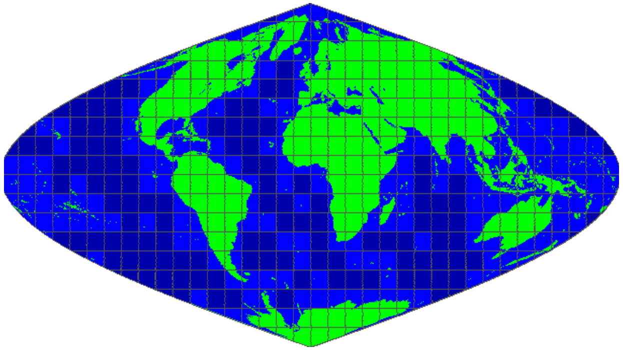
Detecting changes in biomass productivity in different land management regimes in drylands using satellite-derived vegetation index



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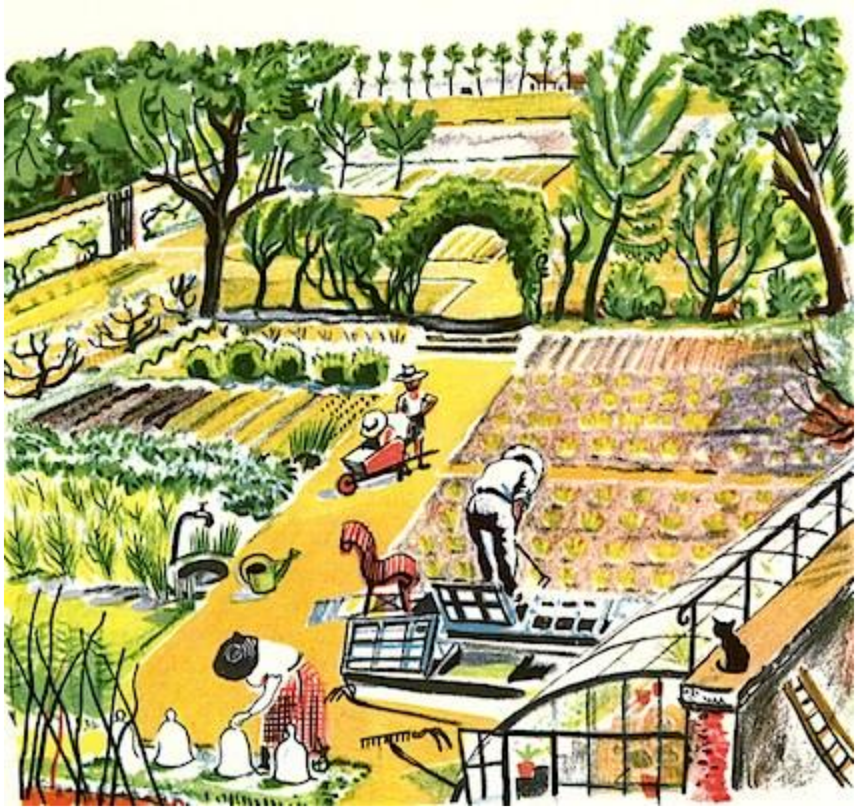
Ben-Gurion University of the Negev
The Jacob Blaustein Institutes for Desert Research

Does land use and land management affect biomass productivity of native vegetation?

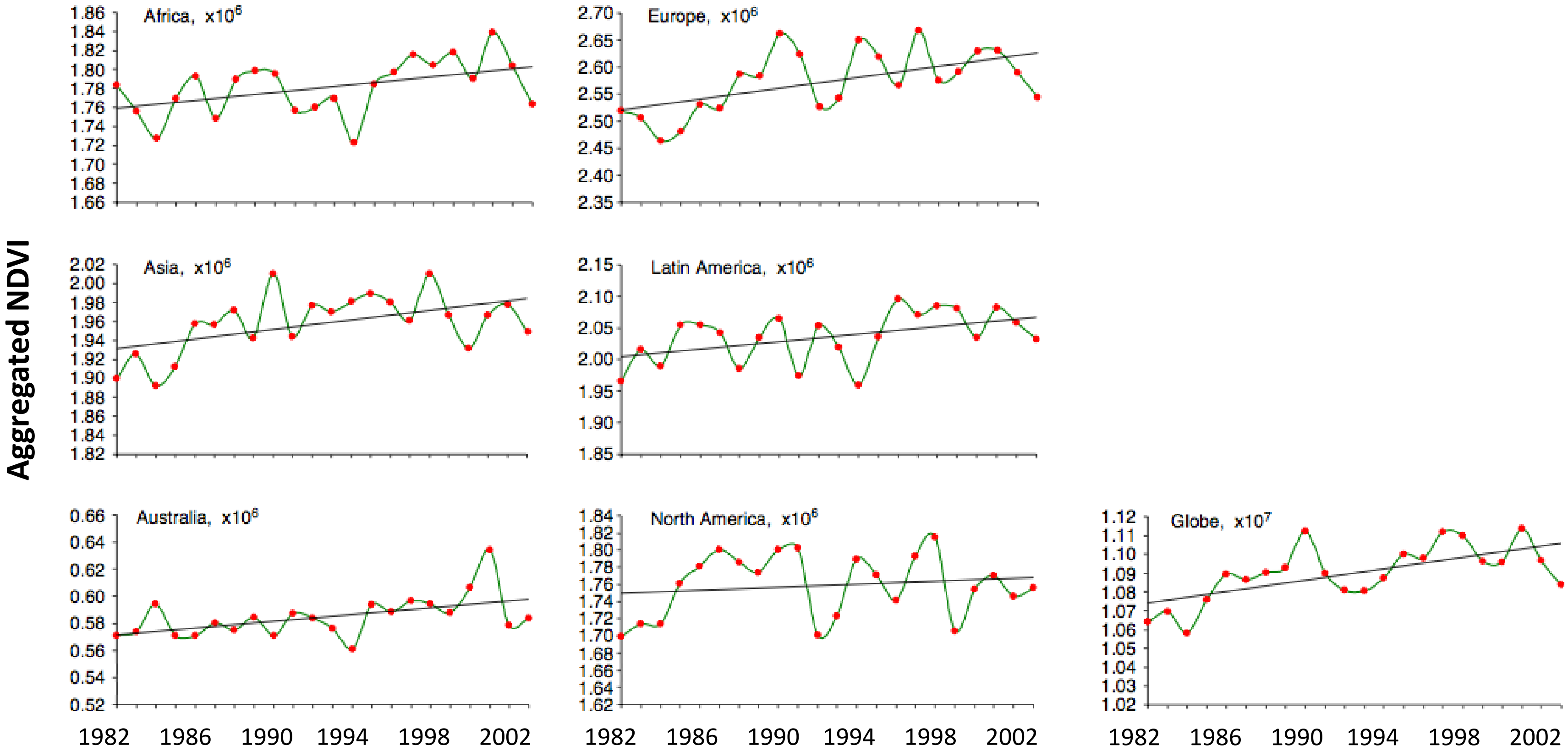


Decrease in biomass productivity is a good indication for land degradation

Detecting human-induced land degradation - methods

I. Trends in NDVI

Bai *et al.* (2008)

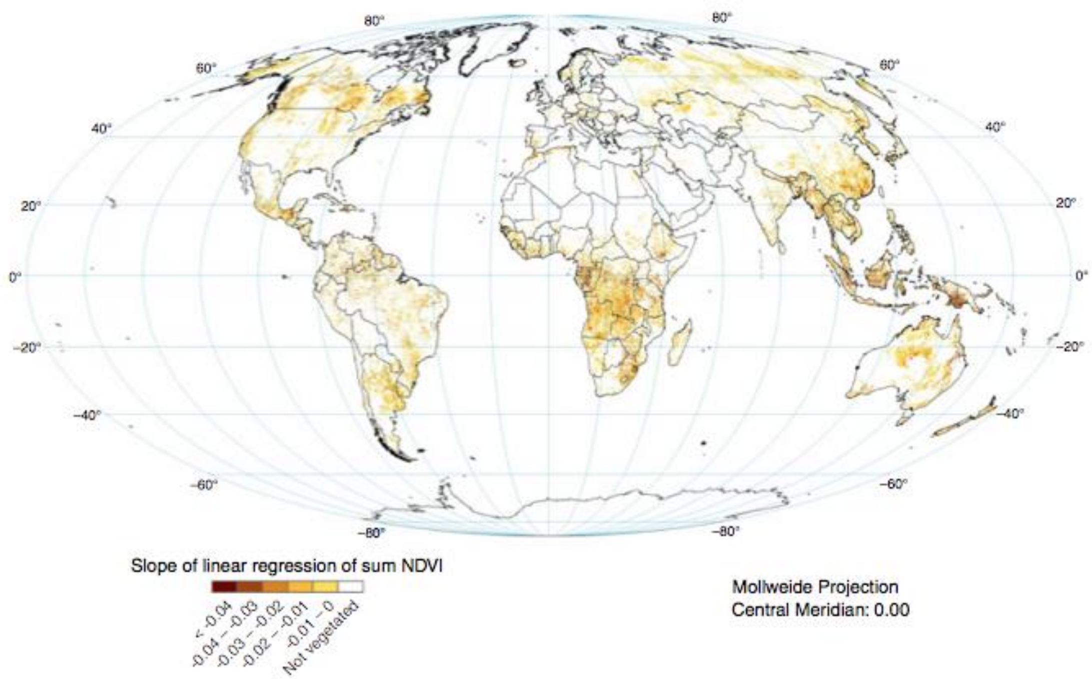


Trends in NDVI as indication for change in biomass production at a continental level – but what is the role of precipitation in these trends?

Detecting human-induced land degradation - methods

II. Trends in Precipitation Use Efficiency (PUE)

Because rainfall affect biomass production the Precipitation Use Efficiency ($PUE = \frac{NDVI}{Precipitation}$) is suggested to offset this effect



Bai *et al.* (2008)

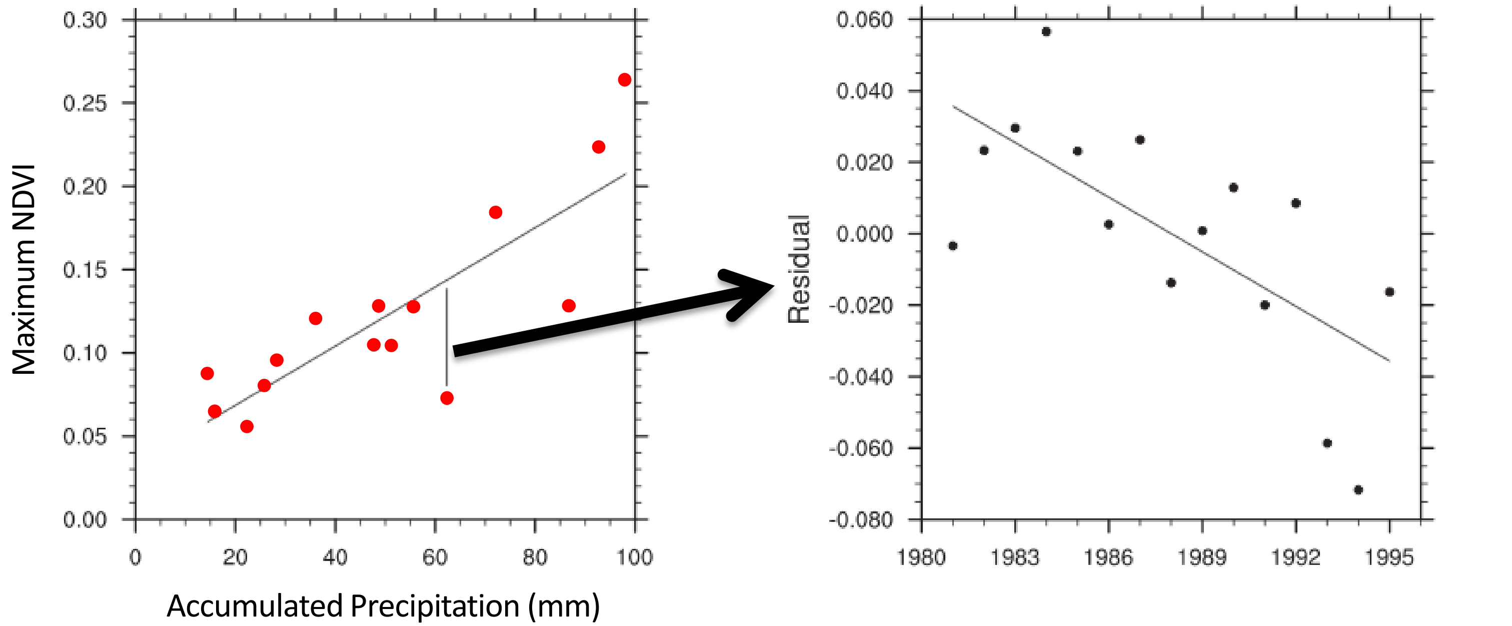
Bai *et al.* (2008) produced global map of land degradation using PUE trends – negative trends are interpreted as land degradation caused by human activity

Detecting human-induced land degradation - methods

III. Trends in Residuals (the RESTREND technique)

Evans and Geerken (2004)

Wessels *et al.* (2007; 2012)



RESTREND is proposed to offset the effect of rainfall allowing the detection of human-induced land degradation even in regions where the biomass – rainfall linkage is strong

Detecting human-induced land degradation - methods

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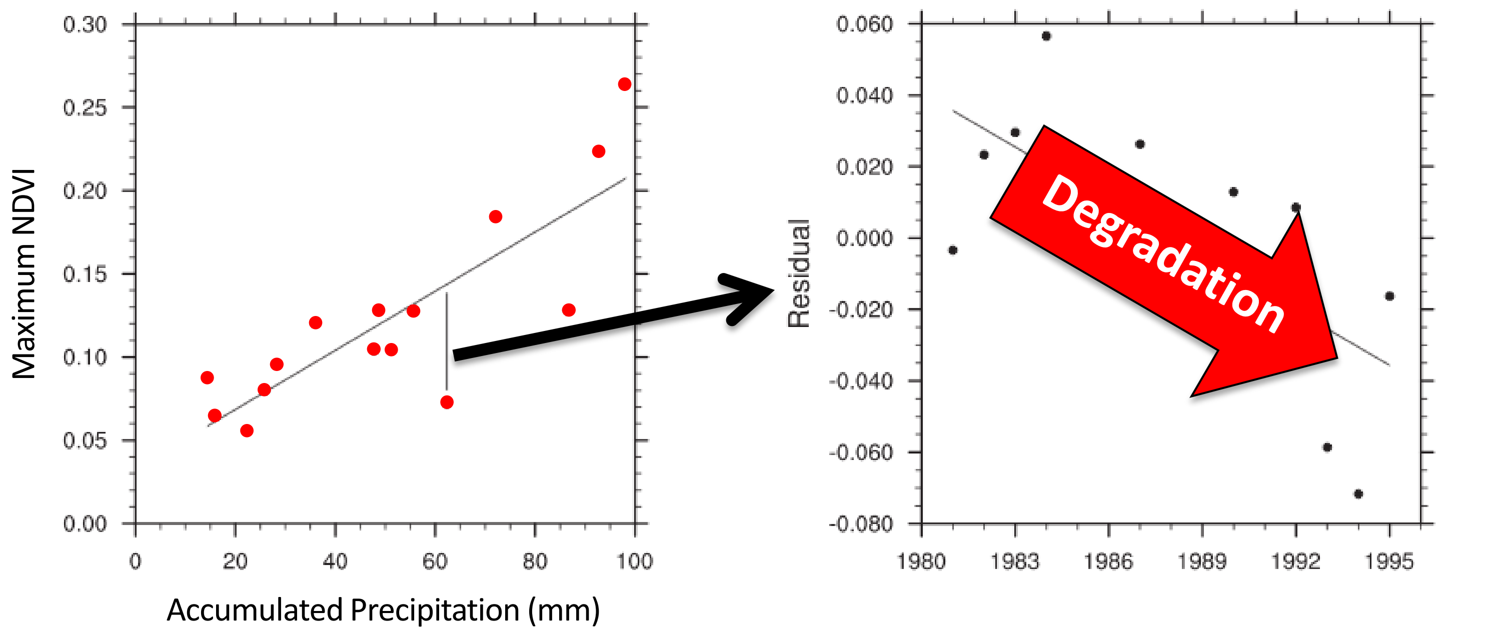
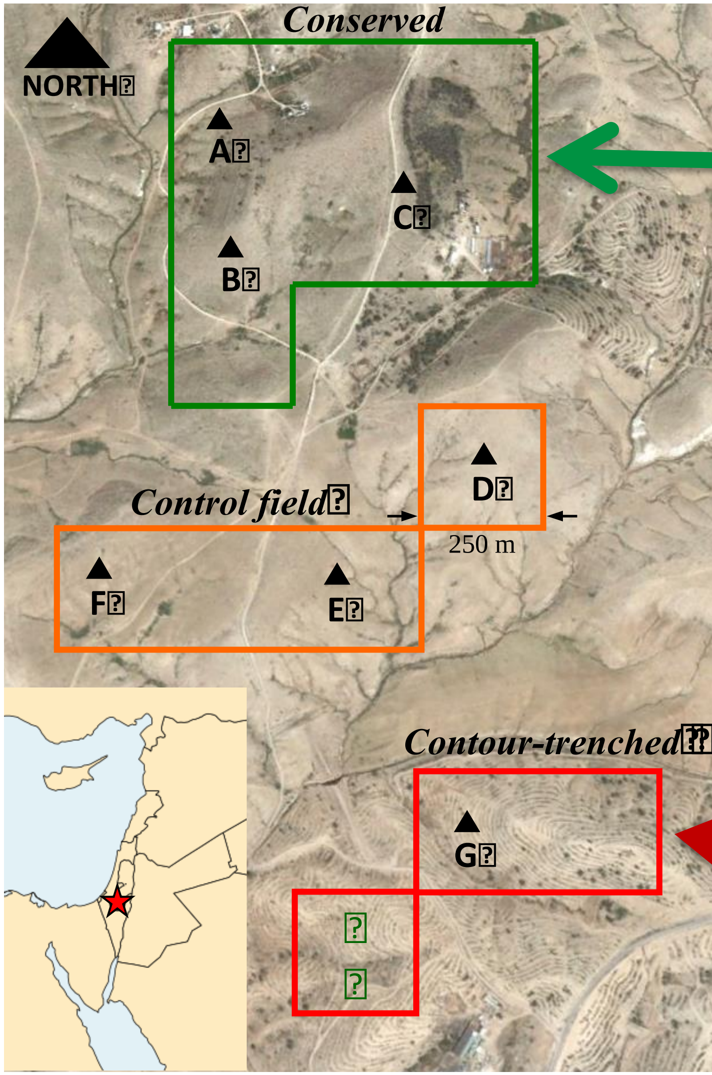


RESTREND is proposed to offset the effect of rainfall allowing the detection of human-induced land degradation even in regions where the biomass – rainfall linkage is strong

But….does conventional trend analysis can always detect human-induced land degradation?

Two land management regimes (1992) in the Negev

Helman *et al.* (Soil Use and Management, 2014)



Supervised grazing (Conserved)

Afforestation using contour-trenches

Photos credit: A. Mussery 2013

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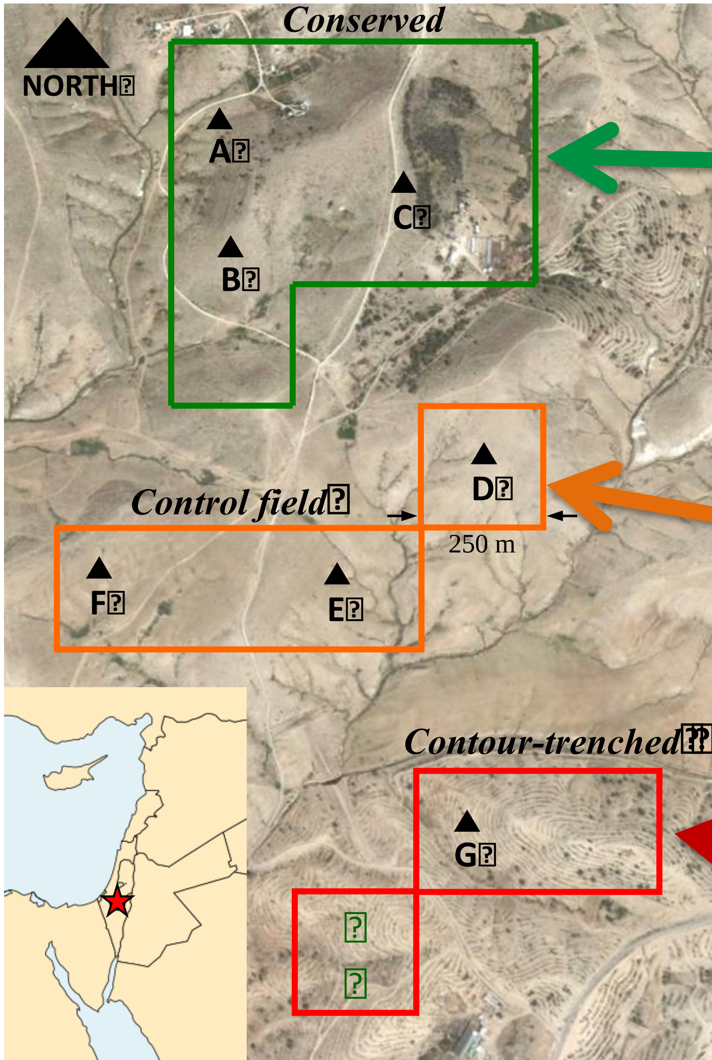


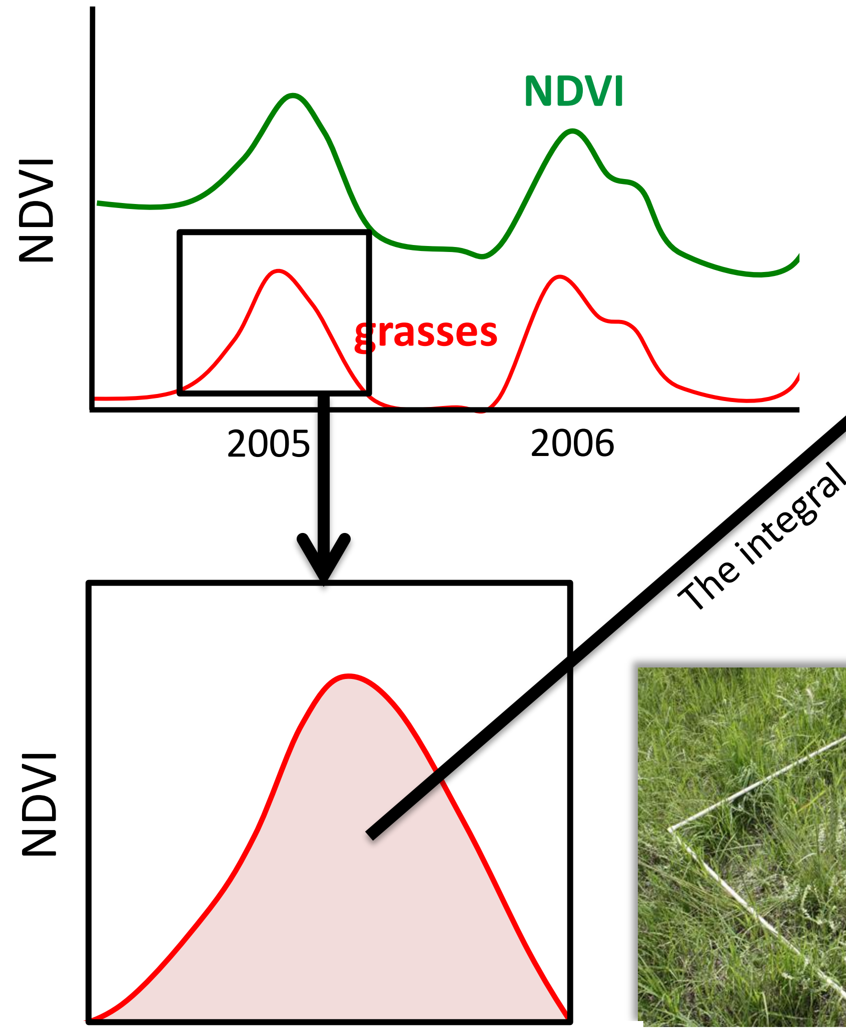
Supervised grazing (Conserved)

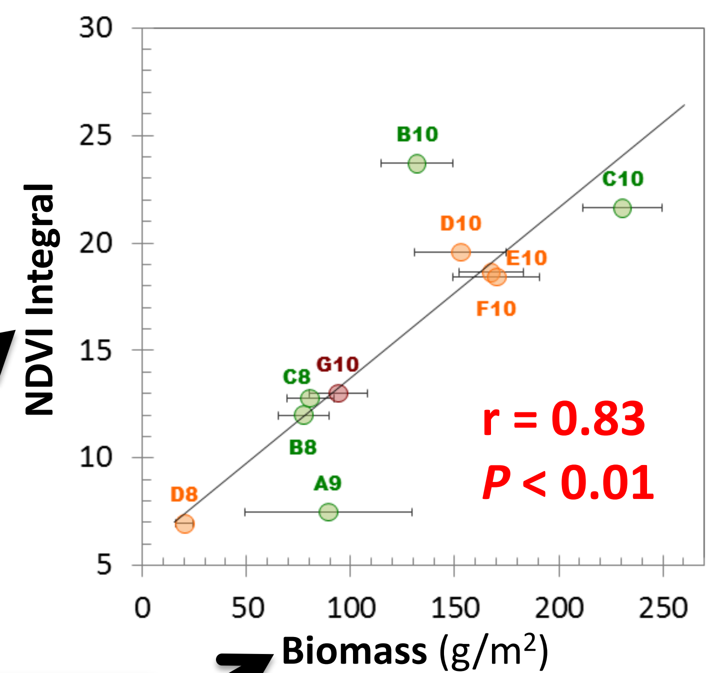
Traditional lands for reference (Control)

Afforestation using contour-trenches

Photos credit: A. Mussery 2013

Validating NDVI against biomass from field sampling



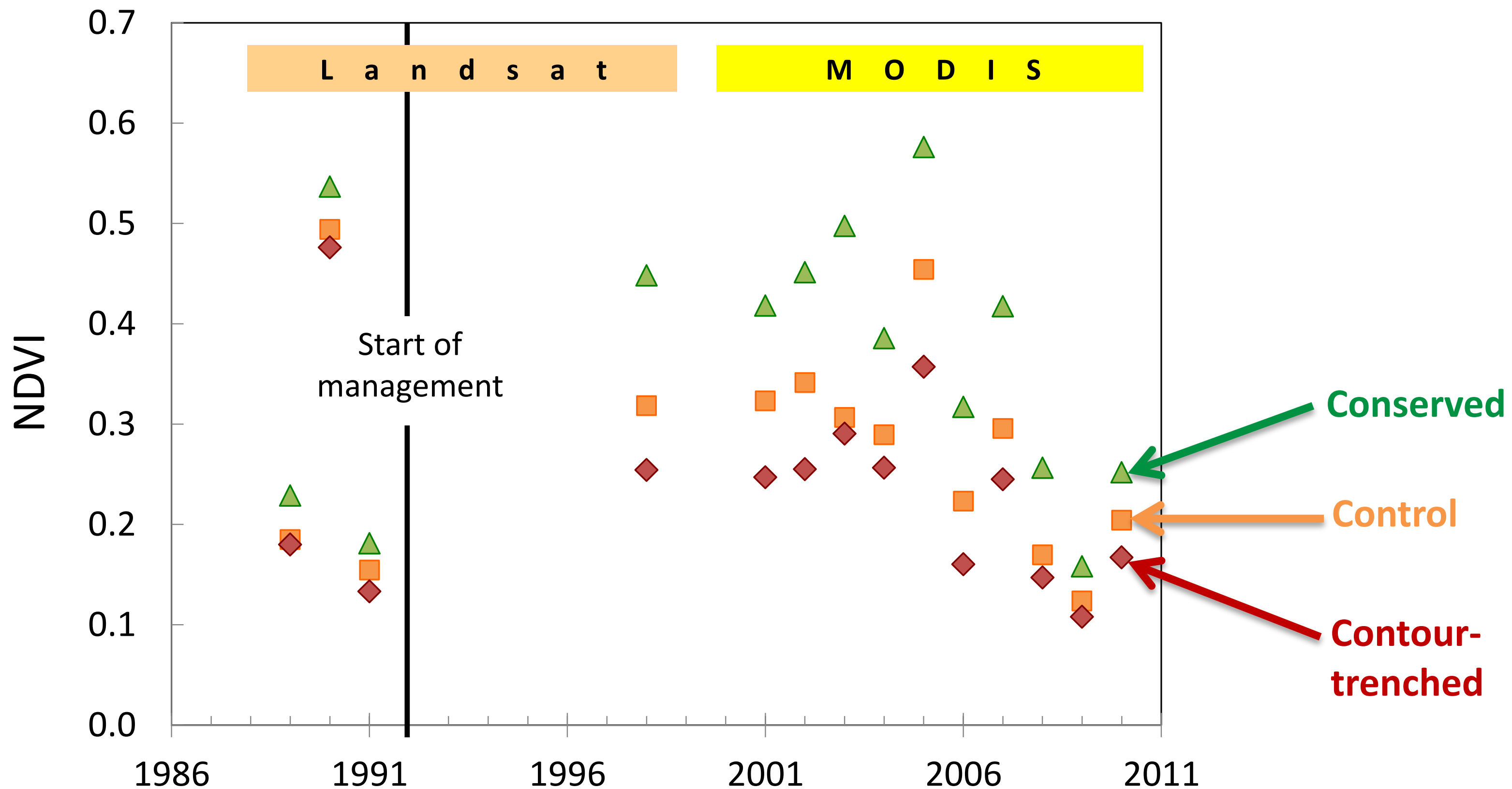


NDVI integrals show strong positive correlation with the biomass of annual grasses

The linear correlation validate the use of NDVI as a surrogate for biomass in this area

Change in biomass (NDVI) with time

Maximum NDVI represent the maximum biomass during the growing season



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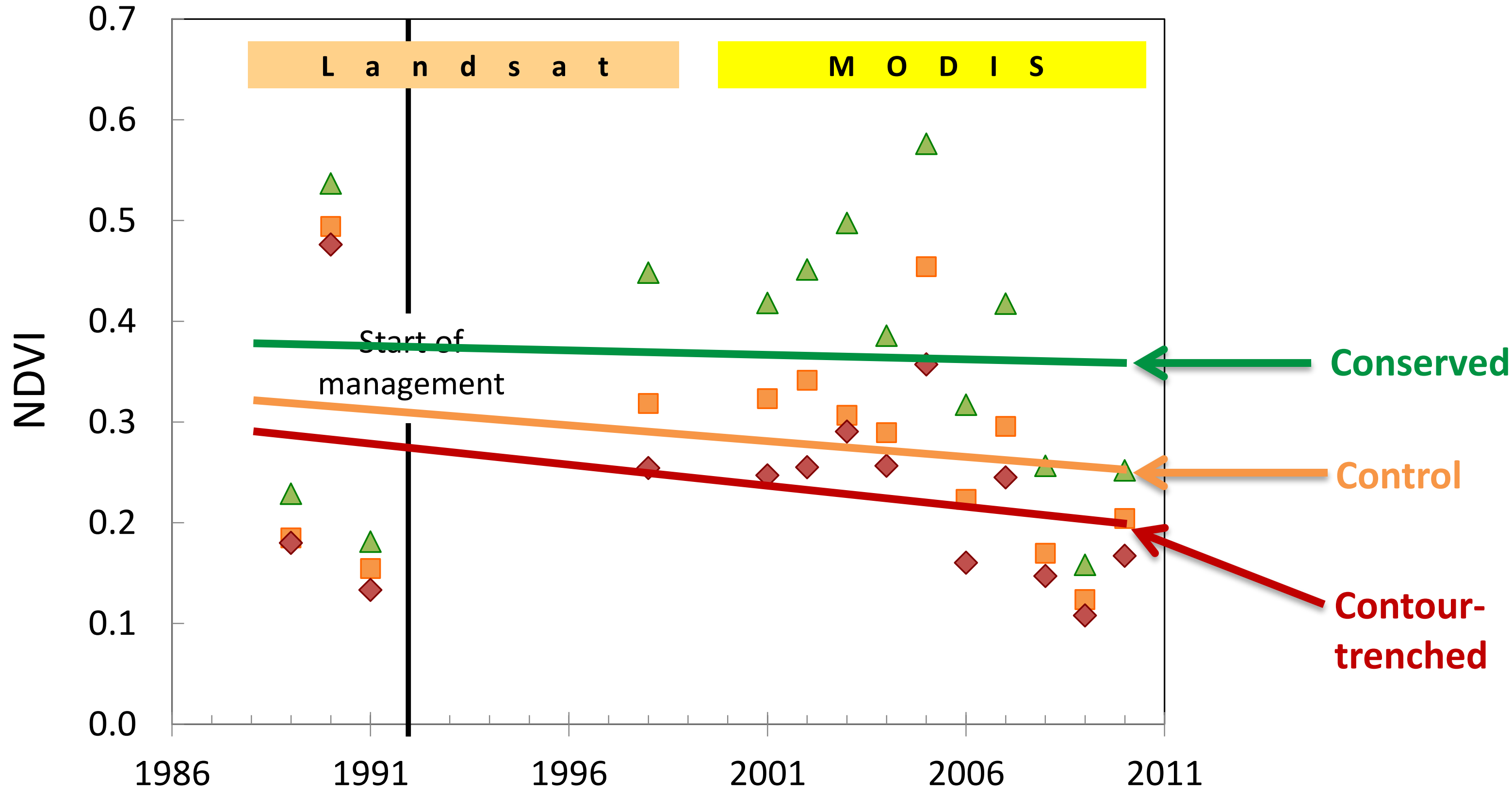
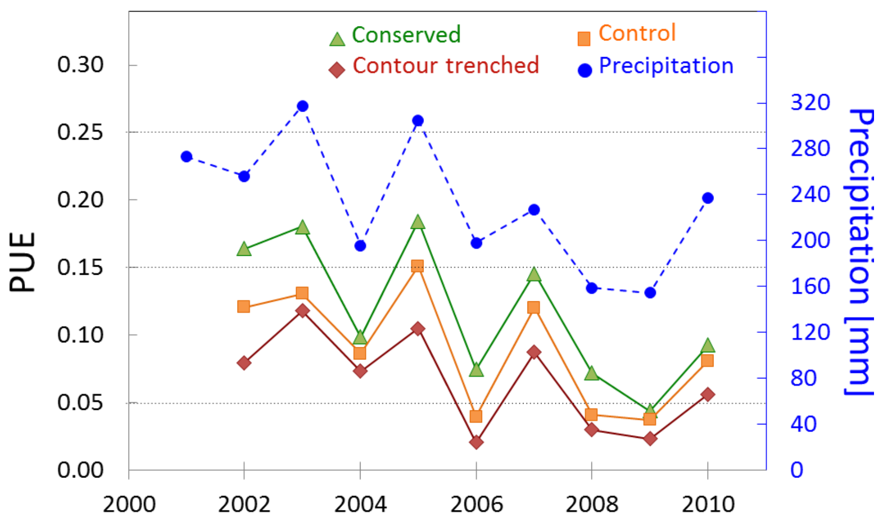


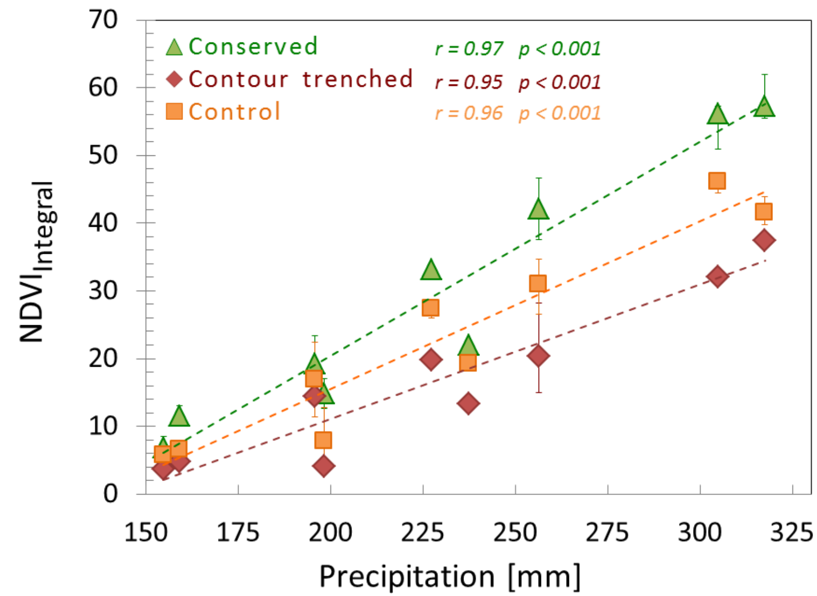
Similar pattern of NDVI in all three sites and no significant trends (*P* > 0.1)

PUE and the rainfall – biomass linkage

Trends in PUE (for the three sites) and precipitation for the entire area during 2001 - 2010



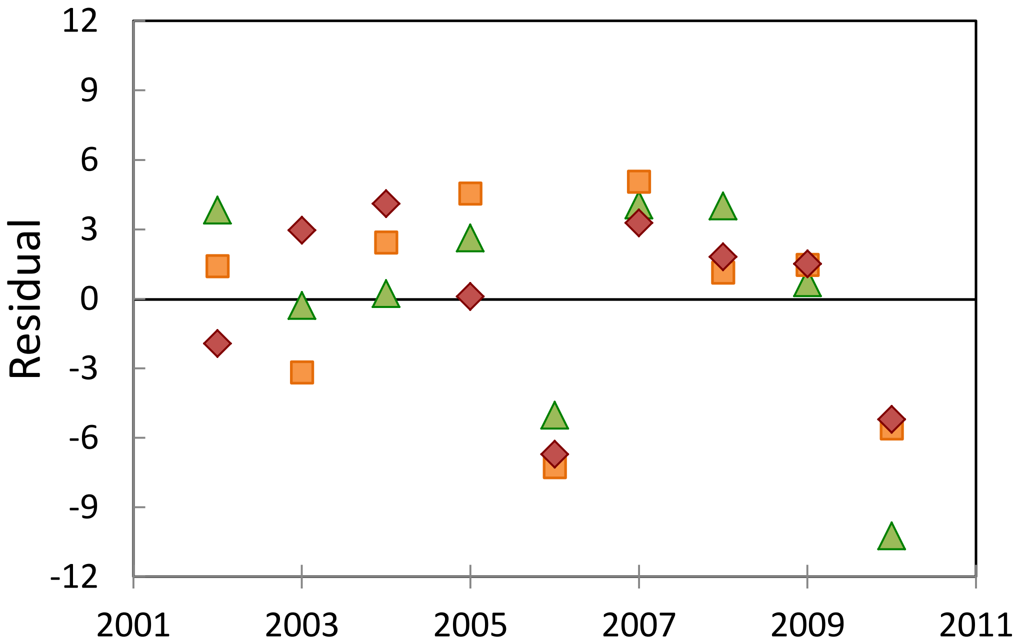
The NDVI – precipitation relationship in all three sites



Similar patterns of PUE and precipitation and a positive NDVI – precipitation relationship indicate the strong effect of rainfall in this low productivity area

The residual technique (RESTREND) for detecting human-induced land degradation

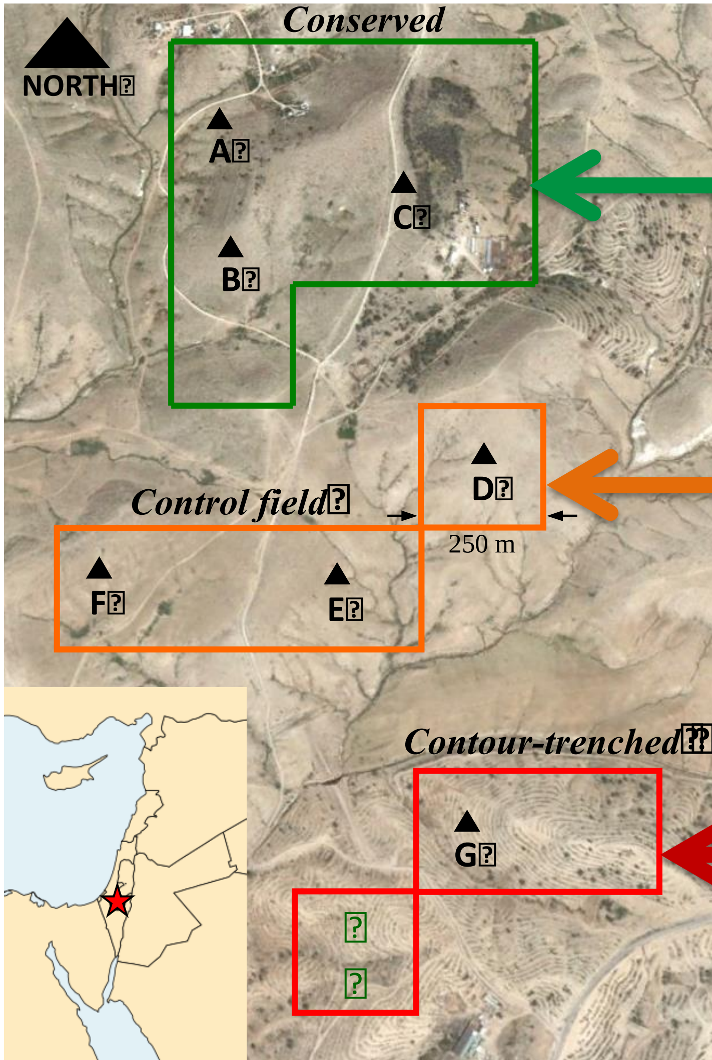
The residual from the expected NDVI (obtained from the linear regression against precipitation) minus the measured NDVI for the three sites during 2001 - 2010



No significant trends (P > 0.1)

The strong rainfall effect did not allow RESTREND to detect changes in biomass productivity due to human activity

Using the traditional lands as a reference

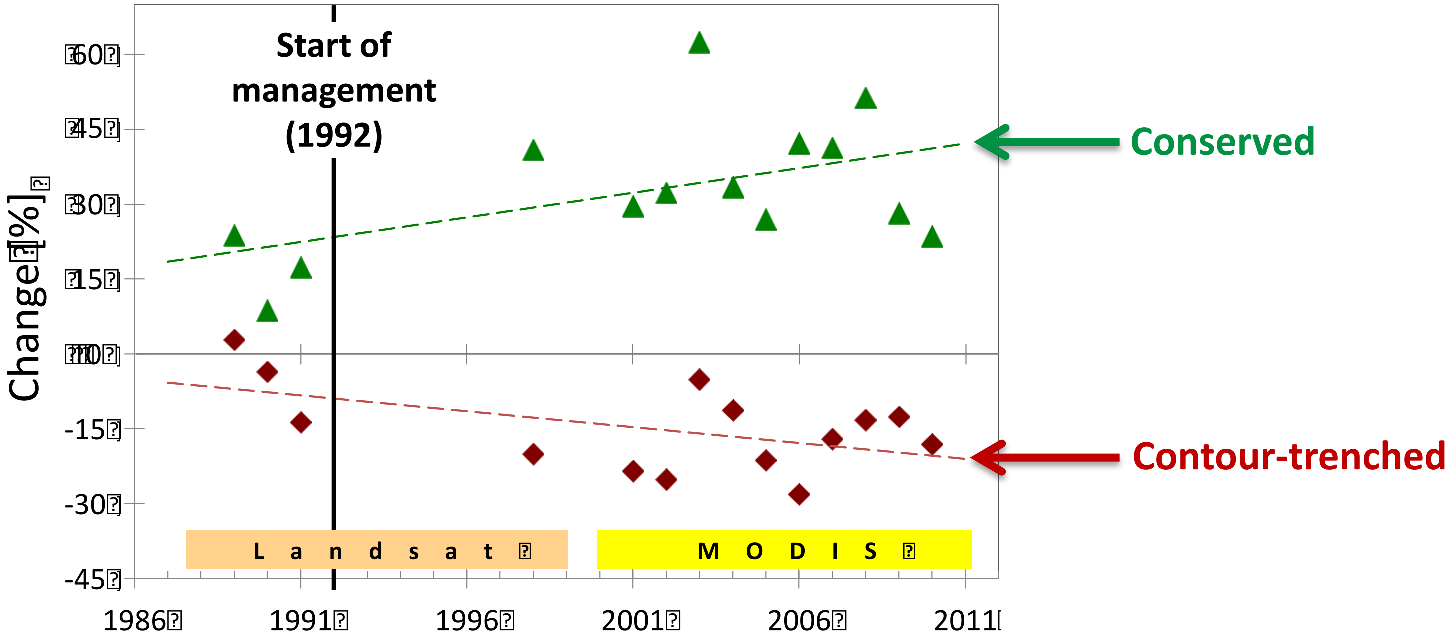


$$\text{\% Change} = \frac{\textit{Conserved} - \textit{Control}}{\textit{Control}}$$

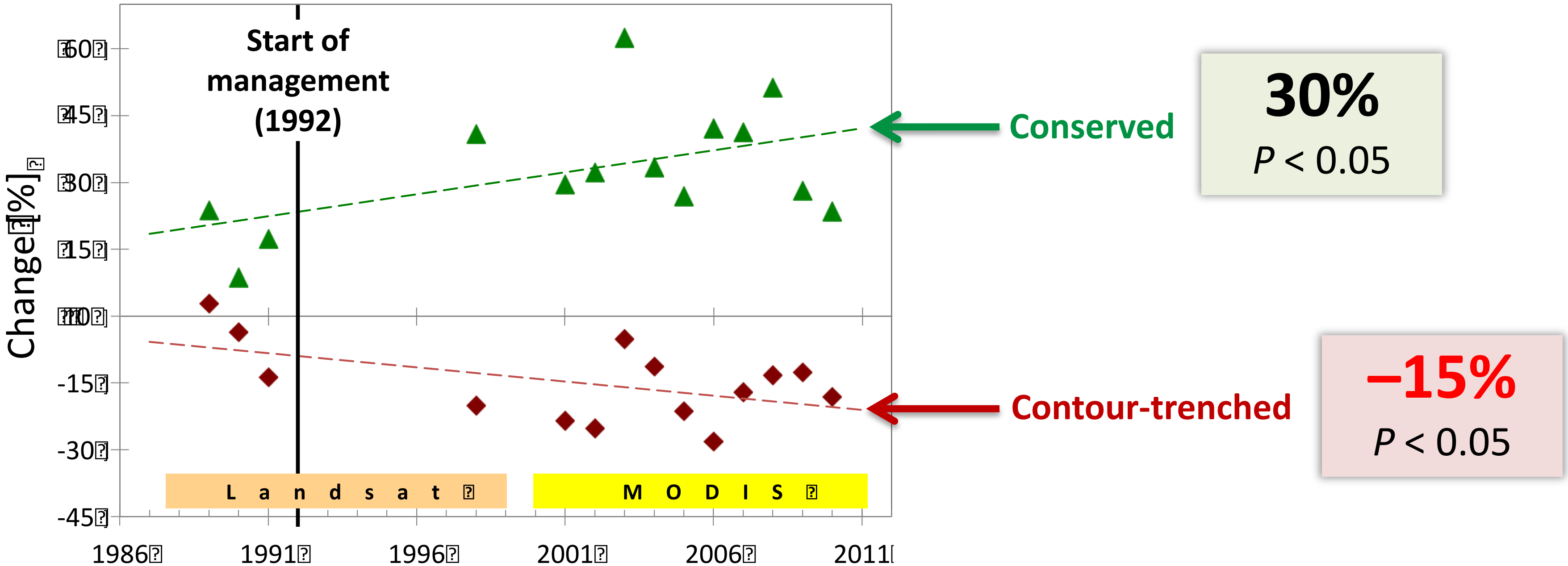
Traditional lands for reference *(Control)*

$$\text{\% Change} = \frac{\textit{Contour-trenched} - \textit{Control}}{\textit{Control}}$$

Change in biomass productivity (1989 – 2010)

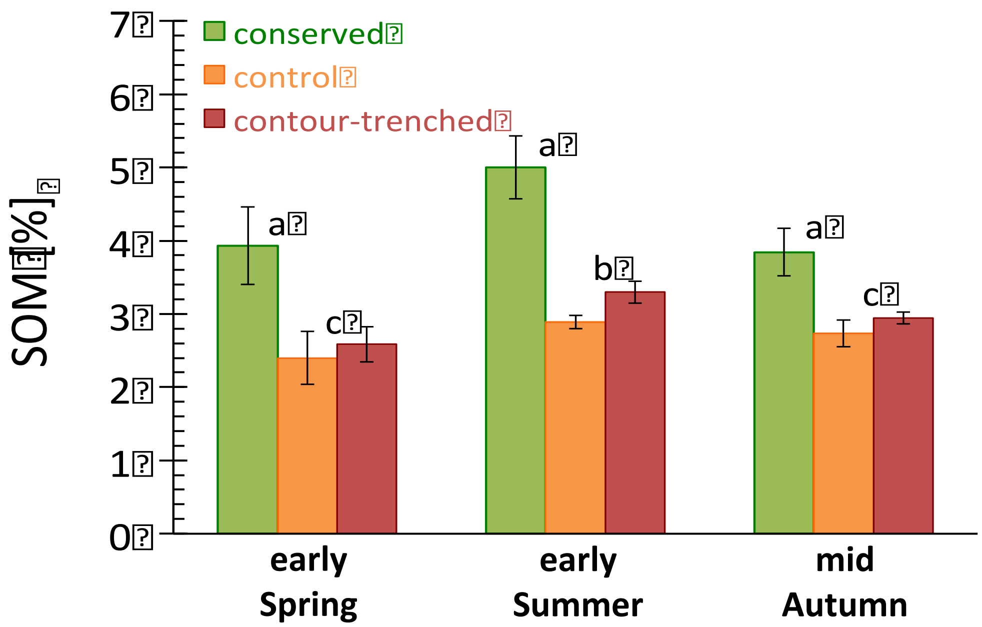


Change in biomass productivity (1989 – 2010)



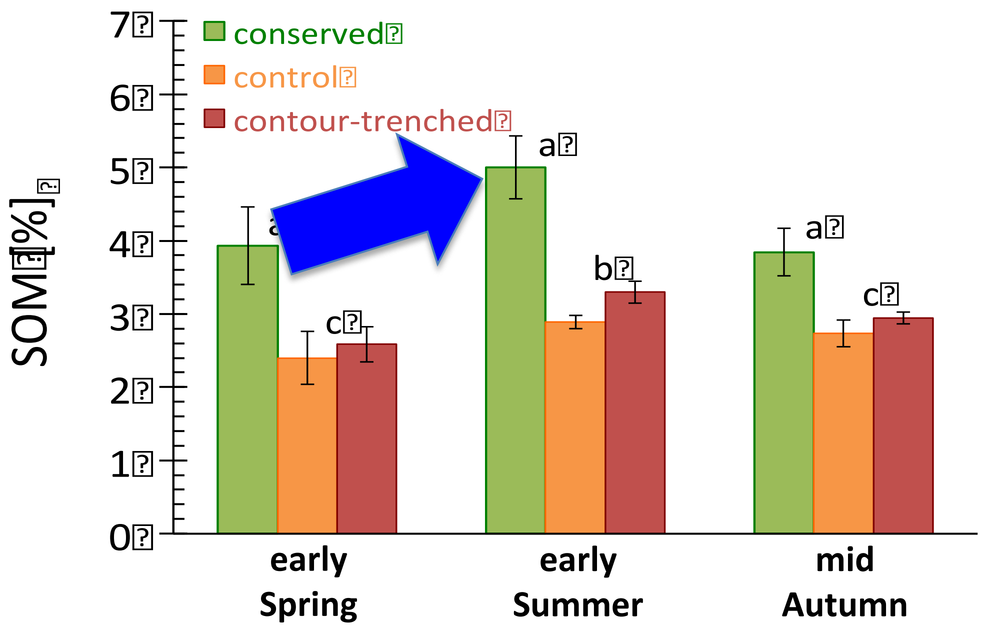
The contrast in biomass productivity is evident while comparing with a reference control site!!

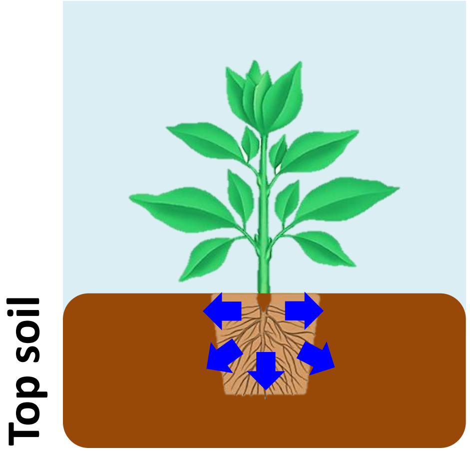
Soil organic matter (SOM) – a field assessment



- Greater SOM in the conservation site during all three seasons (40% – 70%)
- Comparable SOM in contour-trenched and control sites probably due to tilling of the control lands (releasing SOM as CO_2)

Soil organic matter (SOM) – a field assessment

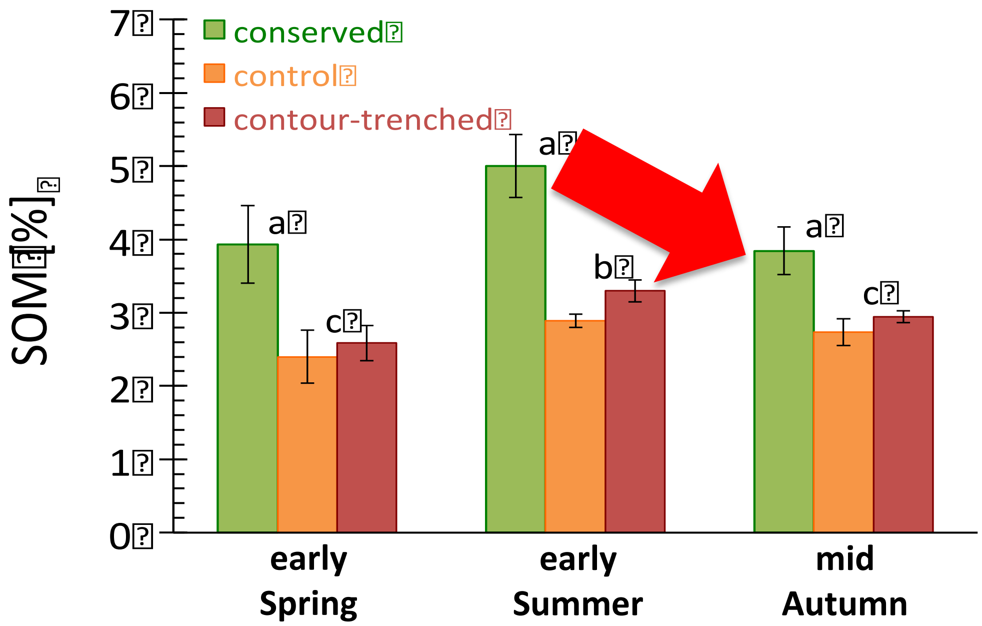


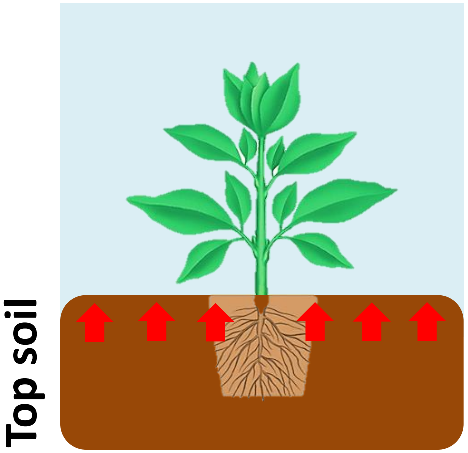


Increase in SOM –
root decomposition during the rainy season

Steinberger & Whitford, 1988

Soil organic matter (SOM) – a field assessment





Subsequent decrease in SOM –
CO_2 exchange back to the atmosphere during the dry season

Austin *et al.*, 2004

Summary

- **Correlation between NDVI and biomass of annual grasses in low-productivity area can be achieved through decomposition of NDVI time series**

- **Strong relationship between rainfall and NDVI prevented the detection of changes in productivity using conventional trend analysis**

- **The use of a reference site from the unmanaged lands allowed quantification of the impact of land management on productivity**

- **SOM from field sampling supported the findings obtained from the satellite-derived information**

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