Disturbance histories increase variability in remotely sensed indices of vegetation in sagebrush-steppe over the past ca. 20 years

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M.S. Thesis Defense

Dec. 1, 2004

Disturbance

- Events that cause abrupt change in ecosystem processes, or population and community structure.
- Alter resource availability or other aspects of the physical environment.
- Influence vegetation response in sagebrush-steppe.

Sagebrush-Steppe Ecosystems

- Experience combinations of natural and anthropogenic disturbances, such as:
    - wildfire and prescribed burning
    - domestic livestock grazing
    - variation in precipitation (i.e. drought)

- Disturbance impacts have mostly been studied separately at the small scale, plot level.

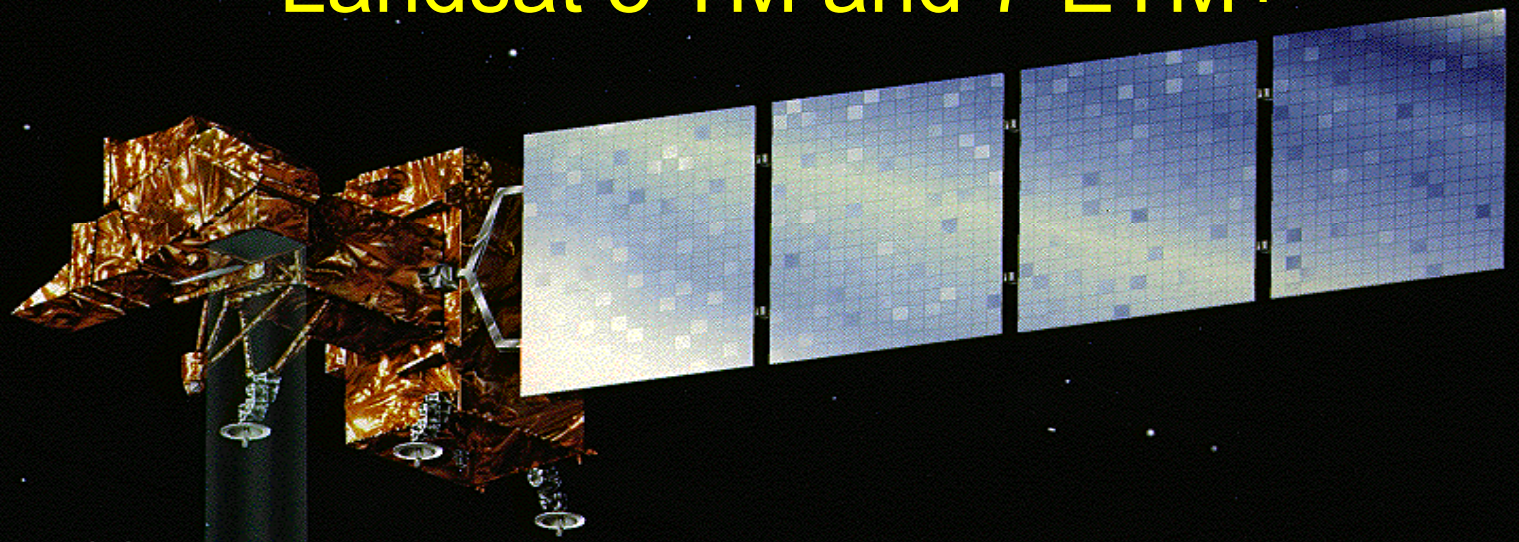
- Landscape-level assessments are needed to better match scale at which rangeland management occurs.

Remote Sensing

- Provides periodic measures of vegetation cover.
- Quicker than field assessments with no temporal variations.
- Large spatial format provides a synoptic view.

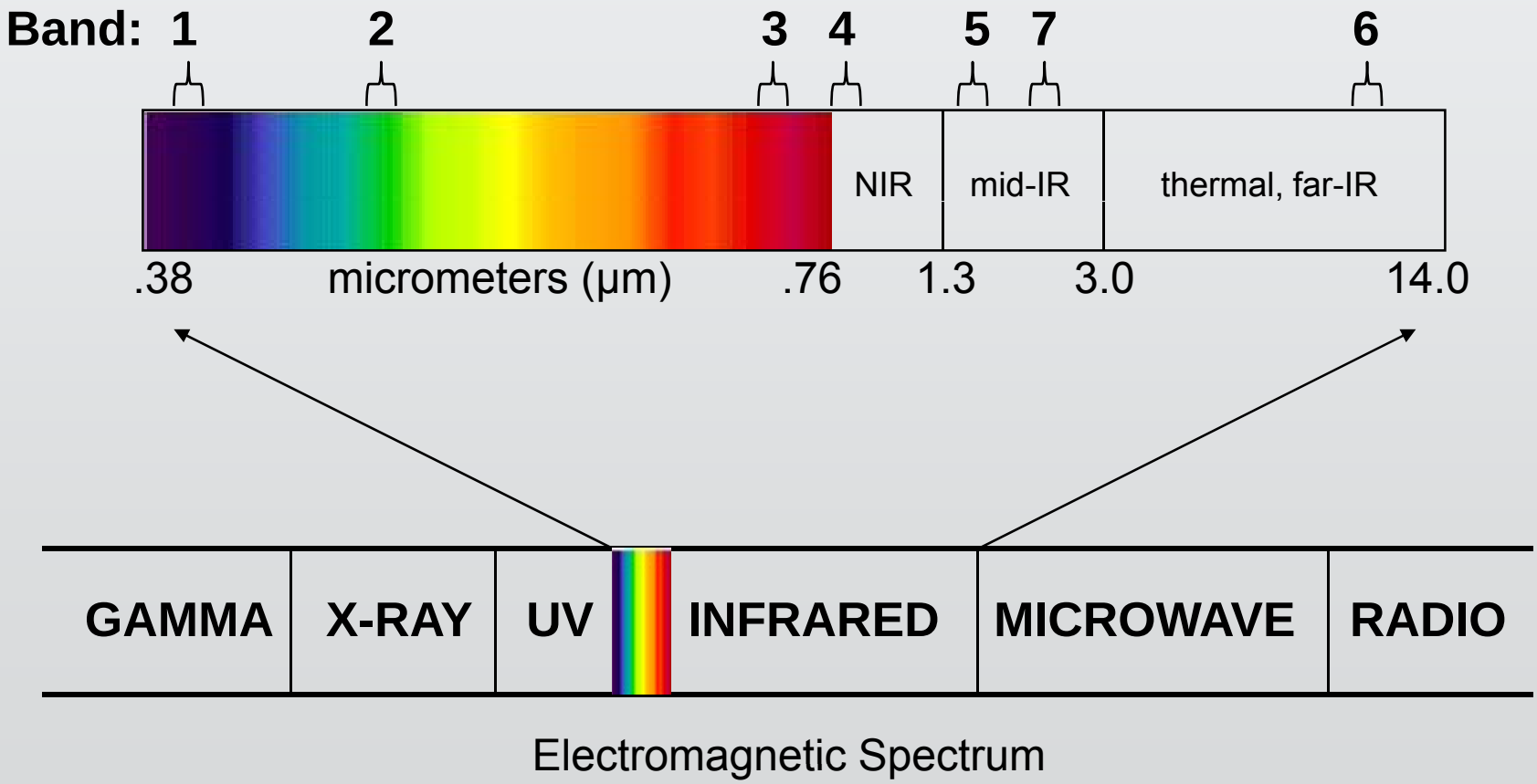
June 5, 2003 Landsat 7 ETM+ path 39, row 30

Landsat 5 TM and 7 ETM+



- 30-m pixel resolution
- 16-day repeat cycle
- 185-km swath width
- 7 spectral bands (visible, NIR, mid-IR, thermal)

Landsat Spectral Resolution



Electromagnetic Spectrum

Research Objectives

1.) Examine landscape-level spatial and temporal variability of sagebrush-steppe rangelands from 1984 – 2003 using GIS and remotely sensed spectral vegetation indices.

2.) Investigate spatial and temporal responses of vegetation index measures to variations in precipitation, livestock grazing, and/or fire disturbances.

Spectral Vegetation Indices
(SVI's)

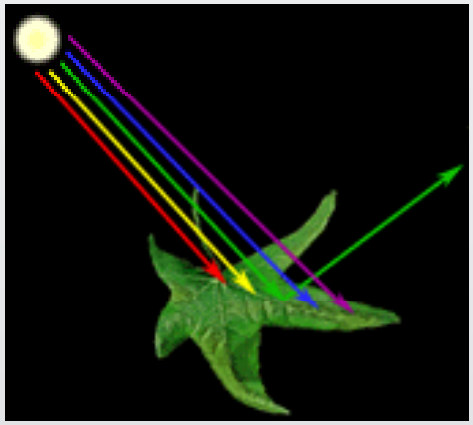
- Dimensionless, radiometric measures that function as indicators of relative abundance and activity of green vegetation.

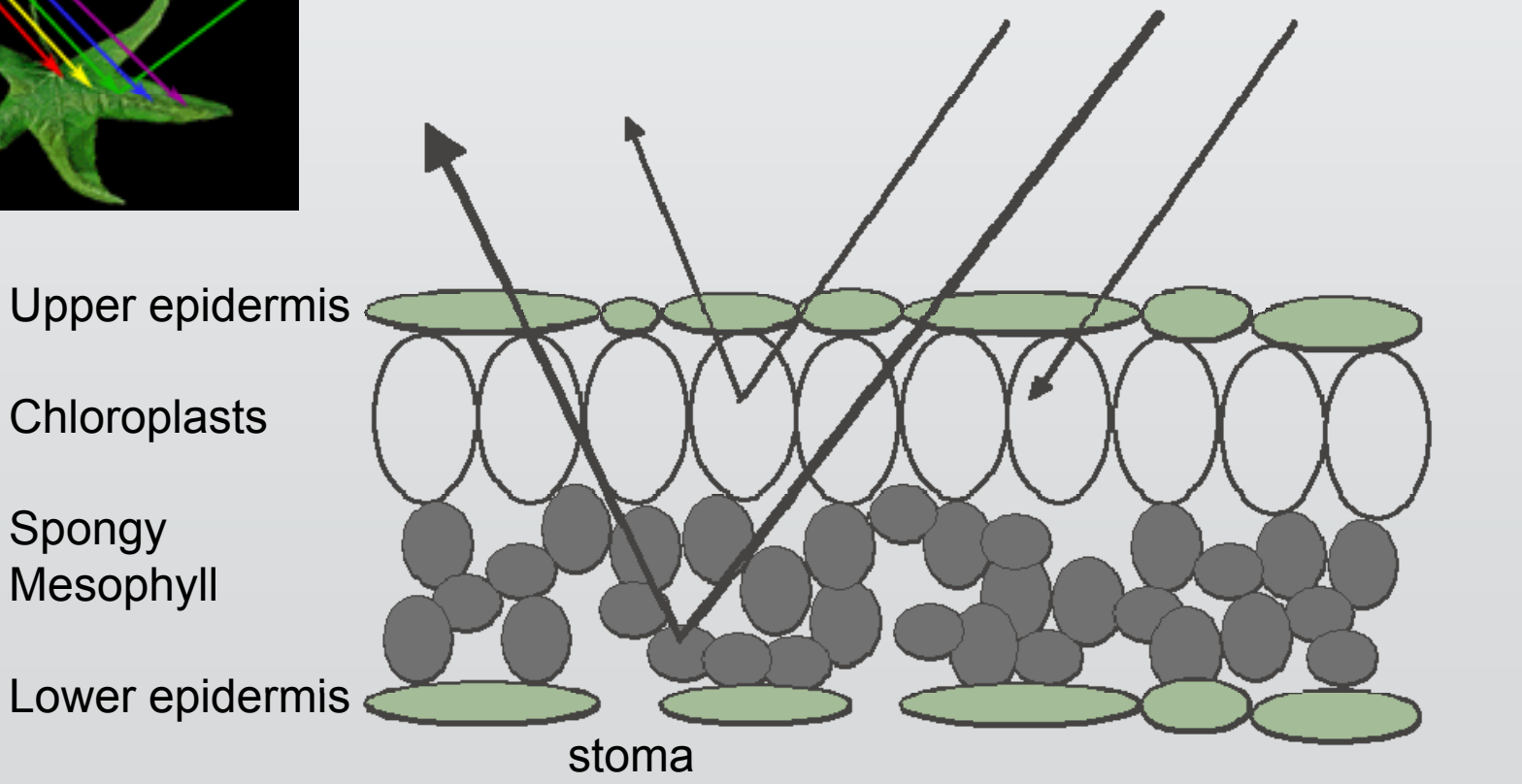
- Correlated with:
  - Areal plant cover
  - Biomass
  - Leaf-area-index (LAI)

- Results range from +1 to -1.

Leaf Cross-section:

Absorbs red and blue, reflects some green, reflects mostly NIR





http://geology.isu.edu/~chadjohn

Soil-Adjusted Vegetation Indices
(SAVI's)

- Necessary for measuring vegetation in semi-arid environments.
- SAVI uses constant, empirical soil-adjustment factor (*L*).
- Example:

$$NDVI = \frac{NIR - red}{NIR + red} \quad \Rightarrow \quad SAVI = \frac{(1 + L)(NIR - red)}{NIR + red + L}$$

Modified Soil-Adjusted Vegetation Index ($MSAVI_2$)

- Uses a variable, inductive *L* function.
- Equation:

$$MSAVI_2 = \frac{2*(NIR) + 1 - \sqrt{(2*(NIR) + 1)^2 - 8*(NIR - red)}}{2}$$

- Increases sensitivity to vegetation signal by further minimizing soil background effects.

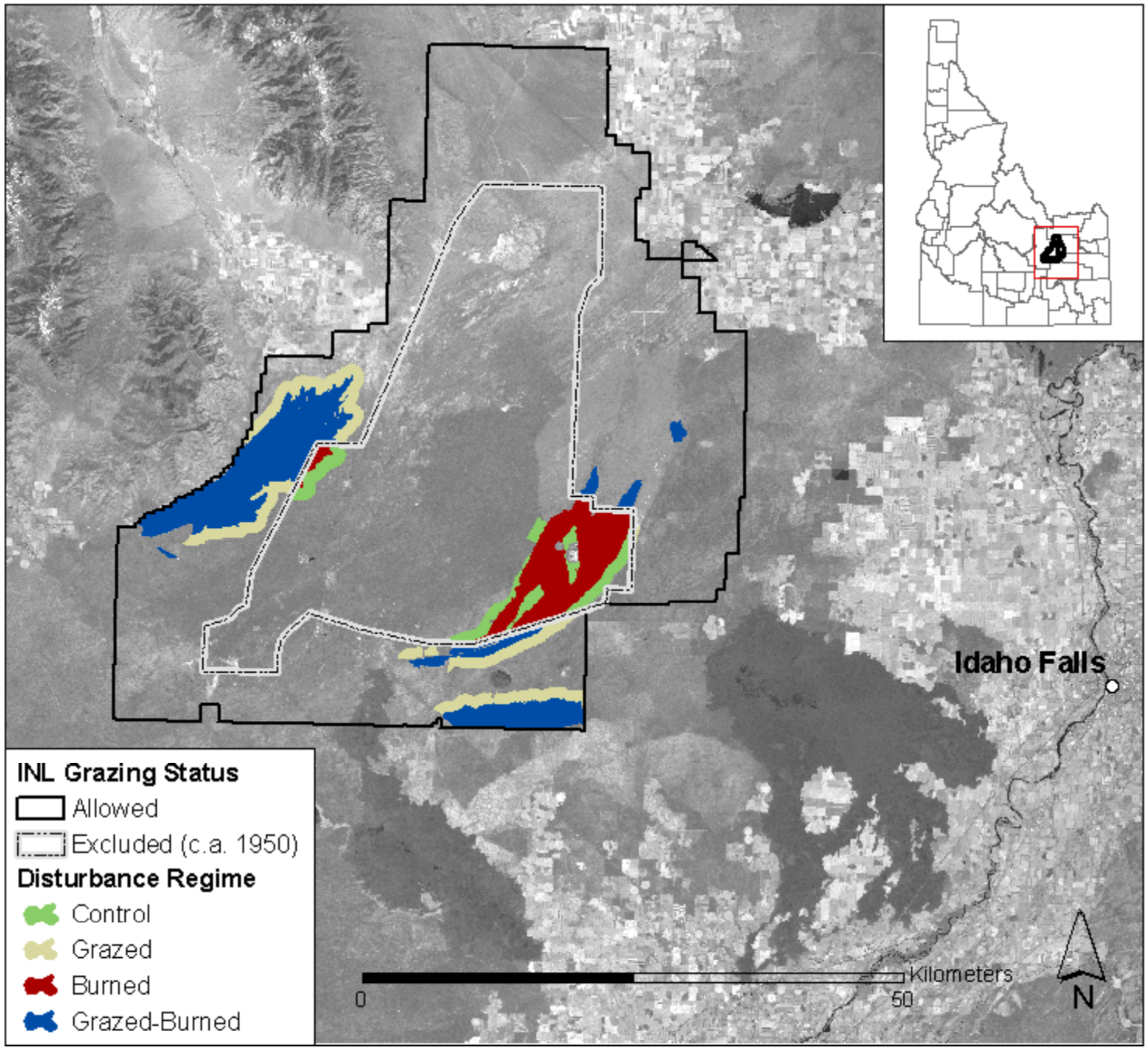
(Qi et al. 1994)

Research Questions

1.) How much spatial and temporal variability in $MSAVI_2$ occurs among undisturbed lands on the INEEL?

2.) How do natural and anthropogenic disturbances, such as livestock grazing, and/or fire influence spatial and temporal variability in $MSAVI_2$?

3.) How does spatial and temporal variability among these lands differ during years of precipitation change (i.e. drought years)?


Idaho Falls
INL Grazing Status
Allowed
Excluded (c.a. 1950)
Disturbance Regime
Control
Grazed
Burned
Grazed-Burned
0
50
Kilometers
N

Examining Temporal Variability
(Inter-annual changes)

- Used one cloud-free Landsat 5 TM or 7 ETM+ image per year.

- Dataset consisted of 17 years spanning 1984 – 2003.

- Image pre-processing (Jensen 1996):
  - converted to at-satellite reflectance
  - co-registered (RMS error < 0.5)
  - radiometrically normalized

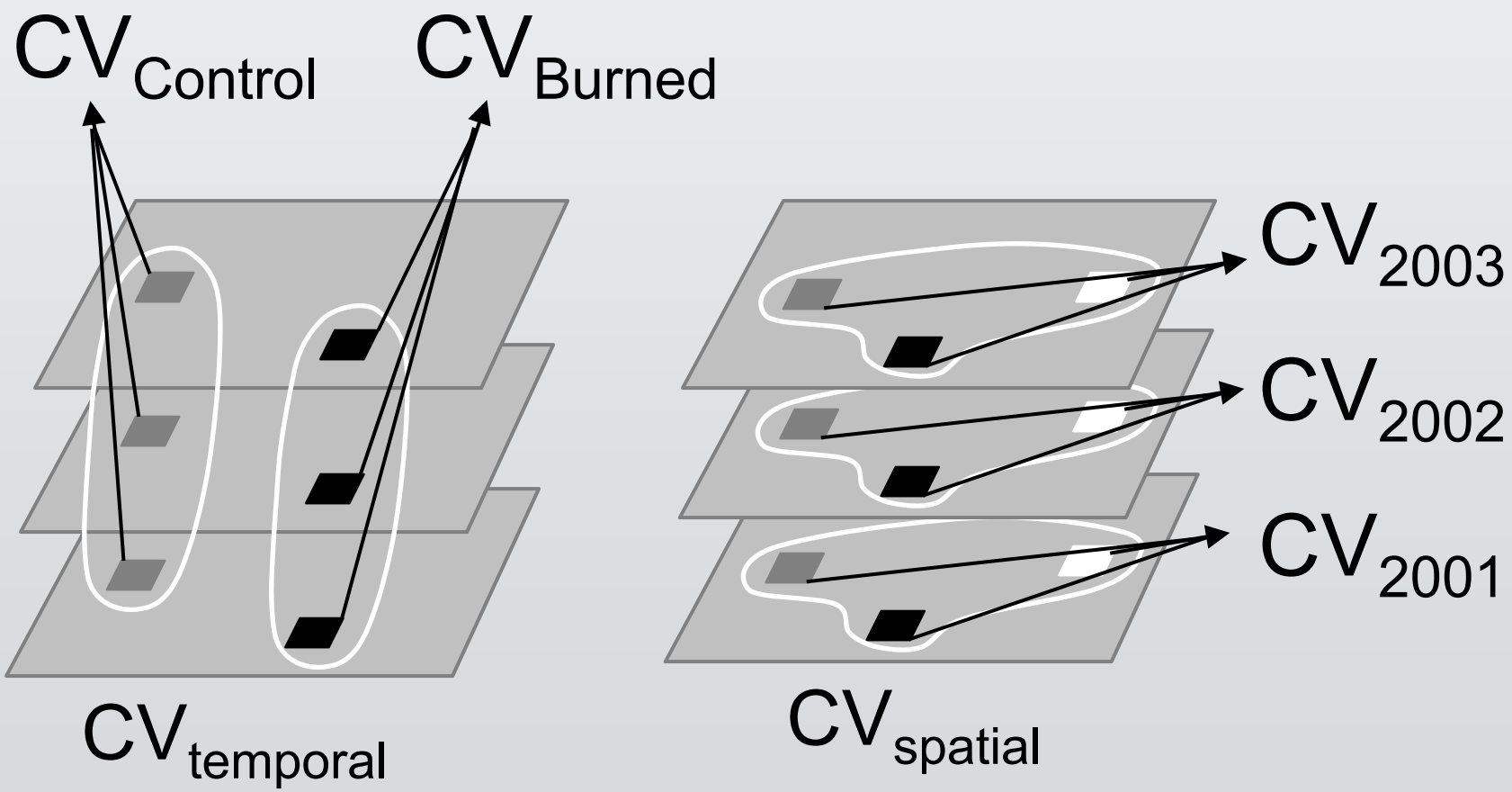
Examining Spatial Variability
(Coefficient of Variation of $MSAVI_2$)

- CV = ($MSAVI_2$ SD/ $MSAVI_2$ Mean)*100
- Measure related to spectral differences among pixels resulting from changes in plant cover.

  (Pickup and Foran 1987)
- Estimate of variability in $MSAVI_2$ among years and among pixels within a year.

Spatio-temporal Variability

($CV_{temporal}$ and $CV_{spatial}$)



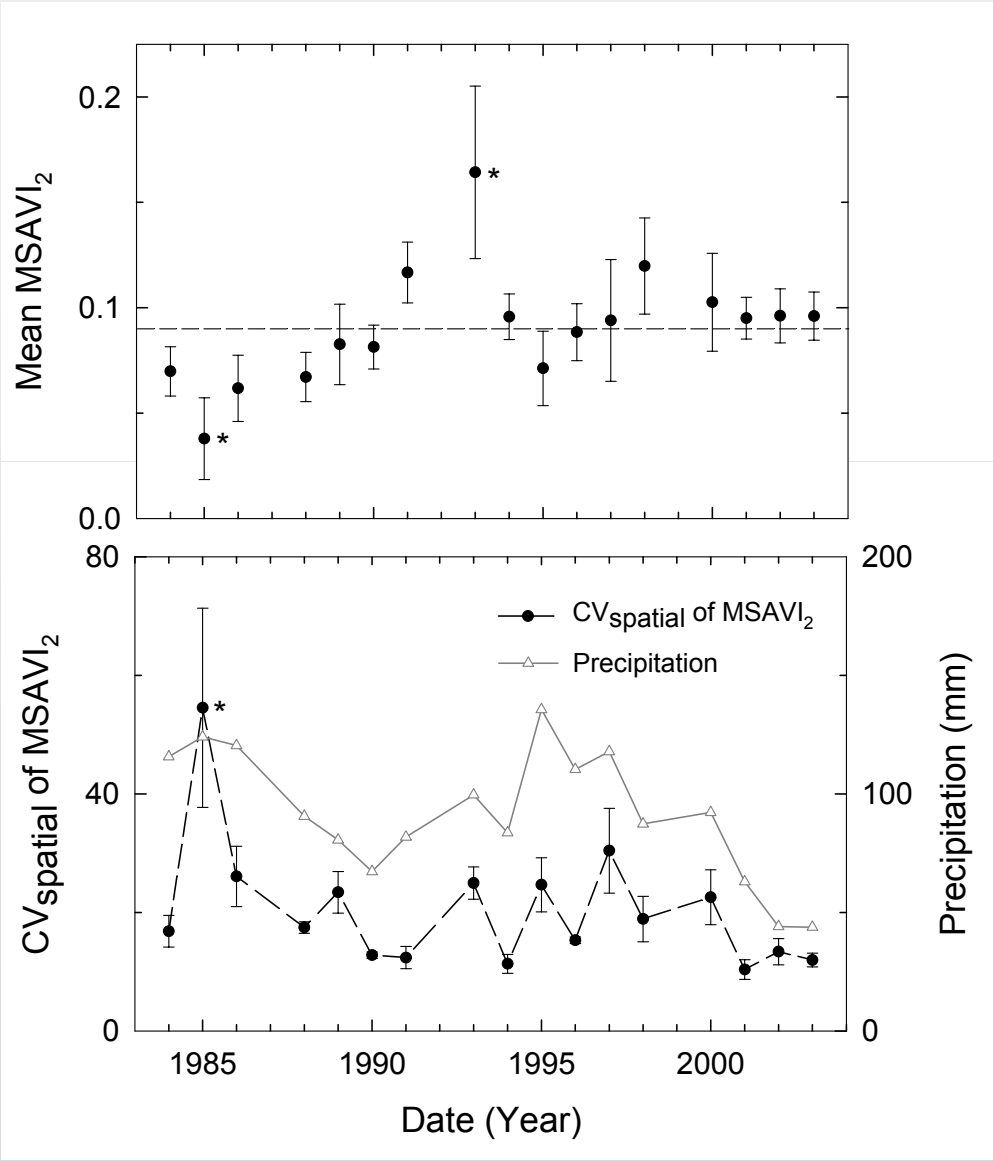
Precipitation Effects on $MSAVI_2$

- Compared mean $MSAVI_2$ and CV of MSAVI2 among disturbance regimes during “wet” and “dry” years.
- Wet and dry years were determined from cumulative annual growing season PPT (April 1 to image date).
- Relationships between PPT and $MSAVI_2$ for disturbance history lands were examined using linear regression.

Question 1:

How much spatial and temporal variability in $MSAVI_2$ occurs among undisturbed lands?

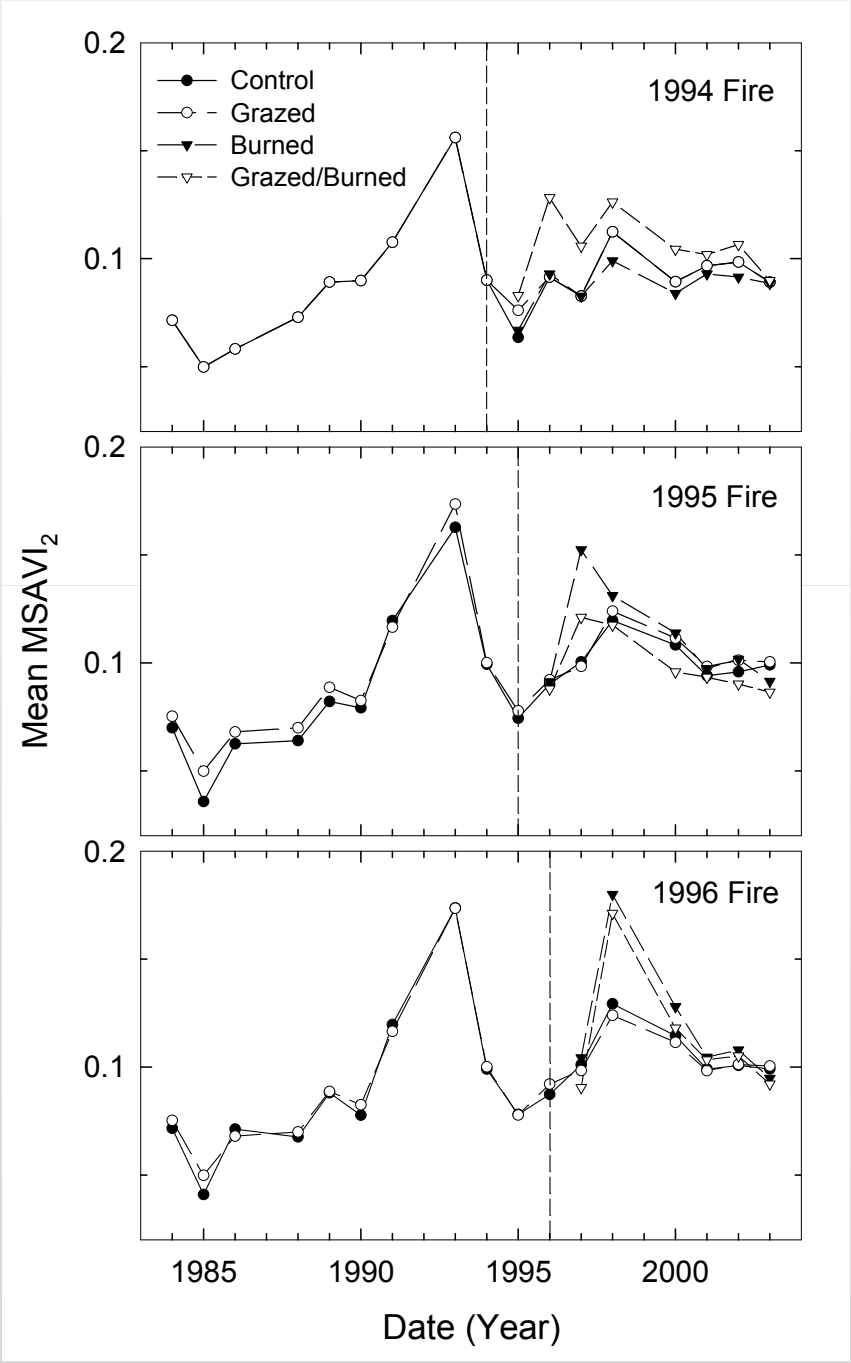
- Mean $MSAVI_2$ ranged from 0.03 in 1985 to 0.16 in 1993.
- Mean $MSAVI_2$ decreased 44% between 1993 and 1994.
- $CV_{spatial}$ of $MSAVI_2$ was significantly higher in 1985.



Question 2:

How do grazing and/or fire influence temporal variability in $MSAVI_2$?

- For 1994 fire, mean $MSAVI_2$ of grazed/burned was 18% greater compared to undisturbed lands.
- No significant differences observed following other fires.



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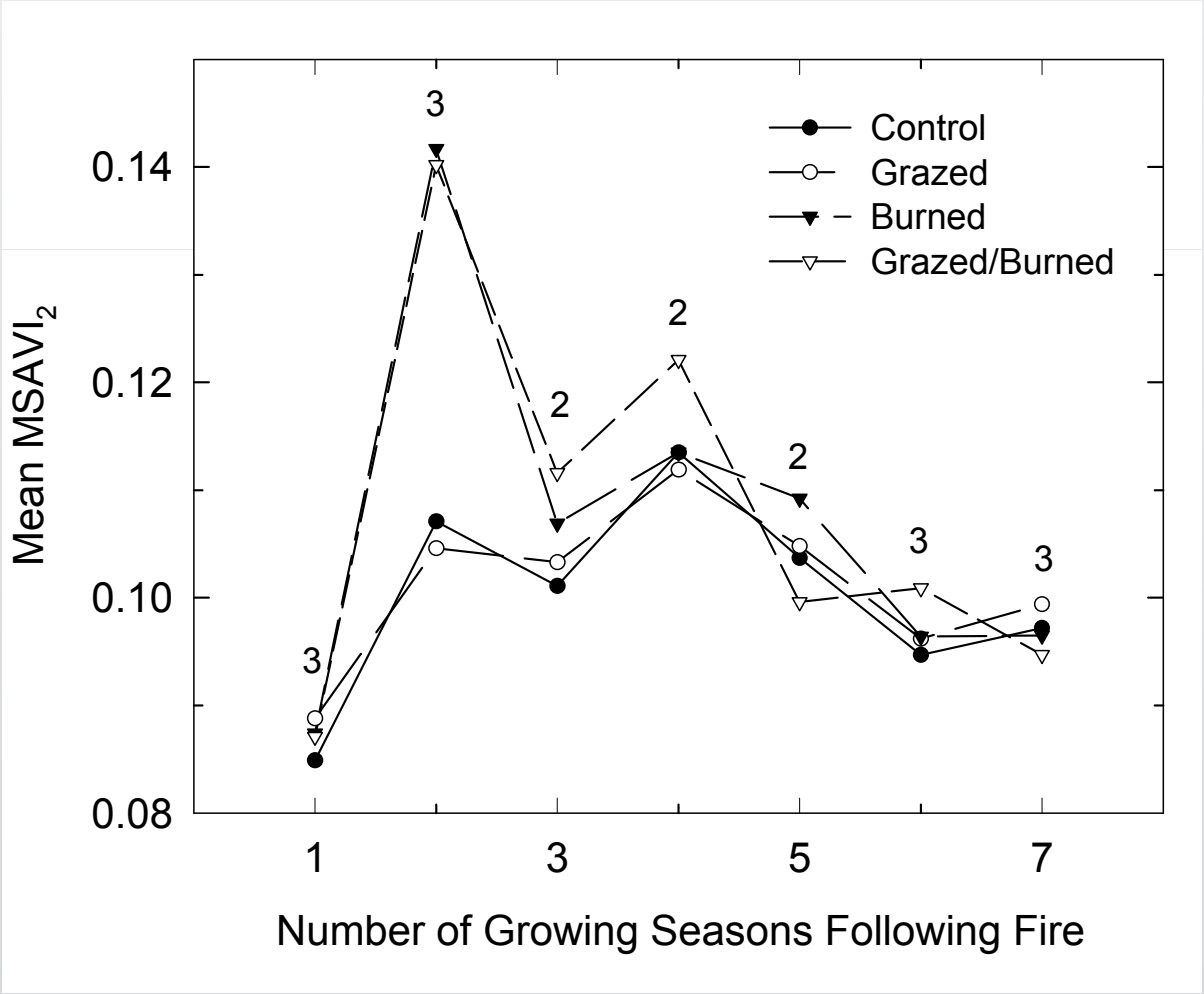
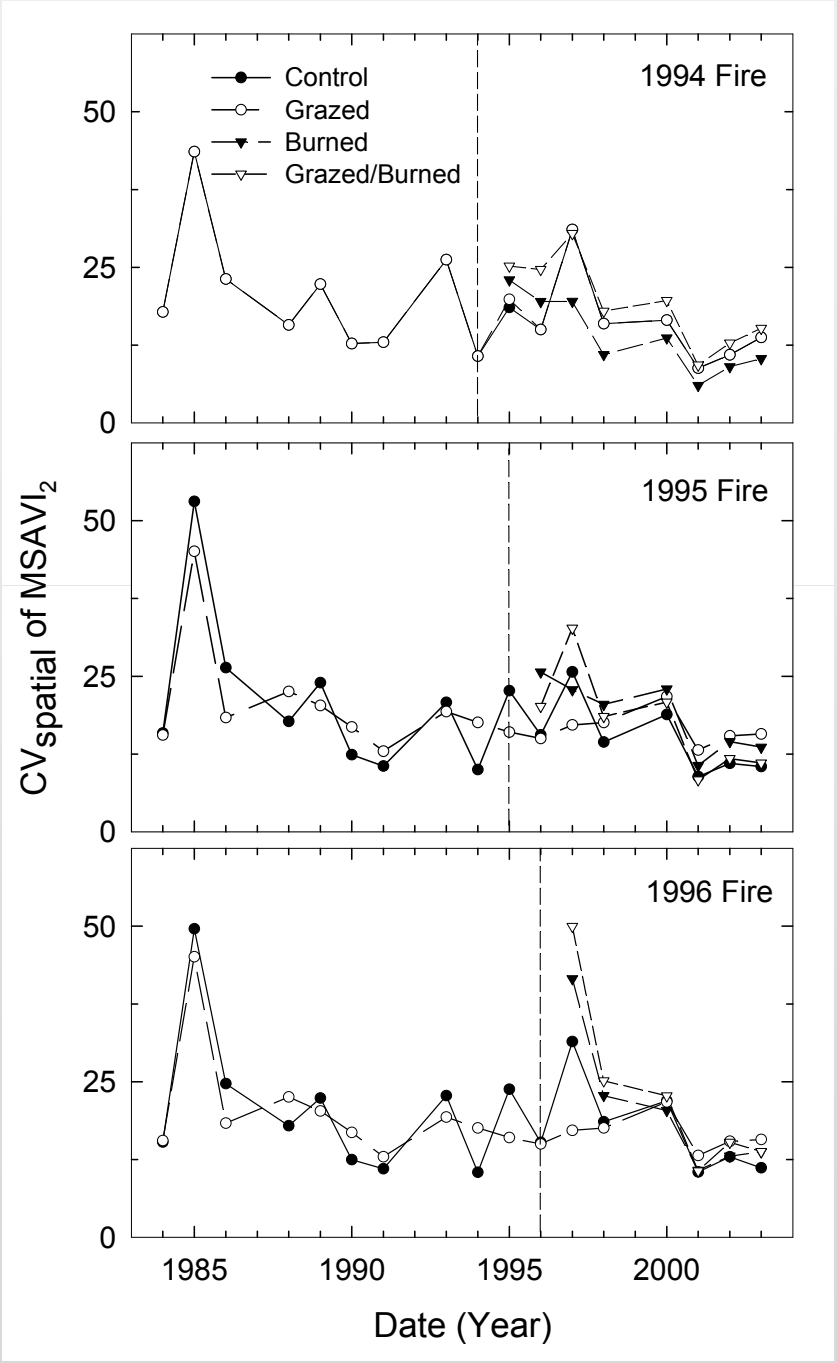


Question 2:

How do grazing and/or fire influence spatial variability in $MSAVI_2$?

- Mean $CV_{spatial}$ of $MSAVI_2$ for lands with similar disturbance histories increased following fire, especially in the second growing season.



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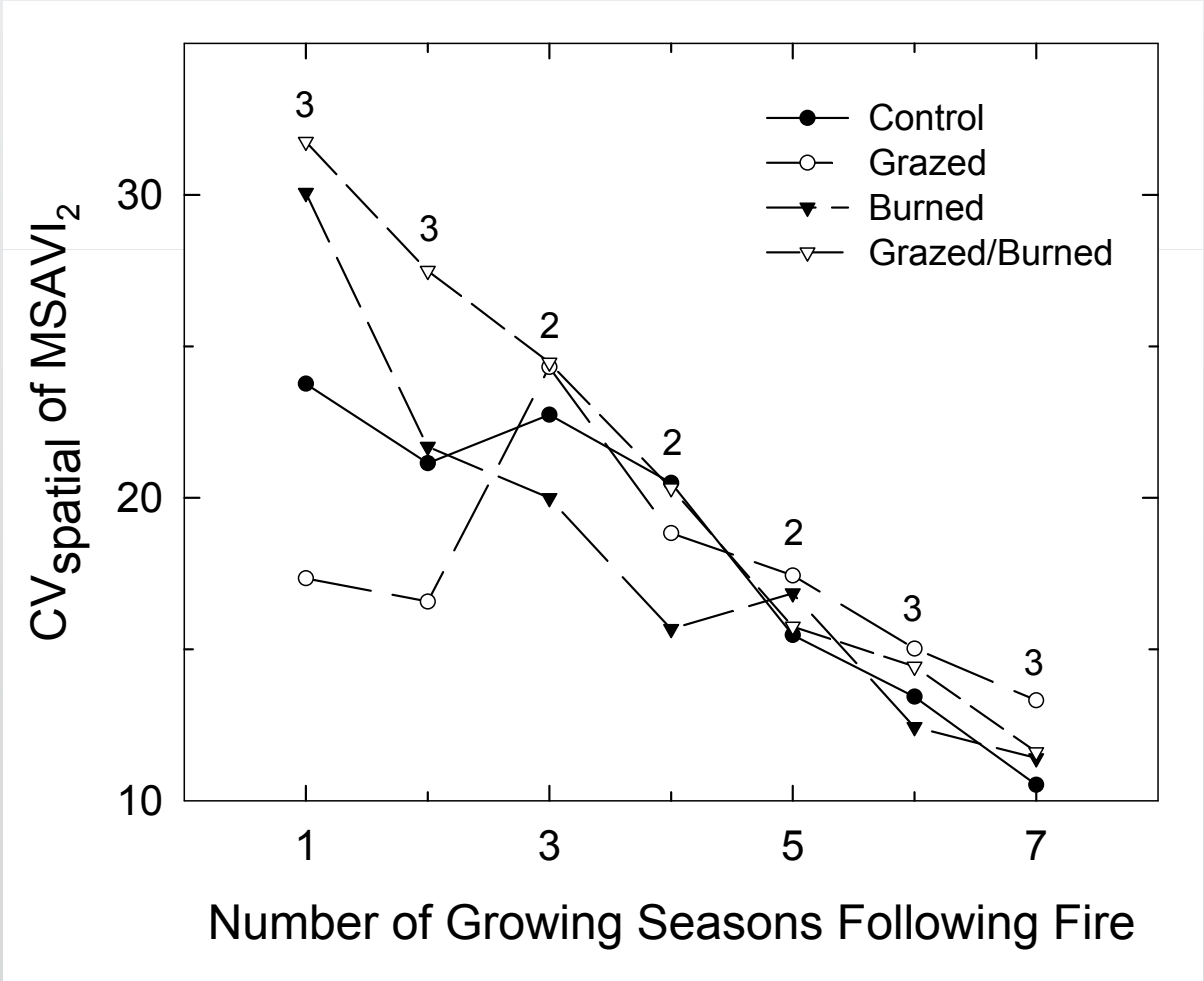
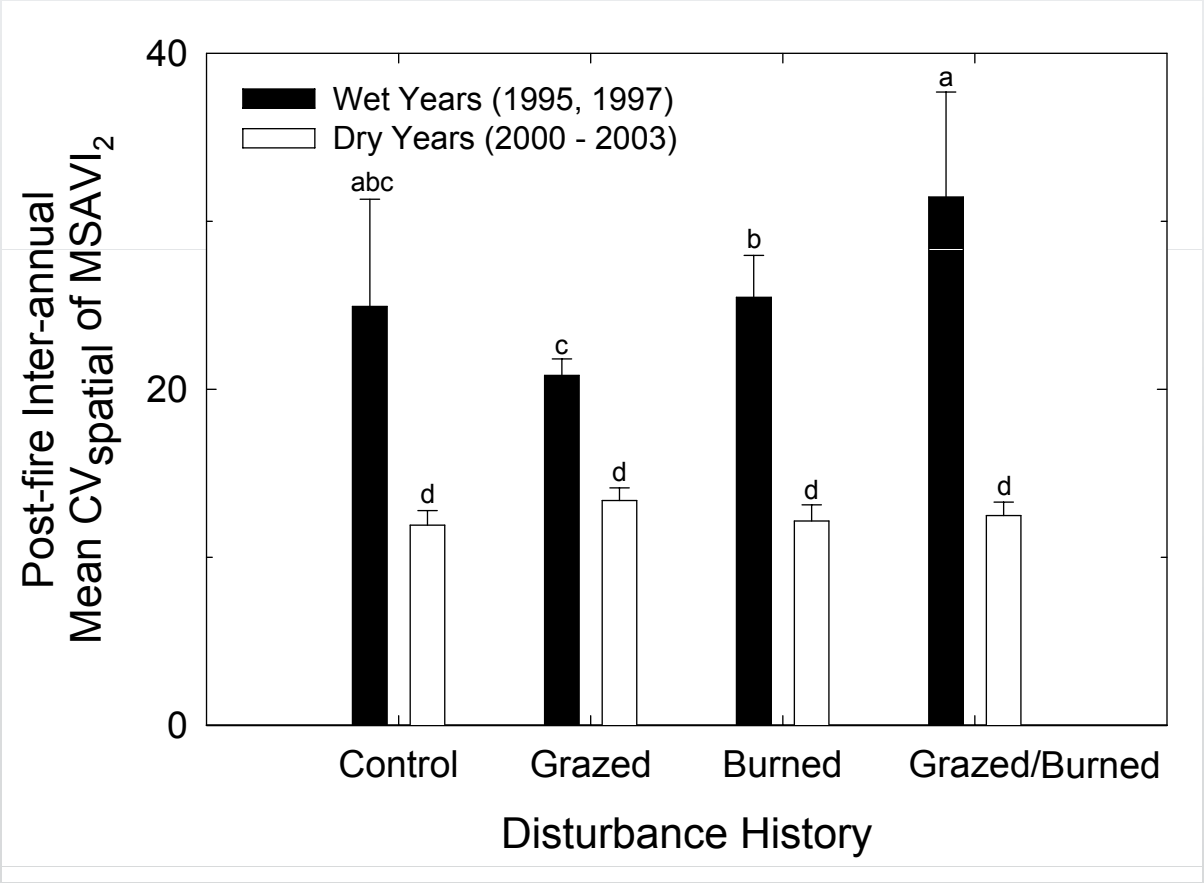
How do grazing and/or fire influence **spatial** variability in $MSAVI_2$?



Question 3:

How does spatial variability differ during years of precipitation change?



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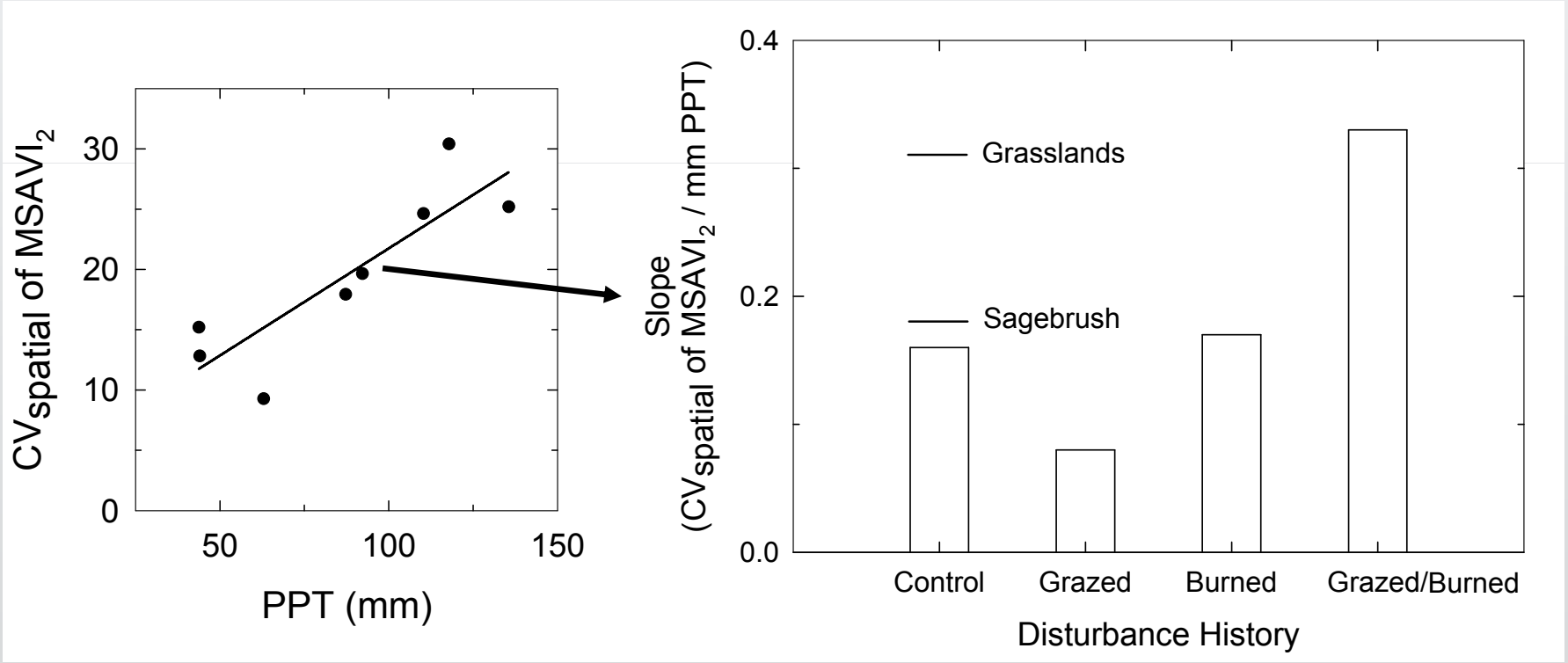

Conclusions
(Disturbance Effects on $MSAVI_2$)

- Differences in $CV_{spatial}$ and $CV_{temporal}$ emerged as more sensitive response variables of disturbance compared to mean $MSAVI_2$.

- Mean $MSAVI_2$ was greater only in the second growing season following fire, but $CV_{spatial}$ was greater in fire-disturbed lands for nearly a decade.

- Fire and the interaction of fire and grazing can strongly influence the stability of $MSAVI_2$ measures.

Conclusions
(Fire-disturbed Lands)

- Annual grasses tend to be the major cover component on burned sites for the first few years following fire.

  (West and Yorks 2002)

- Sagebrush cover varies less than herbaceous or annual species in response to drought.

  (Passey et al. 1982, West and Yorks 2002)

- Increased temporal and spatial variability for pixels among fire-disturbed lands may be attributable to increases in annual and perennial grasses and forbs.

Conclusions
(Interactions of Fire and Grazing)

- Grazing results in higher densities of sagebrush that may persist for long periods.

  (Anderson and Inouye 2001)

- Higher fuel loads may amplify fire intensity and severity, resulting in greater site alterations rather than just changes in floristics.

- Appear to affect sagebrush-steppe communities in ways that are not detectable by simple assessments of mean responses.

Acknowledgements

- NASA
- Matthew Germino, ISU Biological Sciences
- Nancy Glenn, ISU Geosciences; Kevin Marsh, ISU History
- Edwin House, ISU Office of Research
- Ron Rope, INEEL Ecological and Cultural Resources
- Richard Inouye and Chris Jenkins, ISU Biological Sciences; Roger Blew, Stoller
- Keith Weber, ISU GISTreC; Jerry Tagestad, Battelle Pacific Northwest National Lab
- ISU Plant Ecology Lab: Niles, Eliza, Katie, Judd, Sheel

Questions?