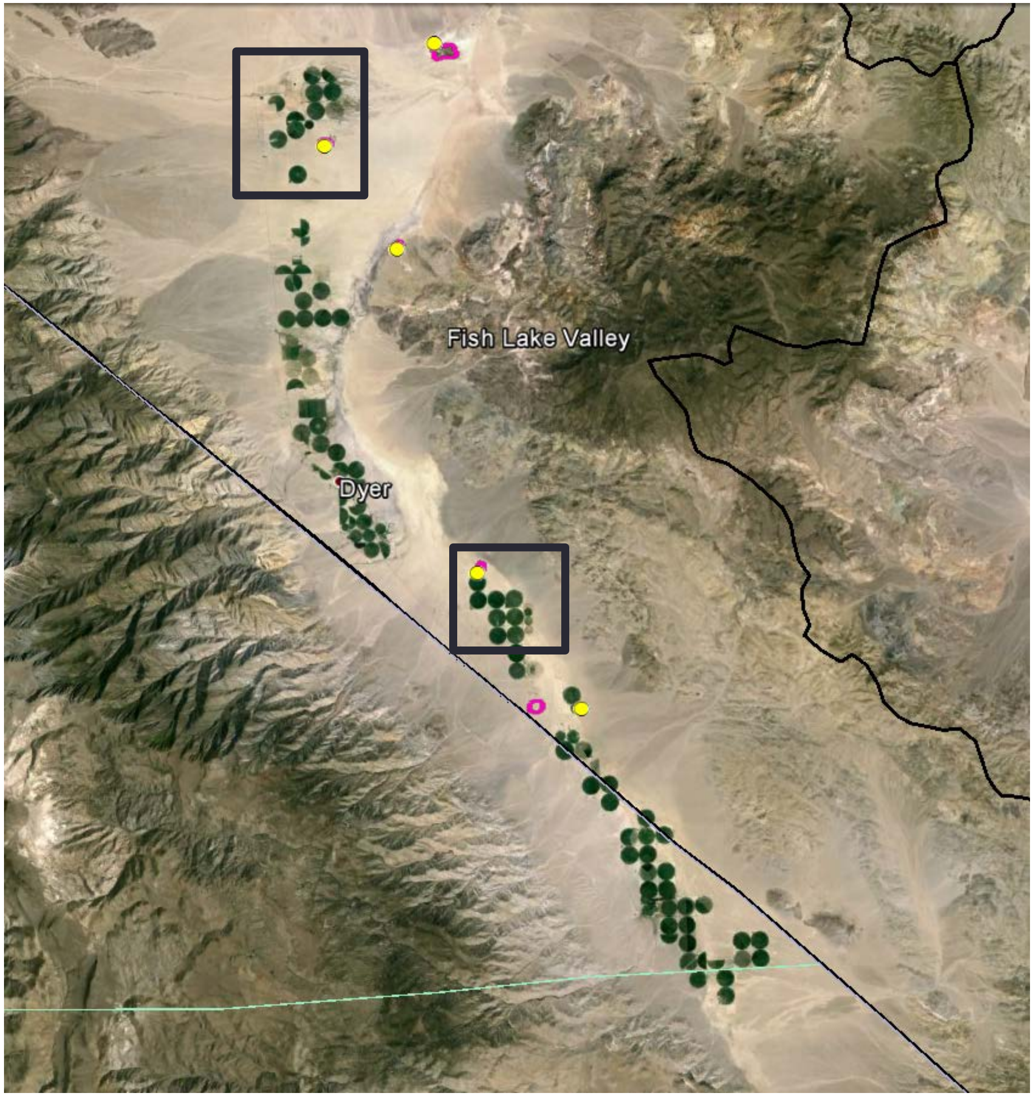


Aug-Sept Avg. NDVI (Grey)

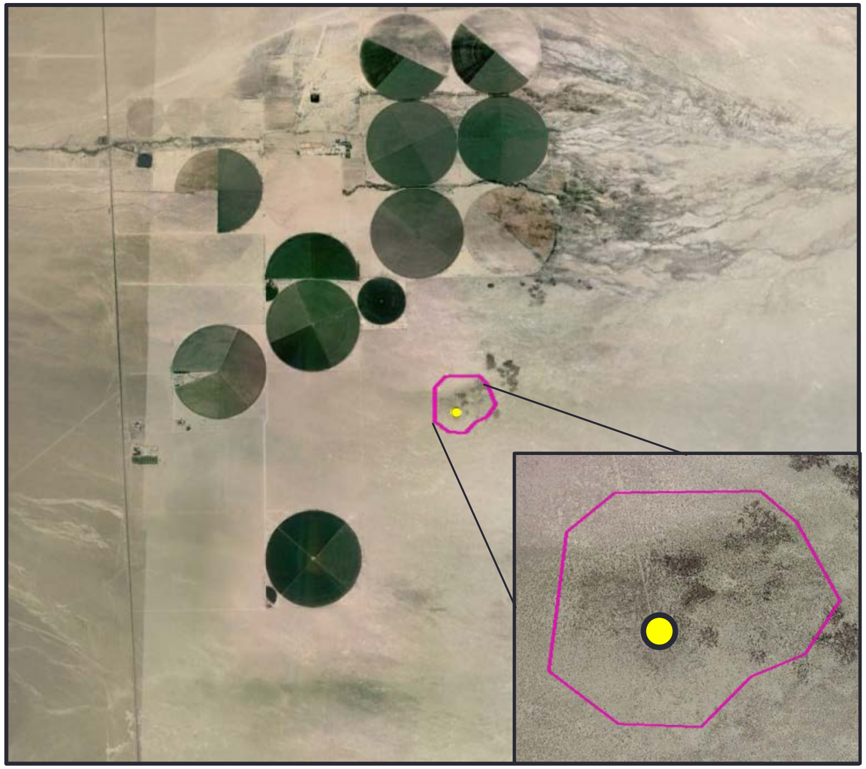
Water Year PPT Anomaly:
WY PPT / Mean WY PPT (Blue)

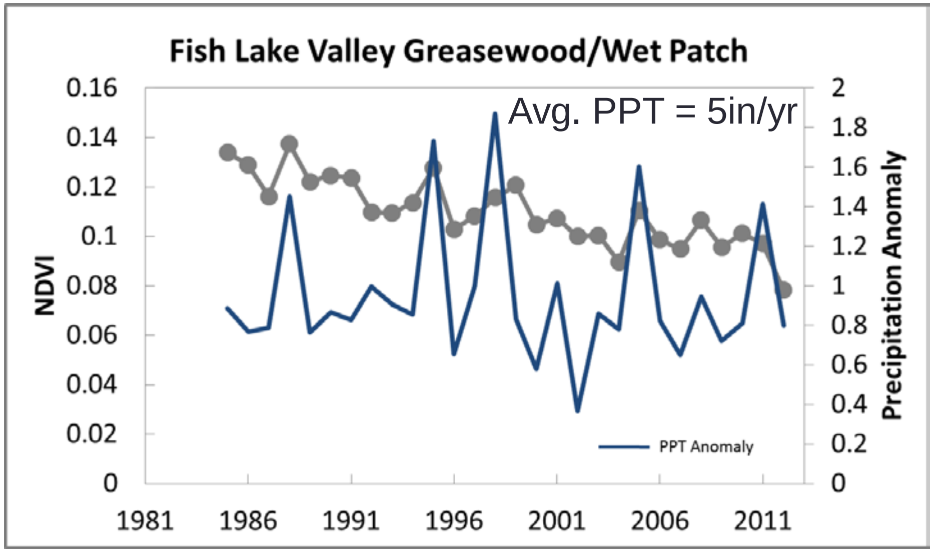
Preliminary Tests – Fish Lake Pumping & Greasewood Phreatophytes

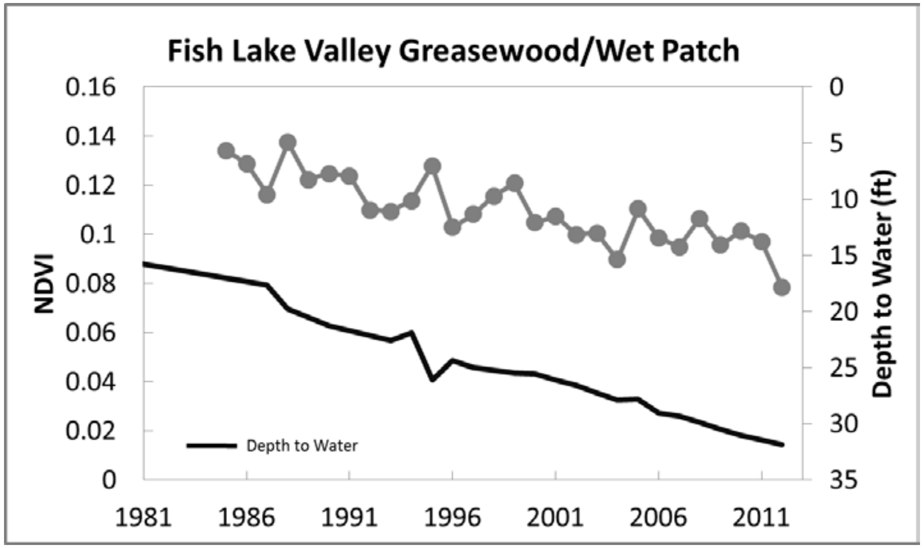
- Fish Lake Valley example of pairing Landsat NDVI with PPT and pumping
- Groundwater is primary source of water for irrigation in the valley
- Test – can we see changes in greasewood due to pumping?



Preliminary Tests – Fish Lake Pumping & Greasewood Phreatophytes

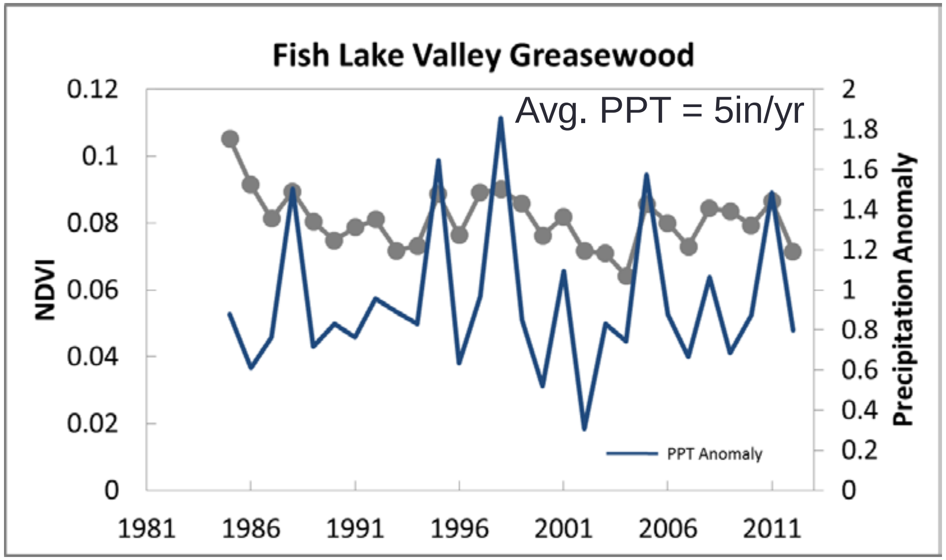


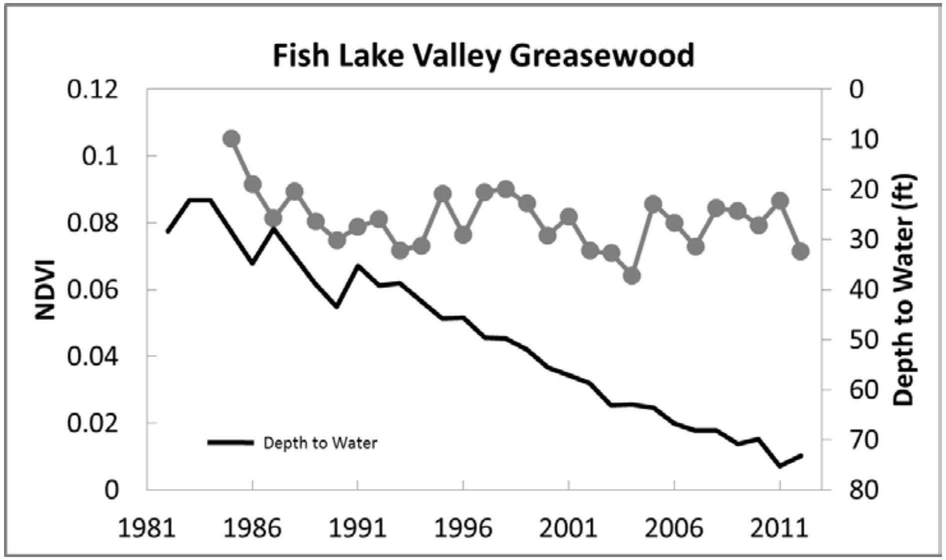




- Arlemont Ranch well (117 S01 E35 35CC 1) measured by NDWR
- Digitized polygon around well, ~ 0.25 miles across; is largerly comprised of greasewood
- Evaluated spatial average Aug-Sept NDVI, PRISM PPT, and water levels
- NDVI declining; GW levels declining

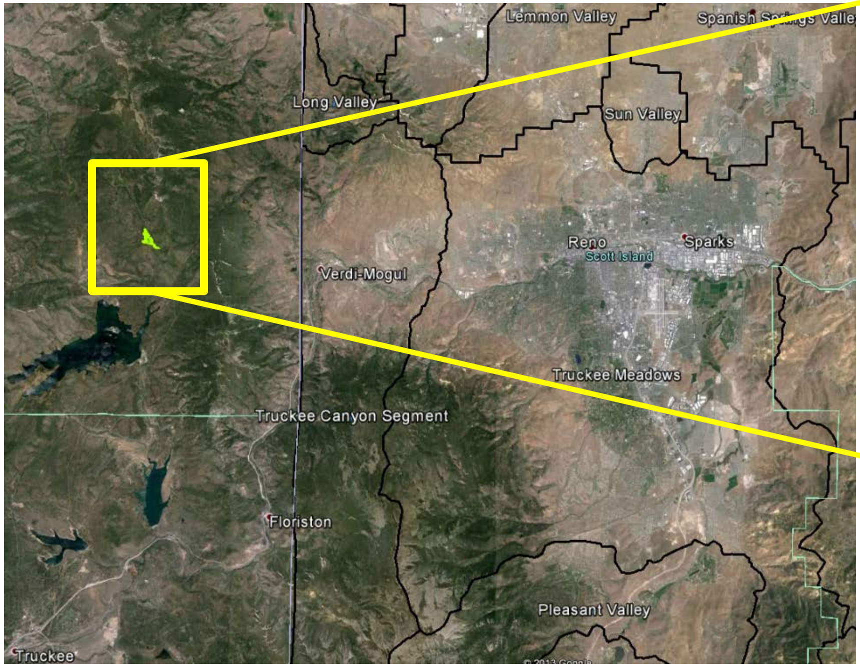
Preliminary Tests – Fish Lake Pumping & Greasewood Phreatophytes

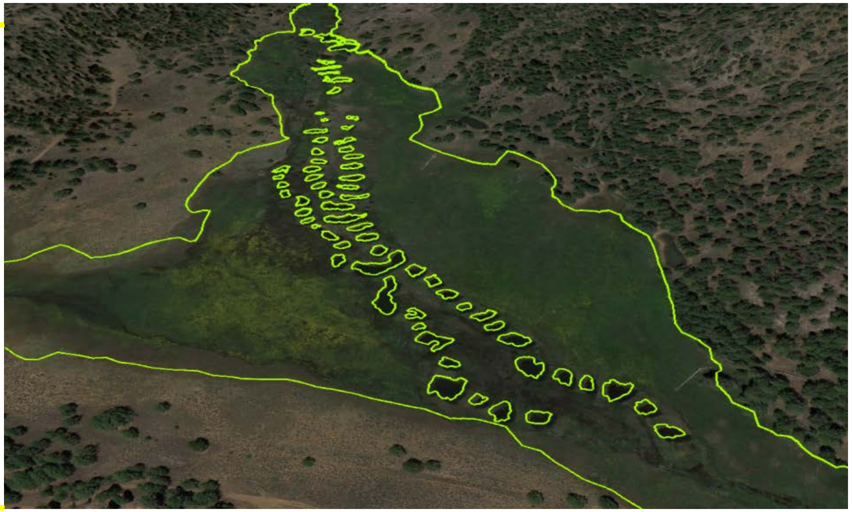




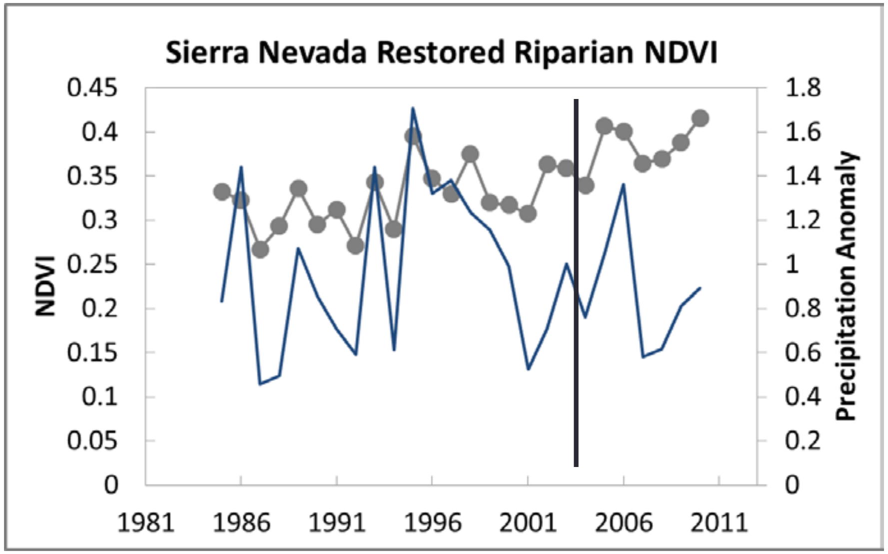
- Baldwin Ranch well (117 S03 E36 32CD 1) measured by NDWR
- Digitized polygon around well, ~ 0.15 miles across; is comprised of greasewood
- Evaluated spatial average Aug-Sept NDVI, PRISM PPT, and water levels
- NDVI slighly declines until early 90s, then stabalizes; GW levels decline
- Looks like we caputred GWET, but Greasewood did not DIE or go away!!!

Preliminary Tests – Sierra Nevada Restored Meadow – Plug and Pond

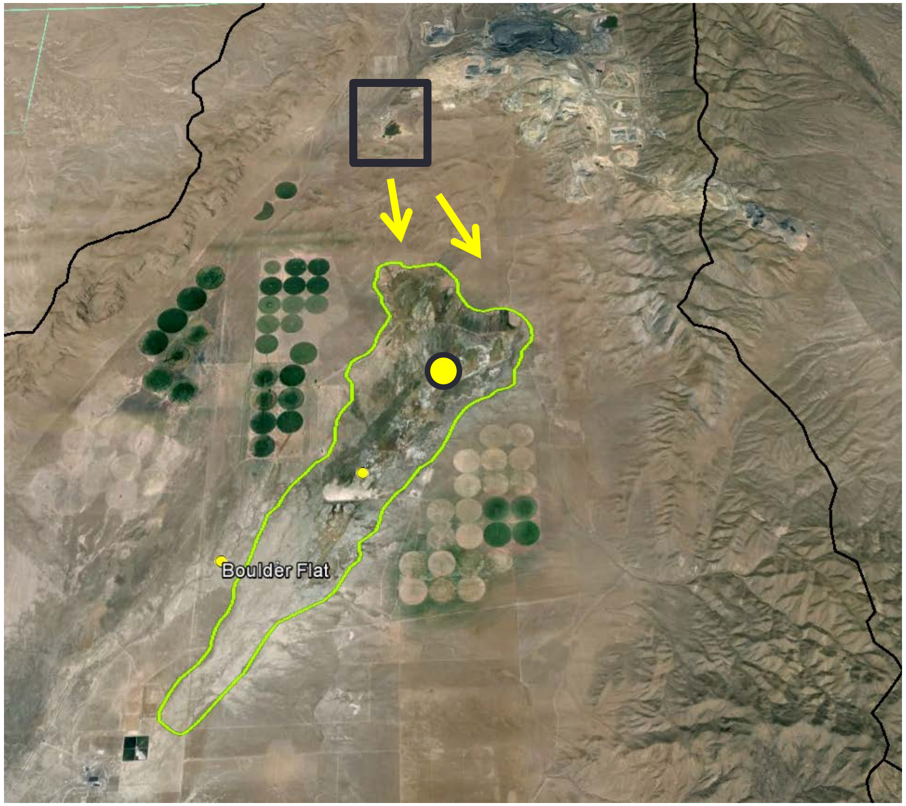


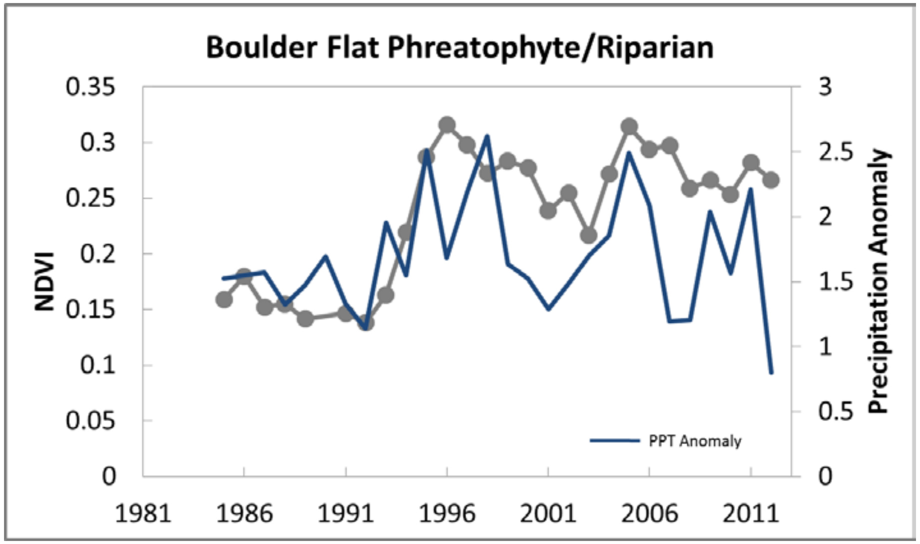


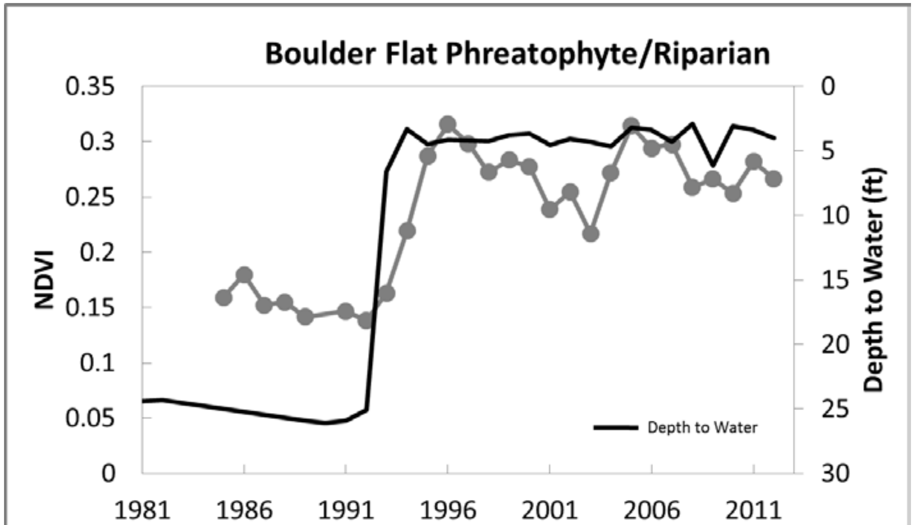
- Sierra Nevada wetland restored in 2004 using plug and pond methods (put a structure in the stream bed, divert the stream into ponds, fill the meadow aquifer)
- NDVI stays high after 2004 while precipitation does not.
- This result is likely related to restoration



Boulder Flat Phreatophyte Increase

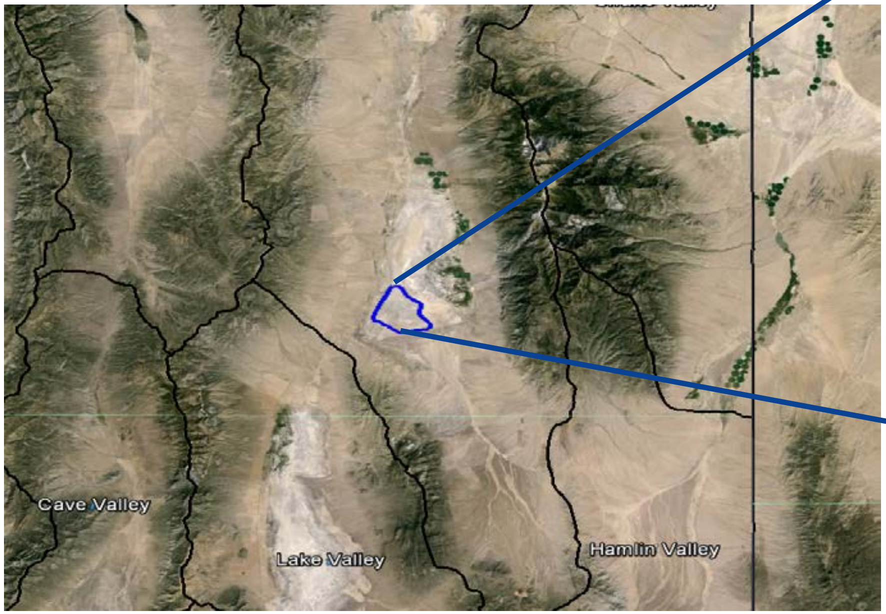


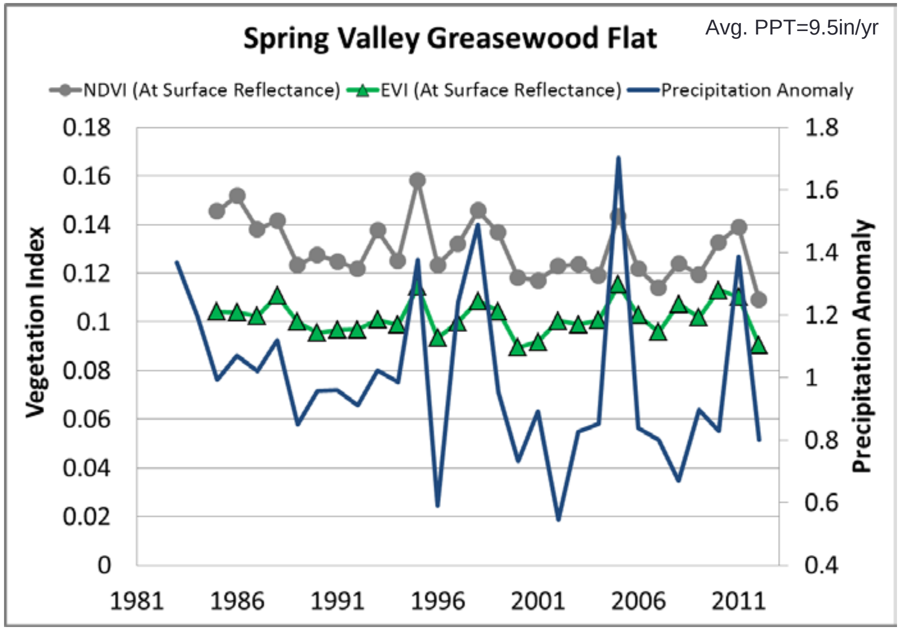




- Recharge of mine water up gradient started ~ 1991, and created springs down gradient
- TS Ranch 3 well (061 N34 E49 02BDAD1) in spring area measured by Barrick
- GW levels increase sharply in 1992
- NDVI (and ET) increases in 1992-1994 and flucutates with PPT thereafter

Background (& Future) Monitoring – Spring Valley





- Background vegetation is closely correlated with water year precipitation variability
- Looks like NDVI and EVI tracks with PPT at long and short time scales
- This is important to know as agencies go foward with biological and hydrological monitoring, and upscale field plant cover monitoring with remote sensing products

Summary

- Cloud computing with Landsat imagery provides, for the first time, the ability to process thousands of images fairly easily, and therefore makes it economically feasible
  - For this presentation > 3,000 images were processed…
- Seems that as we capture groundwater ET from greasewood flat areas, greasewood DOES NOT die, rather vigor is reduced, and then lives of PPT
  - More vigor there is to start before pumping, more declines will be observed
  - If the greasewood flat area is already sparse to moderate, it is unlikely that there will be large changes in vigor… (maybe..)
- Important to know LONG TERM background variability (use Landsat)
- Next steps are to convert vegetation indices into ET estimates, which we have published methods for doing so..

Landsat 8, Launched Feb 11, 2013

Many thanks to:
You
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NV Division of Water Resources
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