

# Detecting phenological changes in vegetation response to climate variation on the SRER and nearby areas

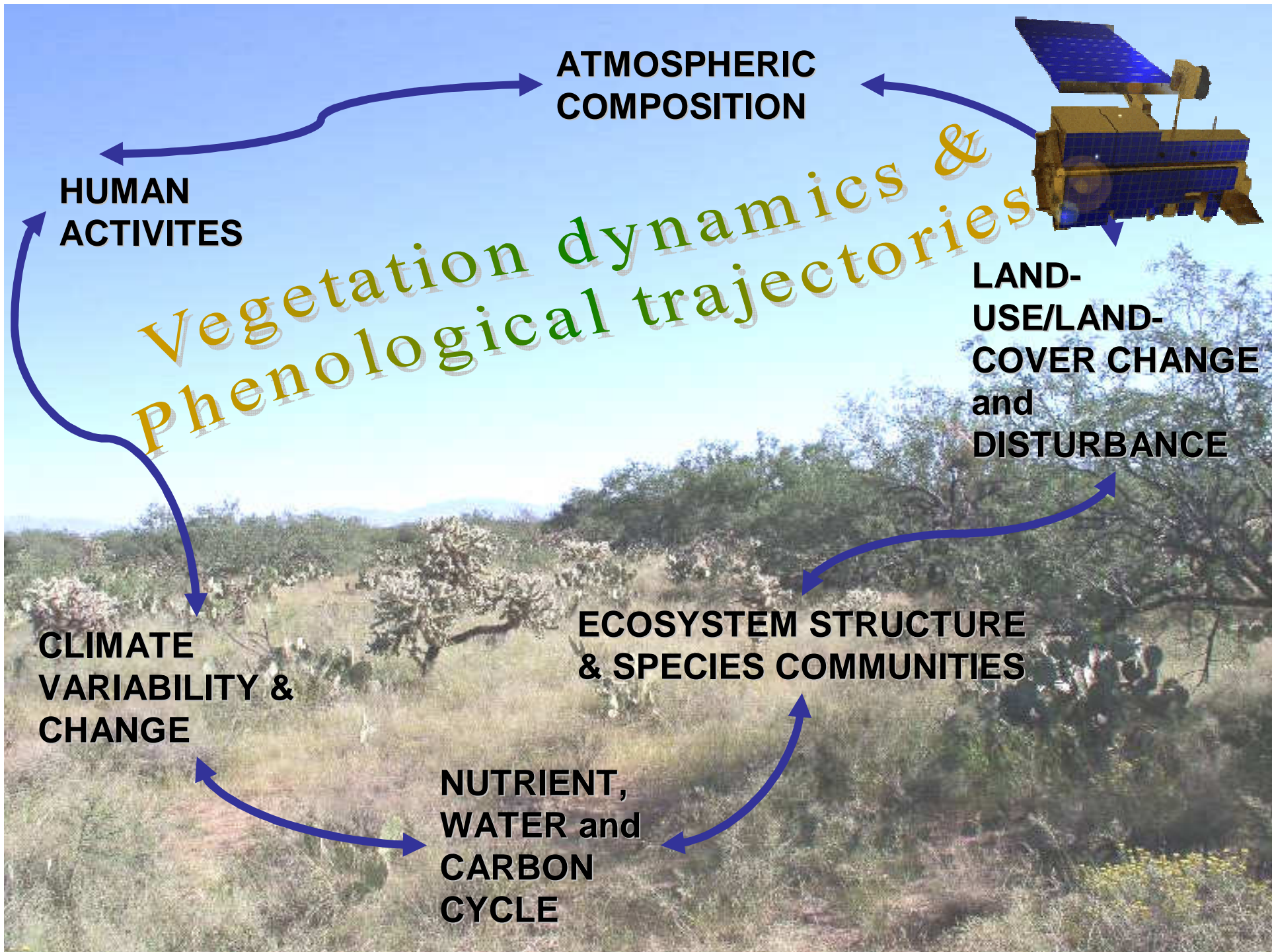
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Aaryn Olsson, Barron Orr, Stuart E. Marsh, ARSC



University of Arizona  
Geography and Regional Development  
Office of Arid Lands Studies





# Why Study Vegetation Phenology?

- Phenology - study of plant and animal life cycle events (biological clock)
- Timings of vegetation growing phases
- Earth systems interactions with seasonality of T, H<sub>2</sub>O, PAR
- Impact of global and regional scale events (Drought, Fire, Extreme weather)
- Metrics about phenological events provide indicators of the impacts of global change and variability

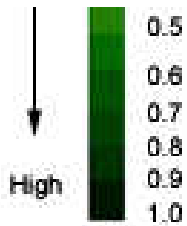
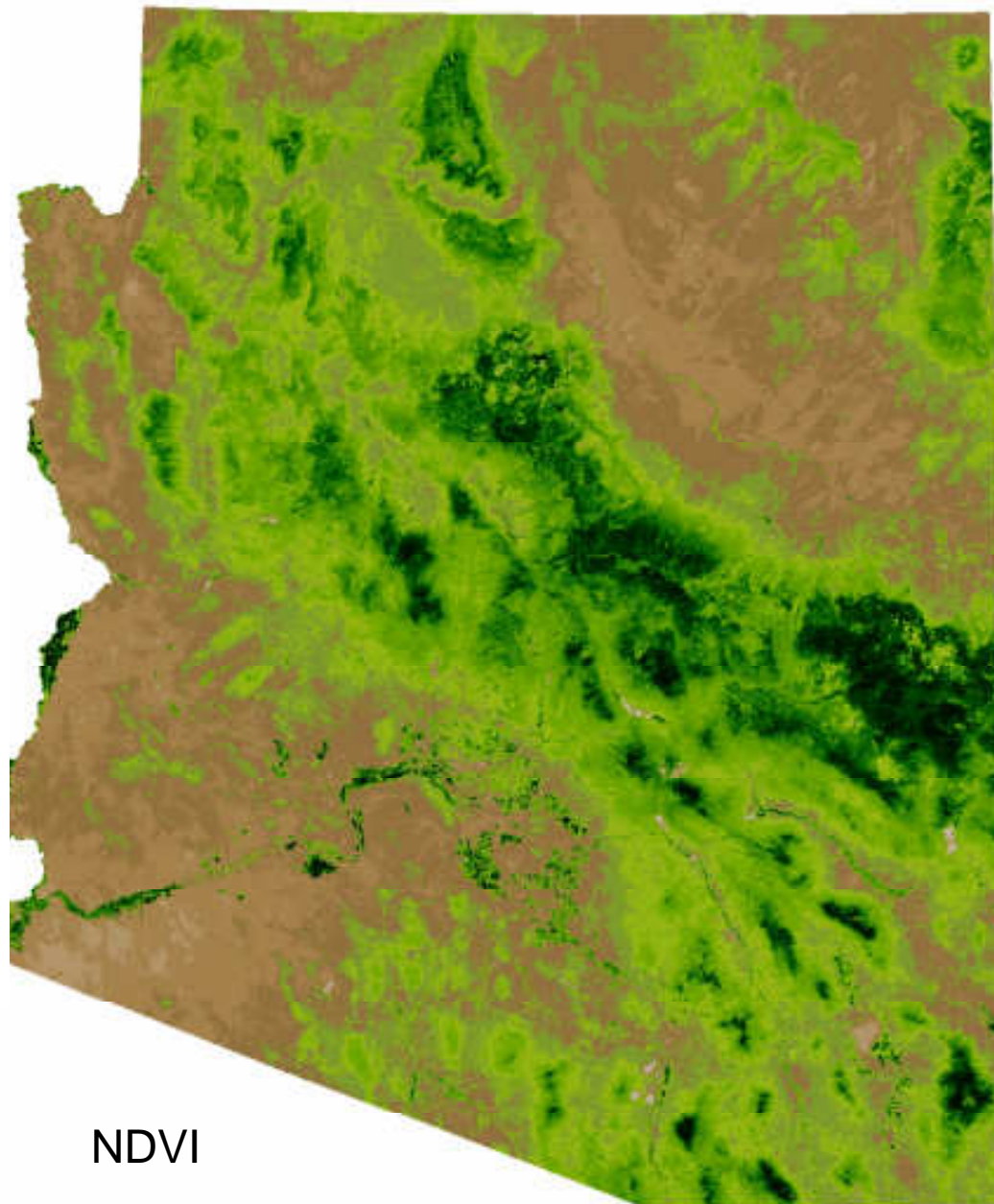
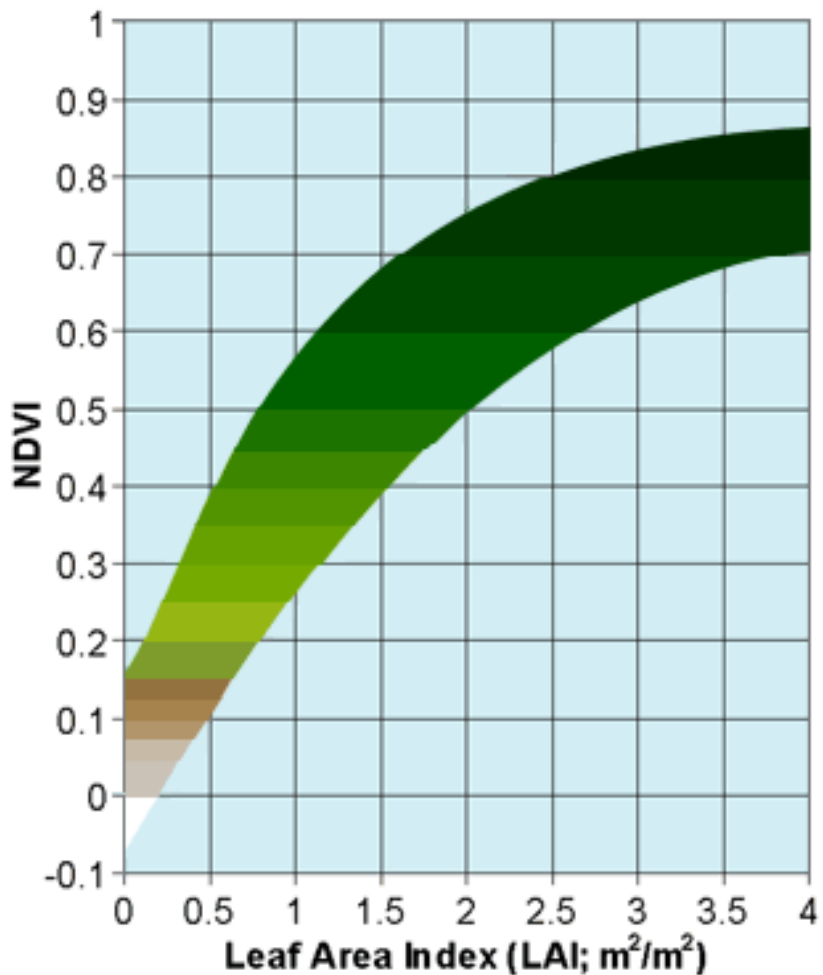
# APPLICATIONS OF PHENOLOGY

- Provide phenological metrics to global climate, ecosystem and other models
- Provide natural resource managers and decision makers information about the timings of vegetation activity
- Agriculture, Natural resources
- Human Health (e.g. Allergies & Vector borne diseases)
- Science Education
- Tourism and recreation

**Ecological and Socio-economic consequences**

# MODIS NDVI 16-day Composite Image

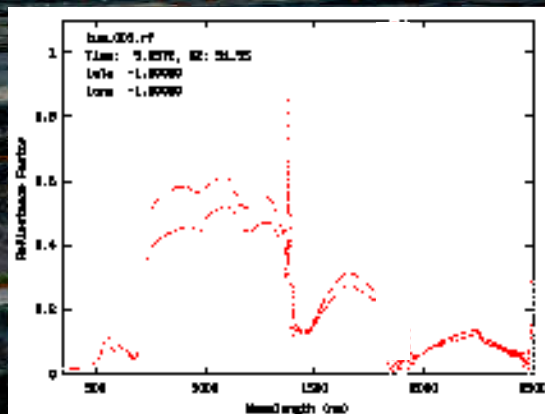
NDVI vs LAI



# Creosote - Pheno-phase – Pheno-spectra

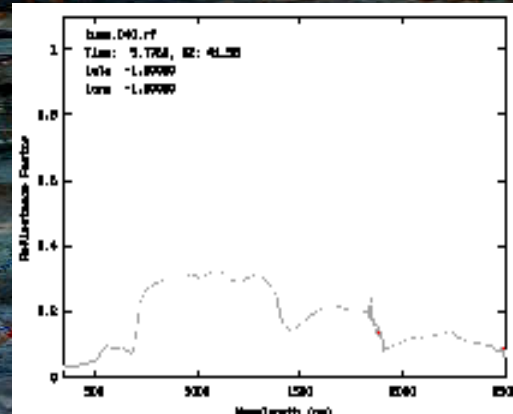
9-22-2006

New leaf



4-16-2007

seeds



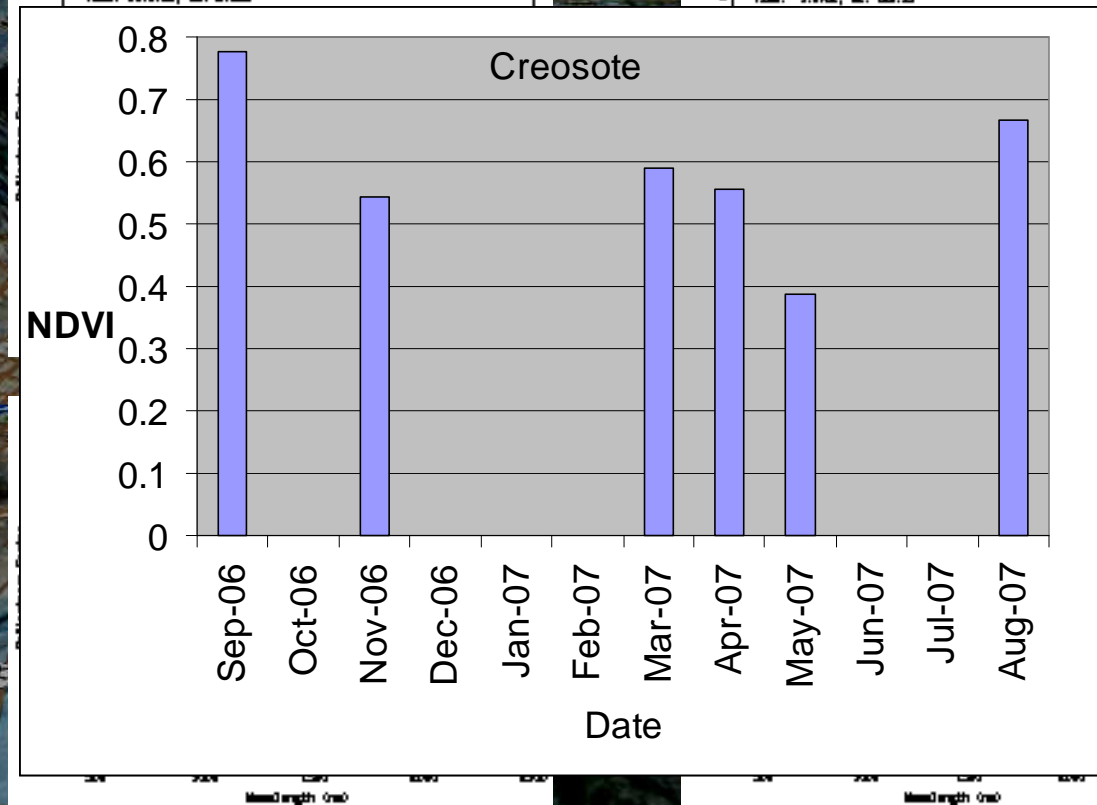
11-6-2006

turning of leaves



5-29-2007

stress seeds



3-16-2007

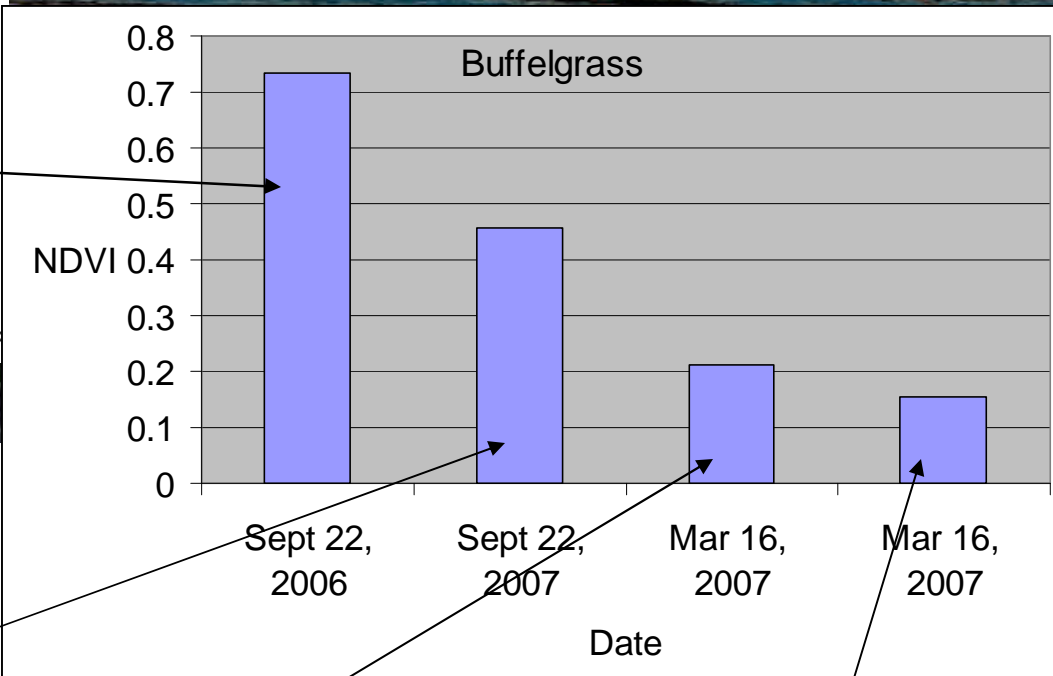
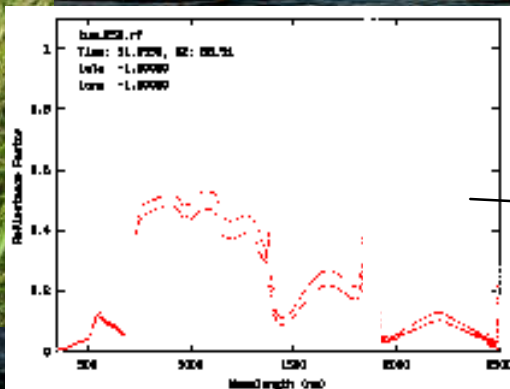
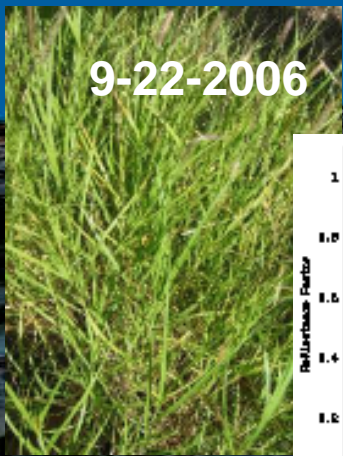
Leaves, buds, flowering

8-16-2007

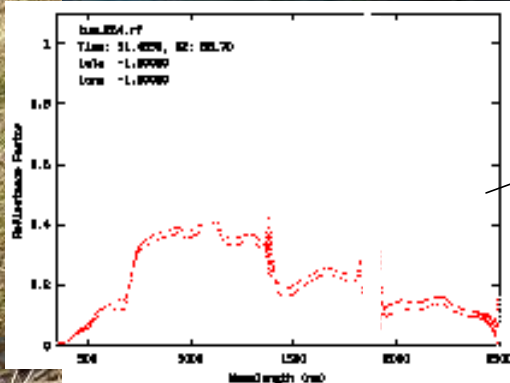
Leaves, buds, flowering, seeds

# Buffelgrass - Pheno-phase – Pheno-spectra

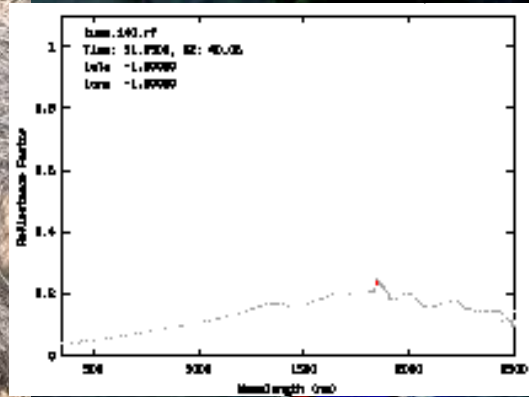
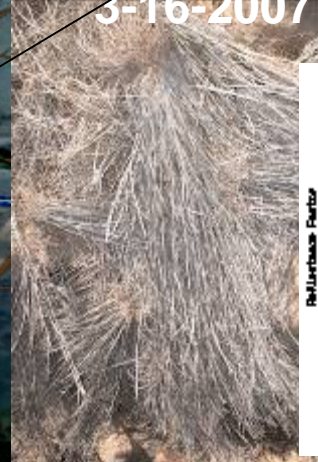
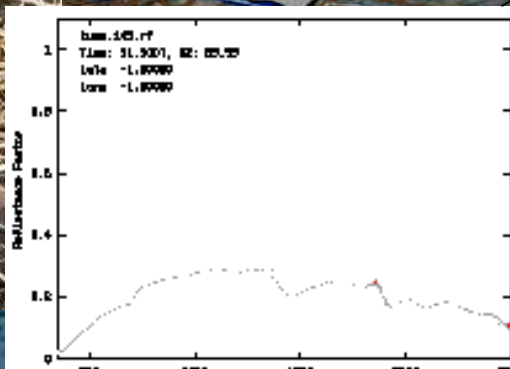
9-22-2006



9-22-2006



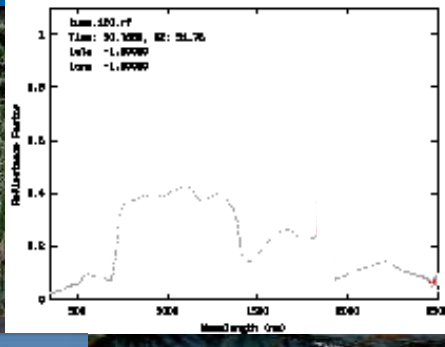
3-16-2007



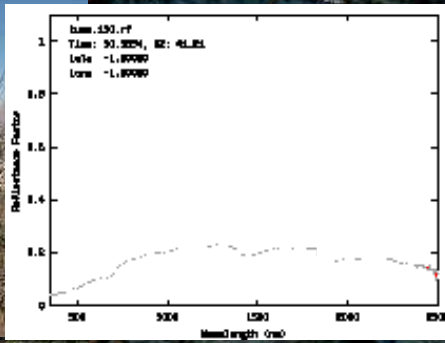
# Mesquite - Pheno-phase - Pheno-spectra



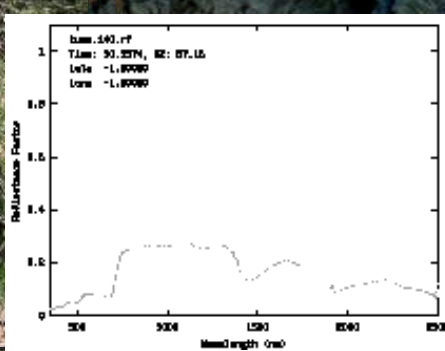
11-06-2006



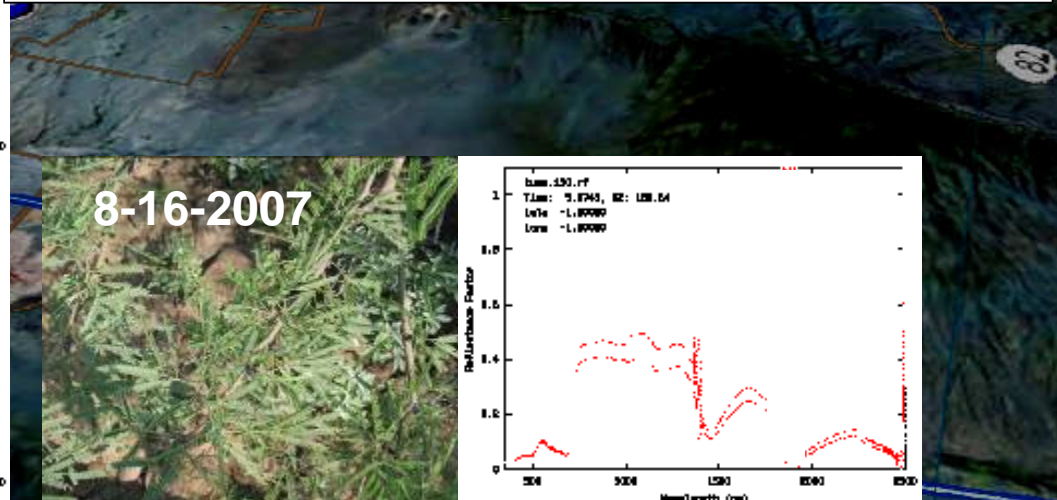
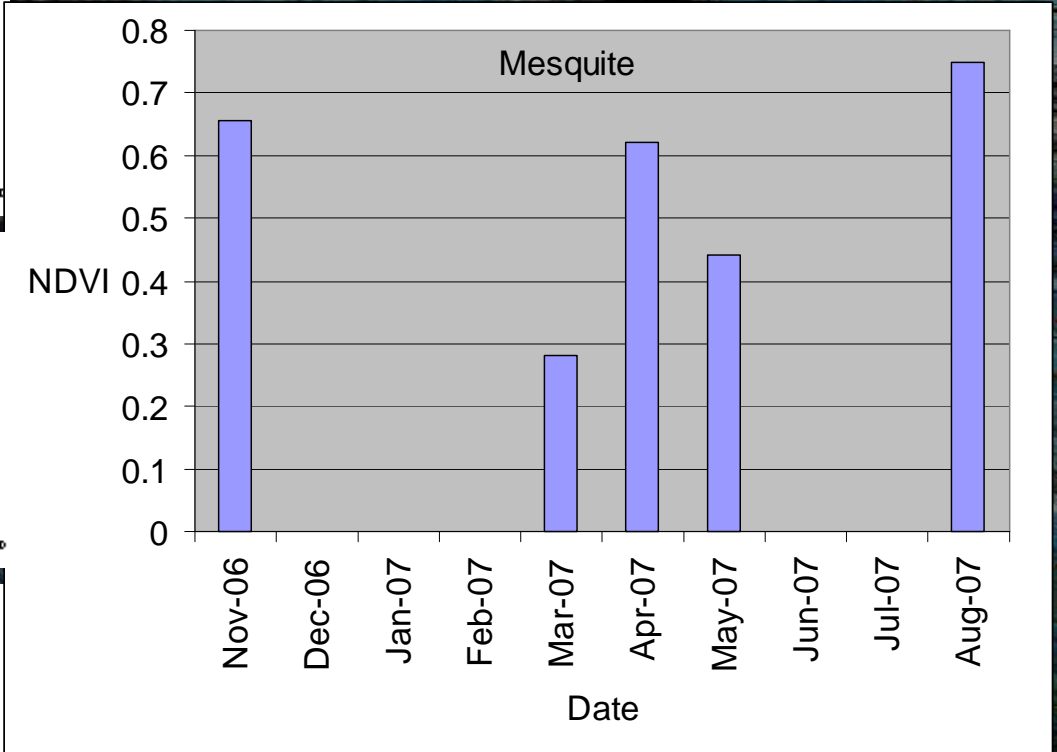
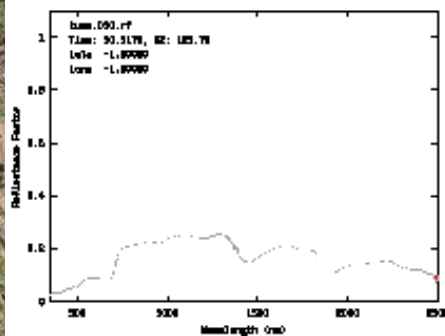
3-16-2007



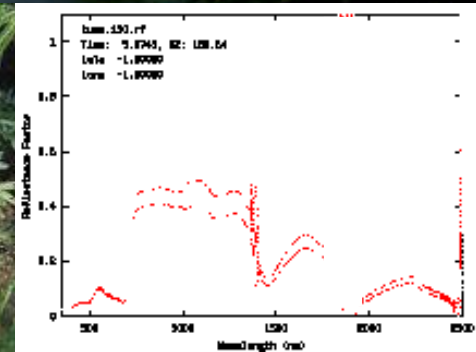
4-16-2007



5-29-2007



8-16-2007





# Satellite based vegetation phenology

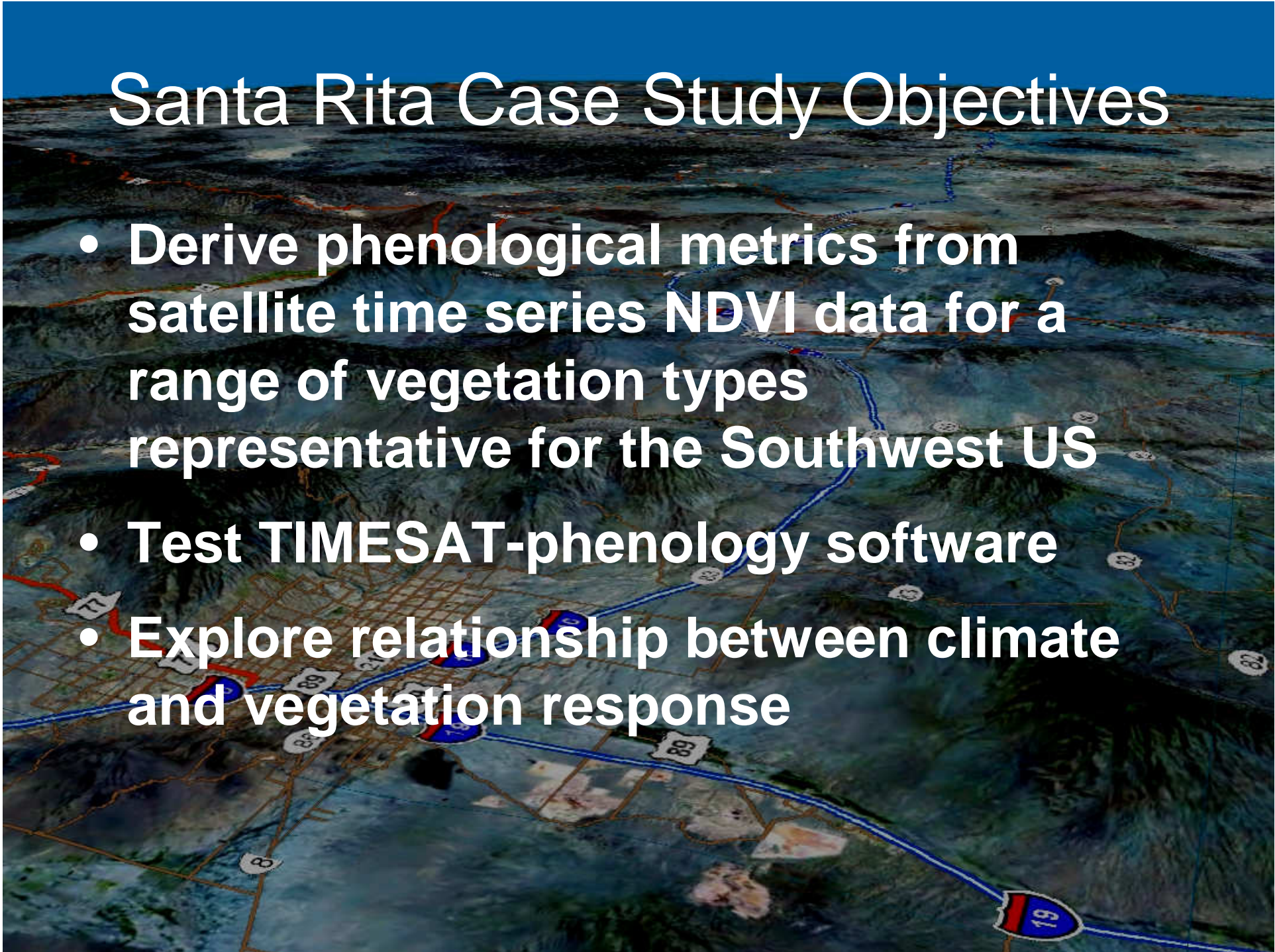
**Advantage:** intra and inter annual, regional - global scale

**Phenological metrics from bi-weekly satellite NDVI data:**

- Timing of Begin, End, Length, Peak
- Modality (bi-modal, uni-modal)
- Amplitude, Base, Integration
- Strength of green-up, green down

# Santa Rita Case Study Objectives

- Derive phenological metrics from satellite time series NDVI data for a range of vegetation types representative for the Southwest US
- Test TIMESAT-phenology software
- Explore relationship between climate and vegetation response



# Data and Methods:

- Major ReGAP vegetation classes (30m)
- Resample Vegetation classes to MODIS resolution 250 m
- PRISM (4 km) and ground based precipitation and temperature data
- Sample NDVI, rainfall and T time series data for 2000-2006 for major vegetation types
  - Use noise reduction and curve fitting software to extract pheno-metrics: TIMESAT - *Jönsson & Eklundh, 2004*
    - *Savitzky-Golay* smoothing method that performs a local polynomial regression around each point.
  - Correlations between climate- and pheno-metrics
  - Visualization of phenological metrics

# NDVI TIME SERIES (2005)

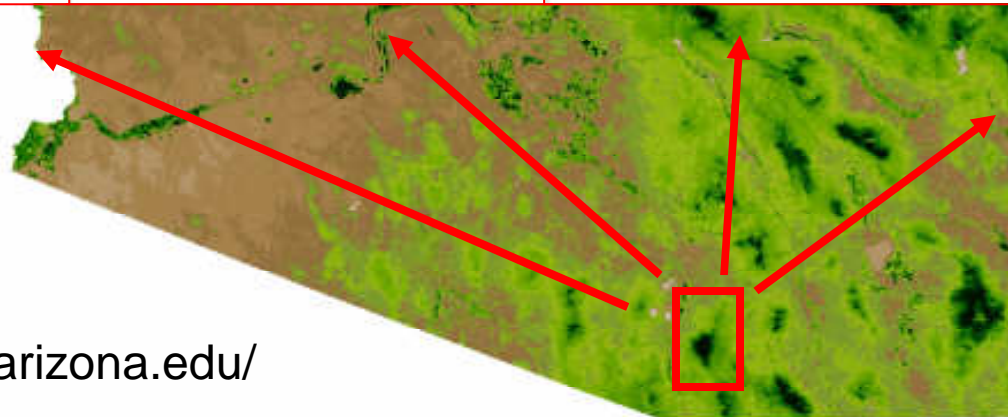
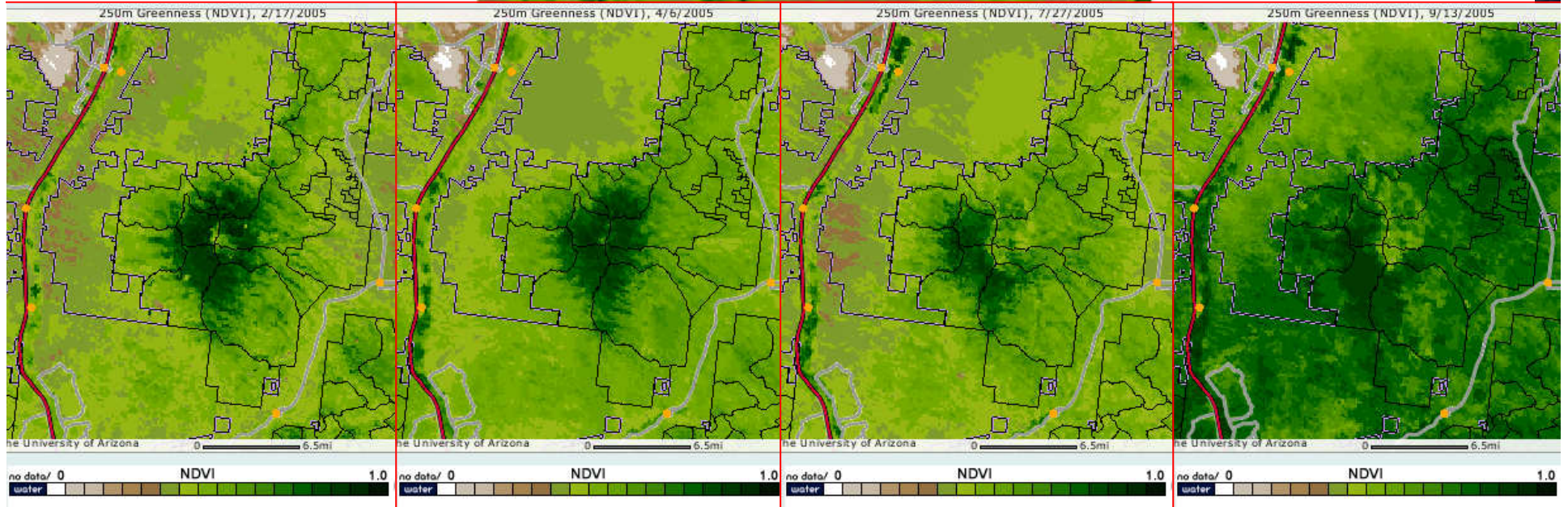
## Santa Rita Mountains

**FEB.**

**APRIL**

**JULY**

**SEPT.**



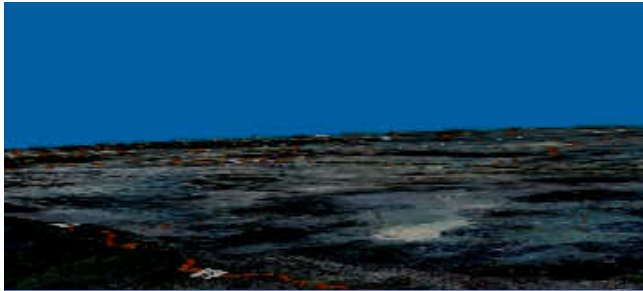
<http://rangeview.arizona.edu/>

Madera Canyon Riparian (cottonwood)  
Pinyon, Juniper, Oak

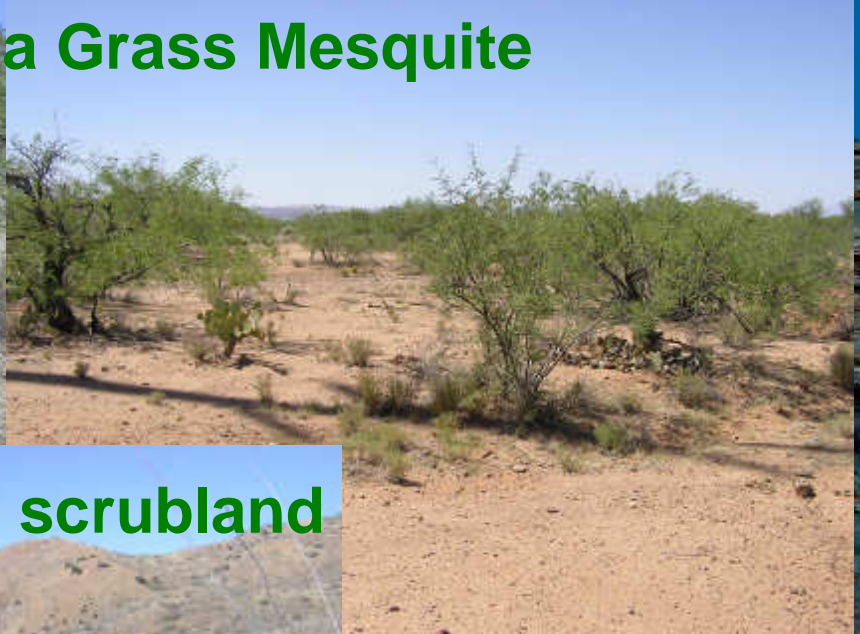
Mt Wrightson

Shrubland

Ponderosa Pine



# Semi-arid Savanna Grass Mesquite



Desert scrubland



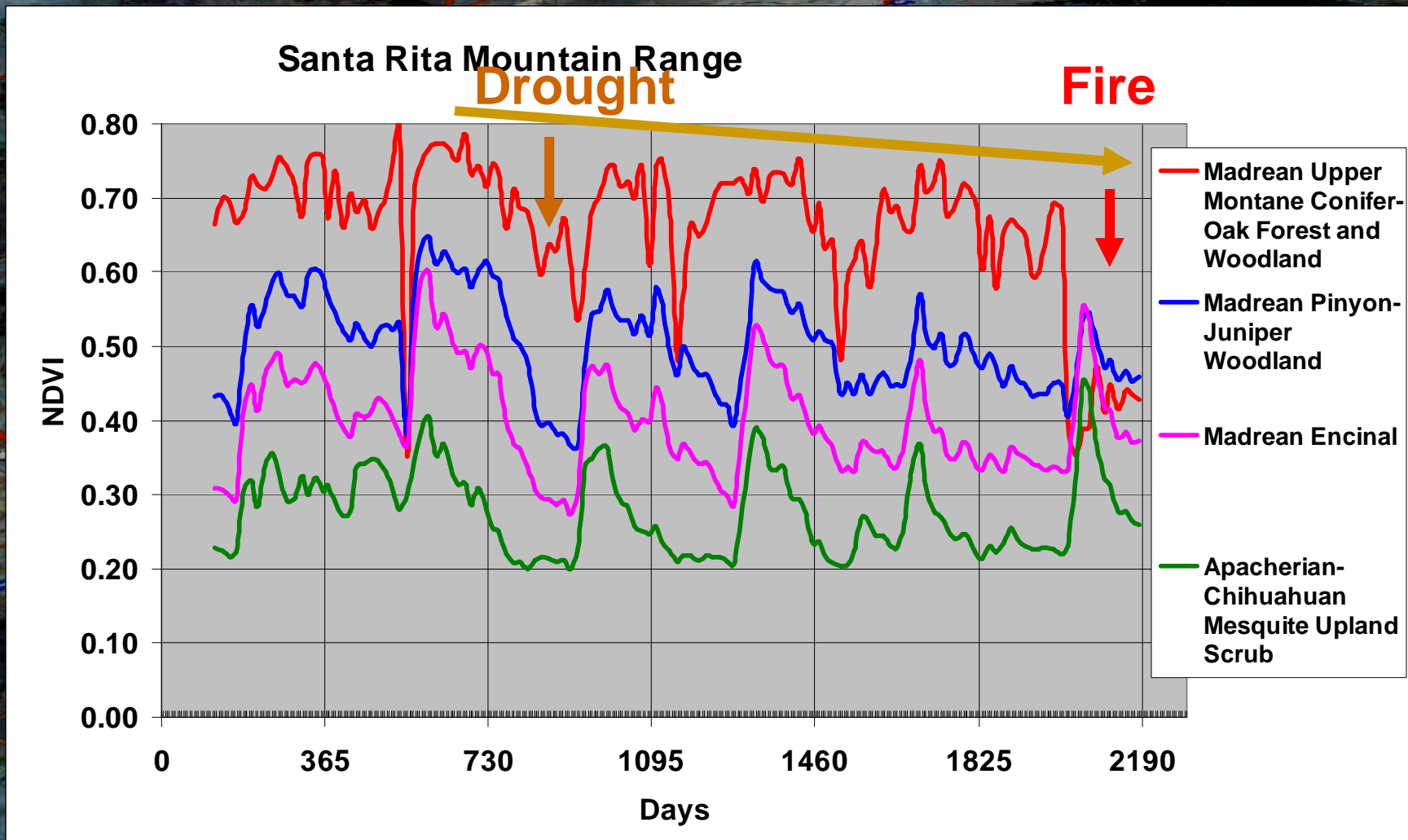
Pinyon - Juniper



Pine-Oak woodland

# NDVI trajectories for vegetation types along an elevation gradient

2000 2001 2002 2003 2004 2005



# Apacherian-Chihuahuan Mesquite Upland Scrub

2000

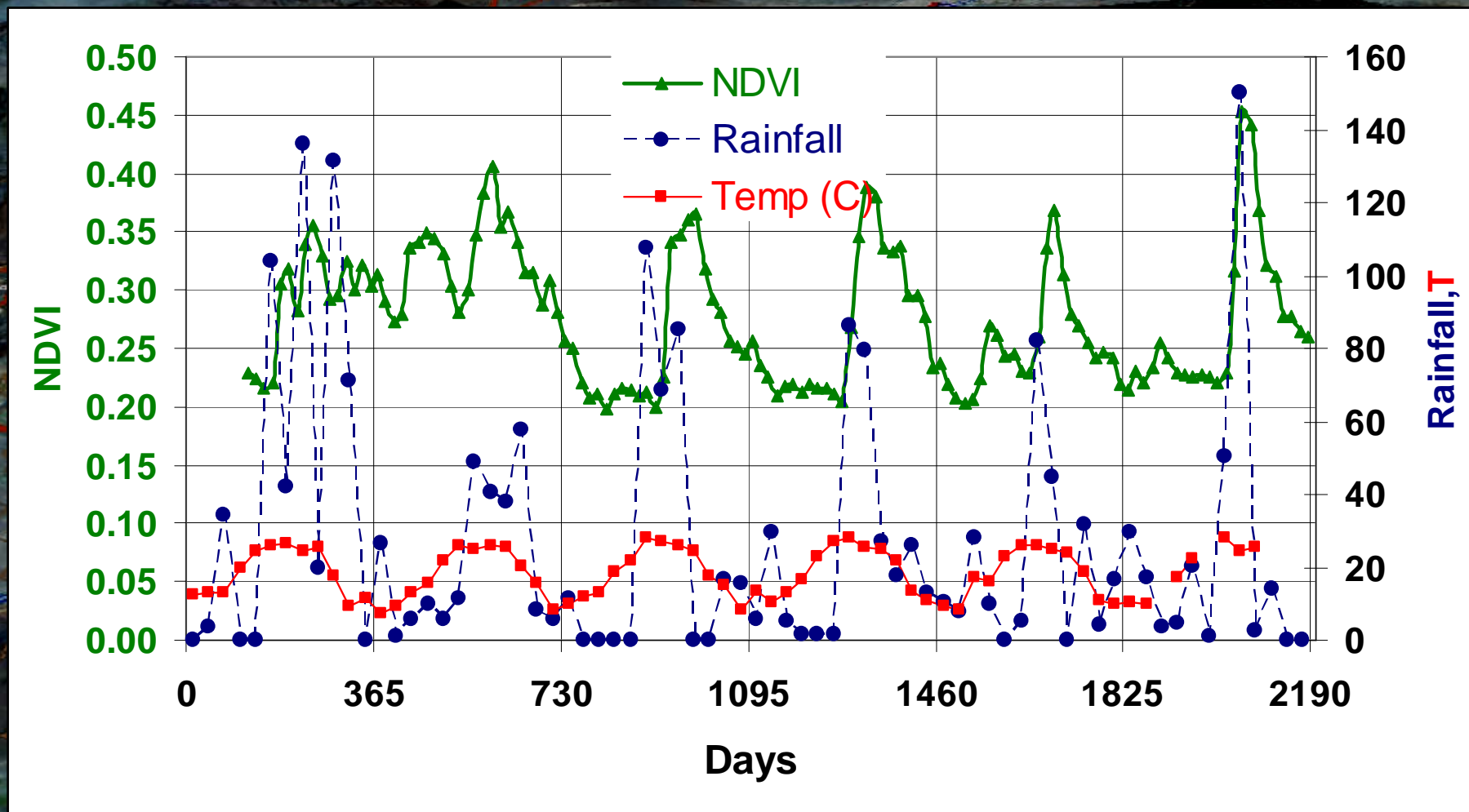
2001

2002

2003

2004

2005





# Madrean Pinyon-Juniper Woodland

2000

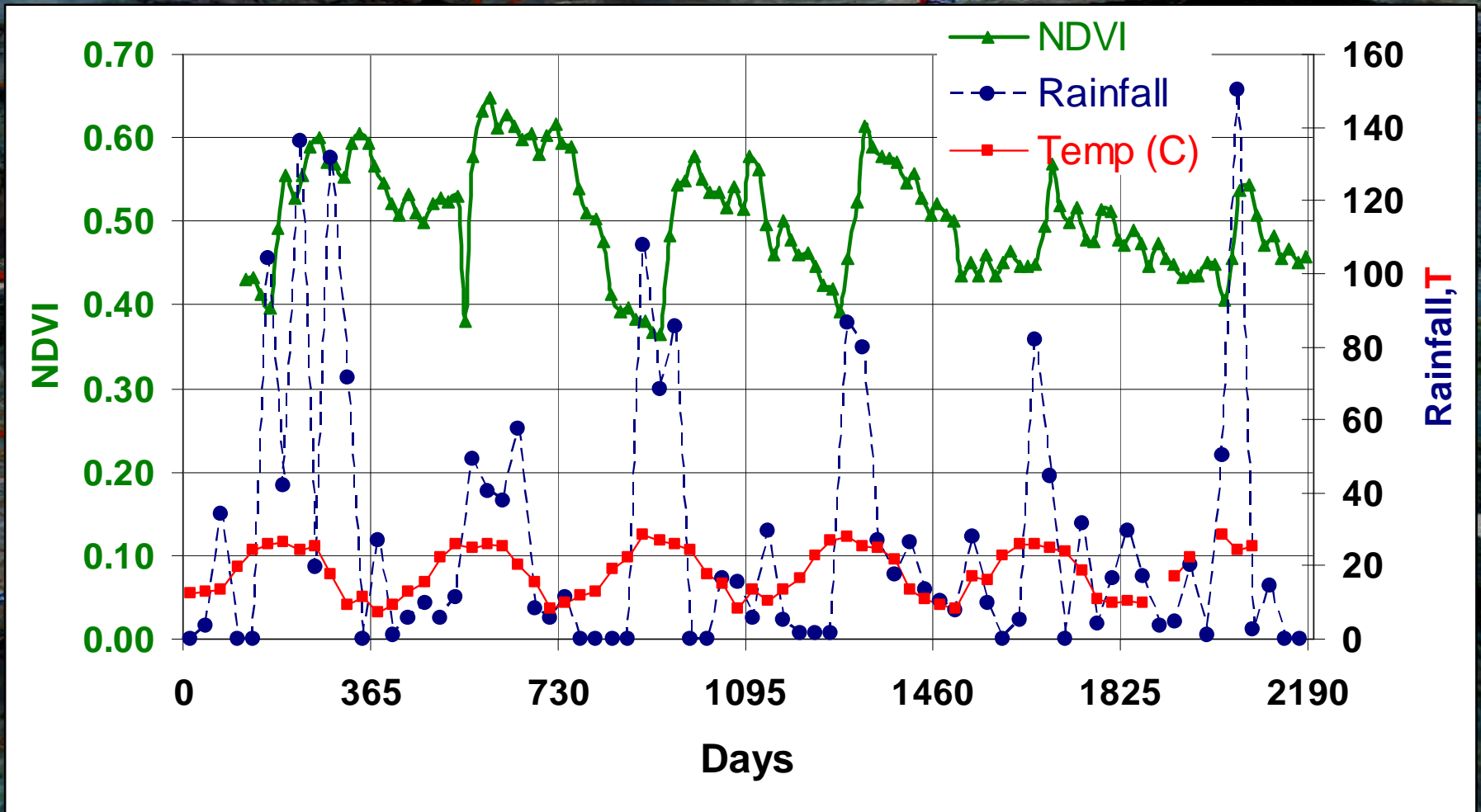
2001

2002

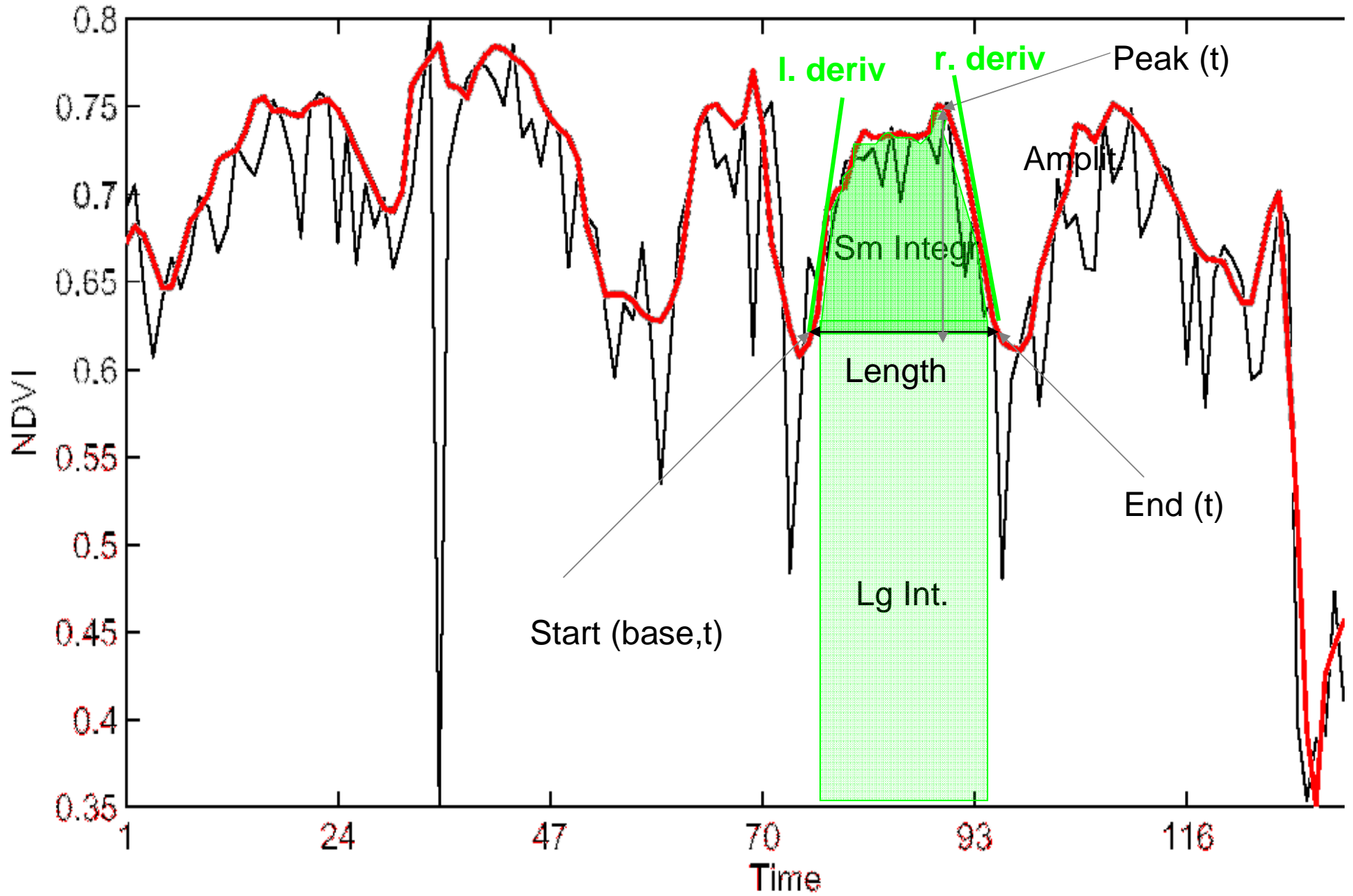
2003

2004

2005

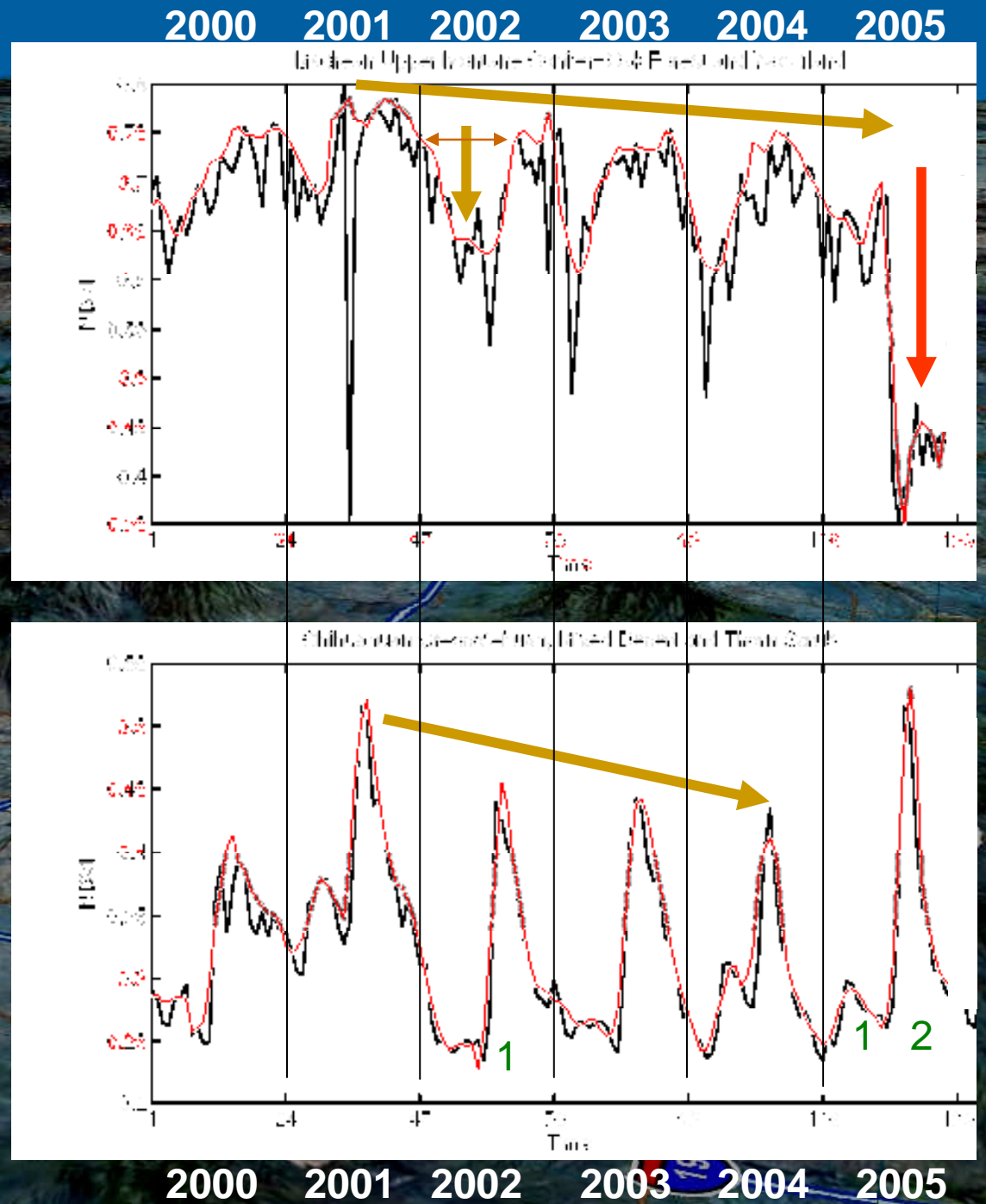


# Madrean Upper Montane Conifer-Oak Forest and Woodland



# TIMESAT

- Unimodal and bimodal growing season
- Post-wildfire effects
- Drought effect



# TIMESAT: Phenological metrics (t, NDVI)

**Data plotting**

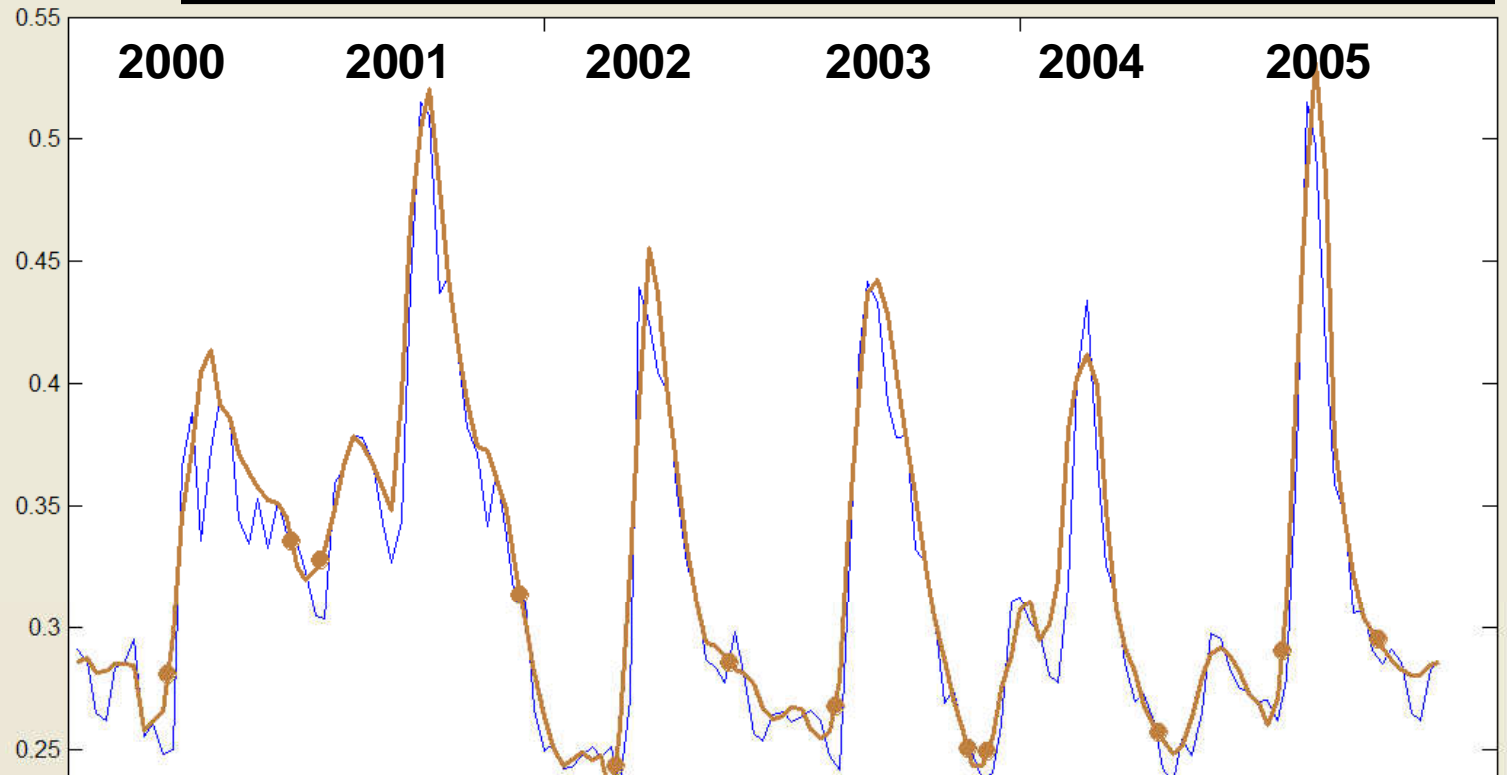
- Points
- Weights
- Gridlines
- Lock axes scaling

Zoom

Plot next series

**Data values**

Valid data range:  to

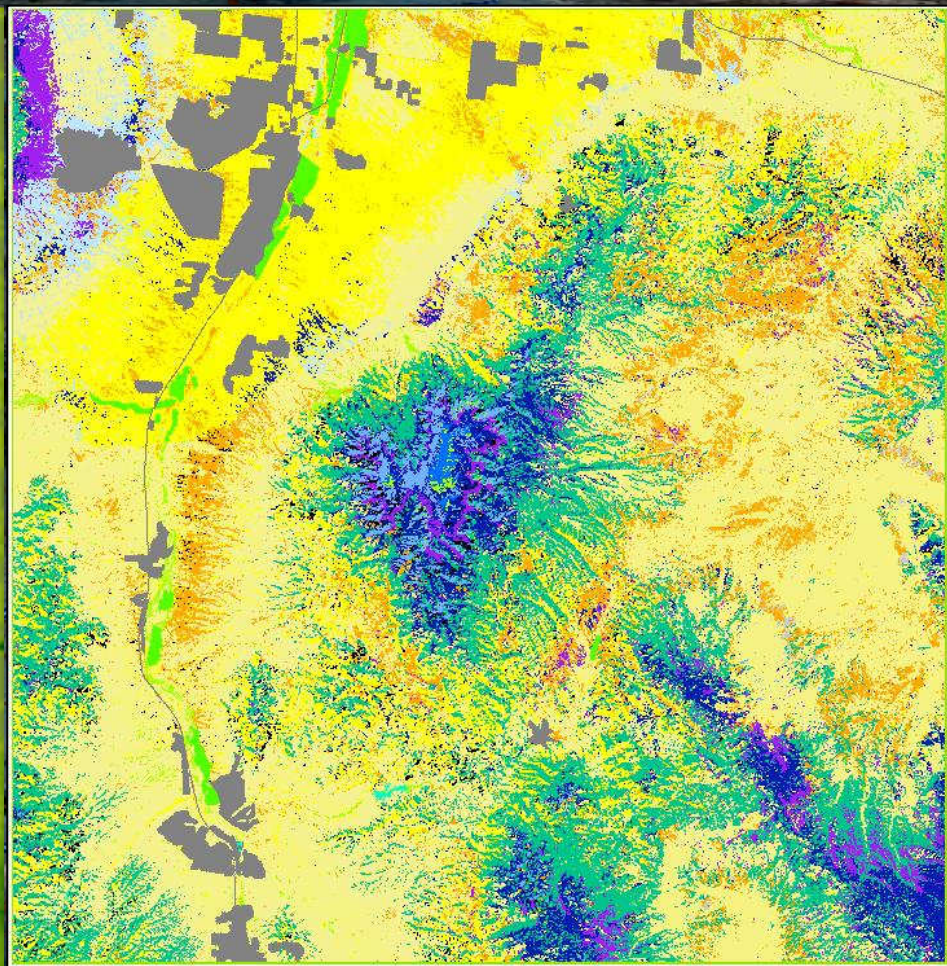
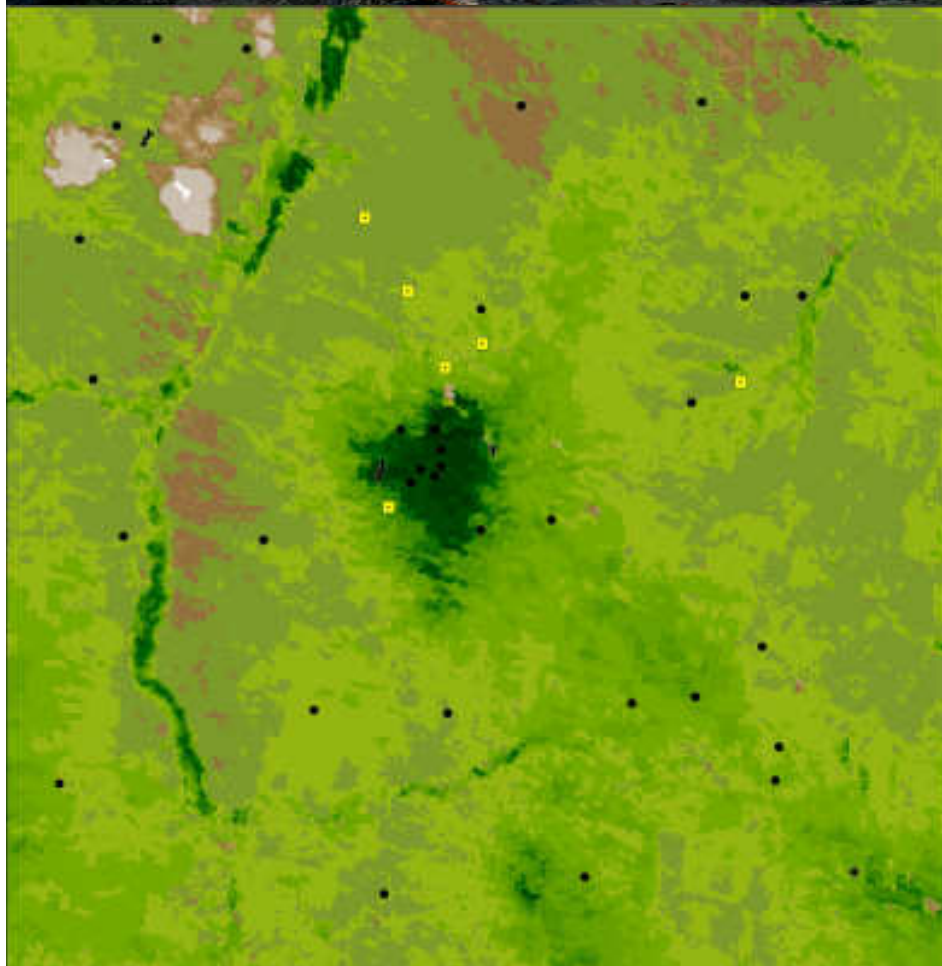


Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe											
season	start	end	length	base	peak time	peak	amp	l-deriv	r-deri	l-int	s-int
2000	168	376	208	0.298	232	0.438	0.14	0.045	0.009	5.57	1.1
2001	72	392	320	0.33	248	0.537	0.21	0.017	0.022	9.05	1.79
2002	184	376	192	0.261	248	0.477	0.22	0.064	0.019	4.79	1.14
2003	184	408	224	0.255	256	0.481	0.23	0.059	0.02	5.64	1.55
2004	72	360	288	0.261	240	0.412	0.15	0.012	0.019	6.28	1.06
2005	200	360	160	0.281	248	0.562	0.28	0.111	0.033	4.63	1.26

150

l-deriv.  
223 0.  
0  
2093 0.0  
0  
2031 0  
0  
1934 0  
0  
1662 0  
0  
0.2611

# Sampling of Study Area

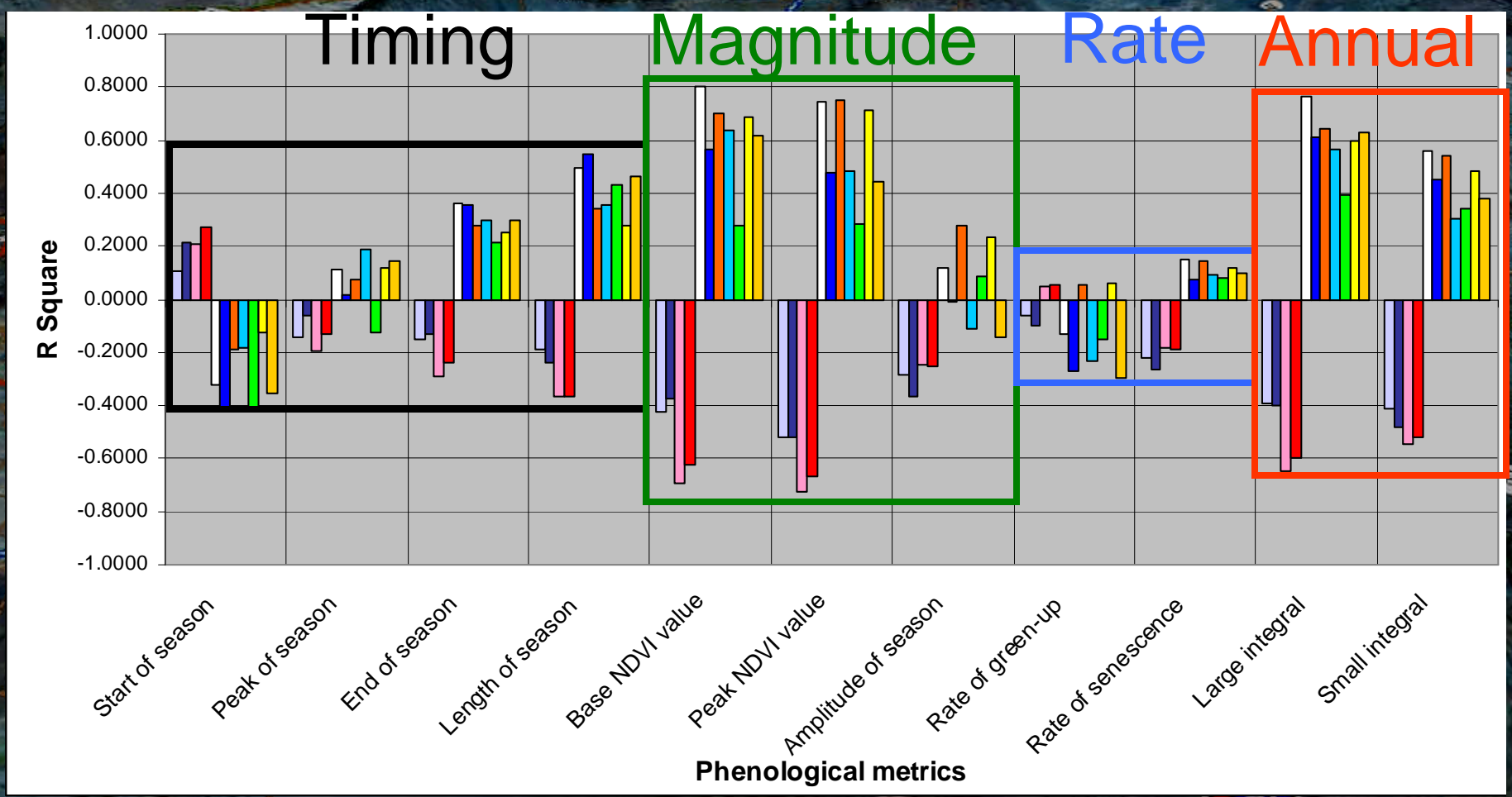


0 5 10 20 Km



# Correlations between Phenometrics and Climate metrics (Desert shrub → Conifer oak)

- Average minimum temp.
- Extreme minimum temp.
- Average maximum temp.
- Extreme maximum temp.
- Annual precip.
- 6 mo. Winter precip.
- 6 mo. Summer precip.
- 3 mo. Winter precip.
- Pre-monsoon precip.
- Monsoon precip.
- Post-monsoon precip.

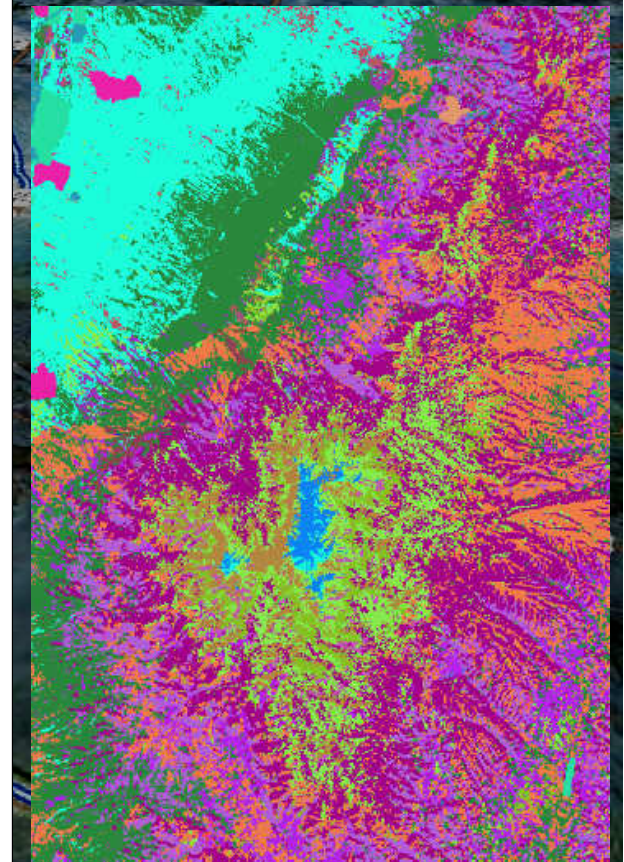
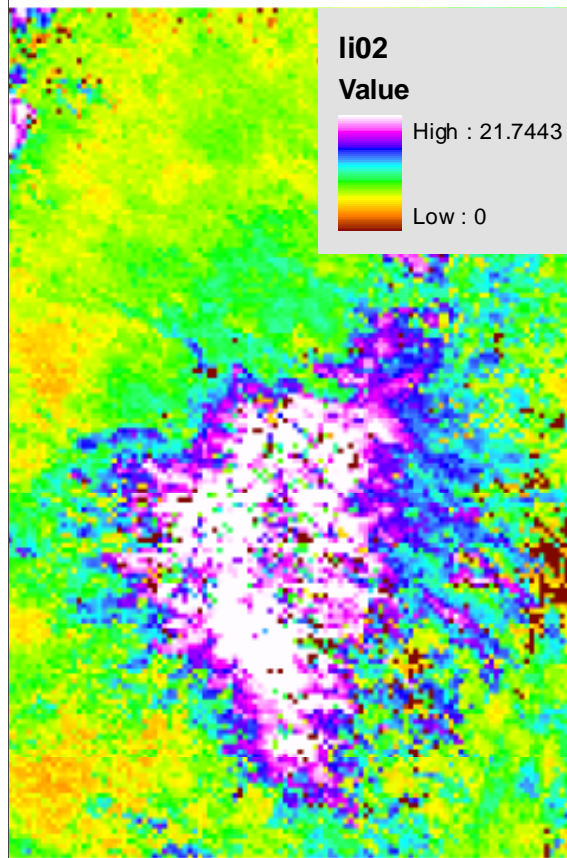
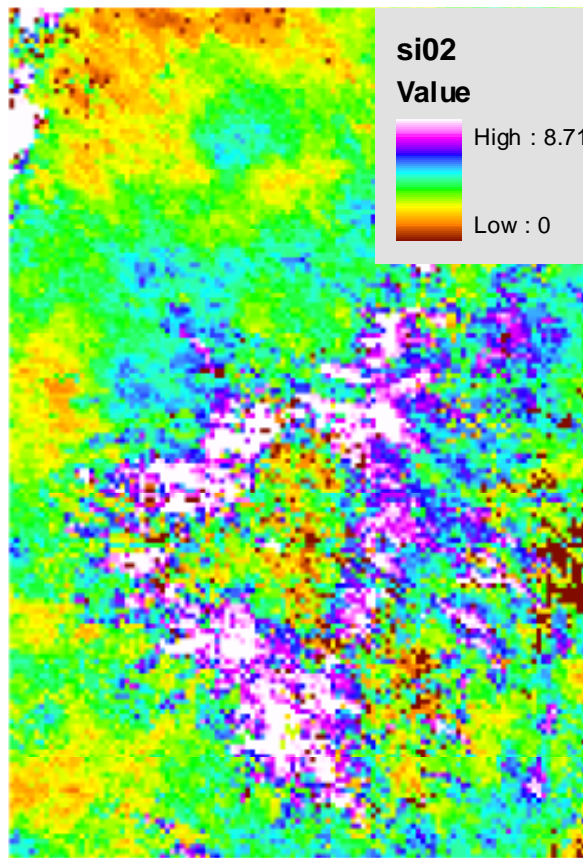


# Spatial patterns of Pheno-metrics (biophysical; 2002)

Integrated NDVI (short)

Integrated NDVI (long)

ReGAP

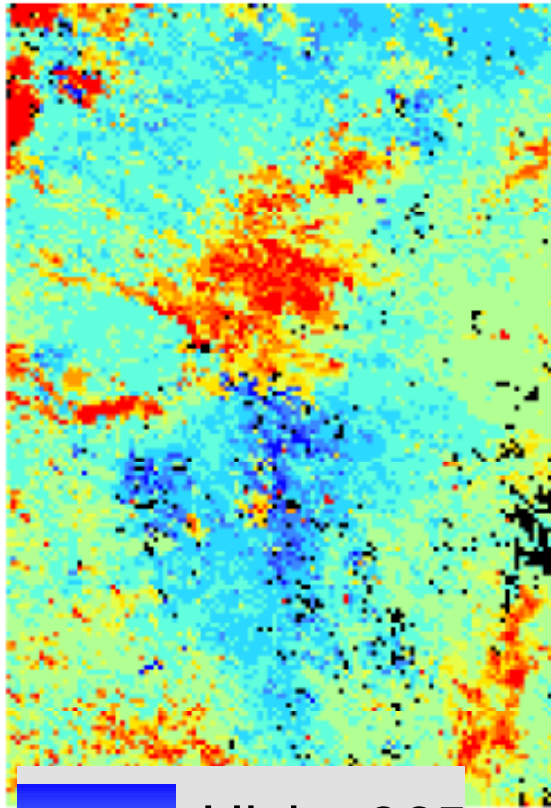


# Spatial patterns of Pheno-metrics (2002; timings)

START

PEAK

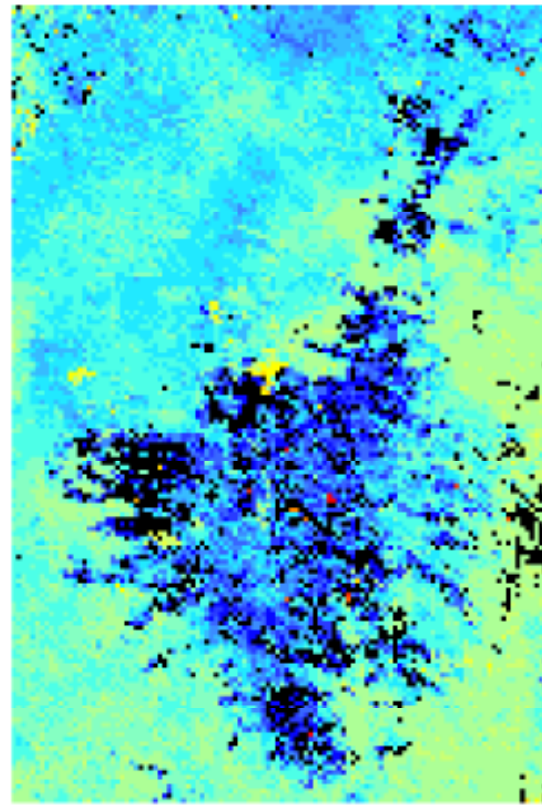
END of Season



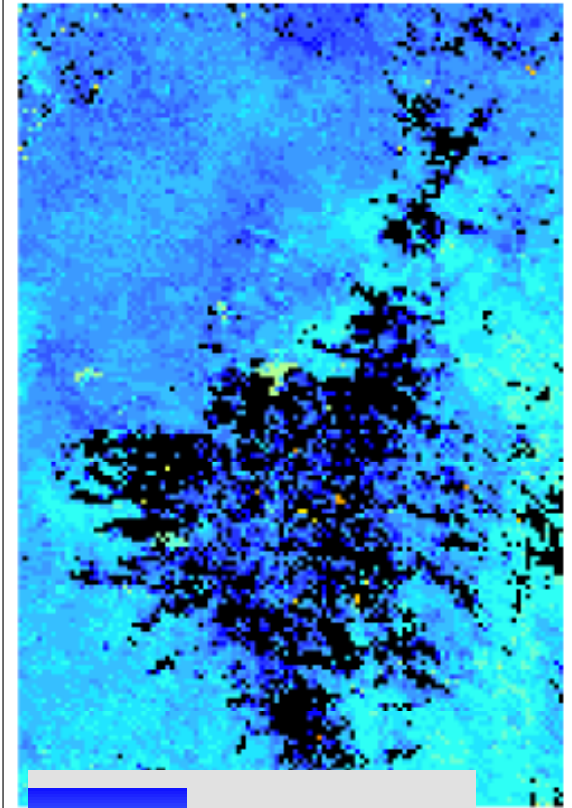
High : 365

**DOY**

Low : 0



0 2 4 8 12 16  
Kilometers



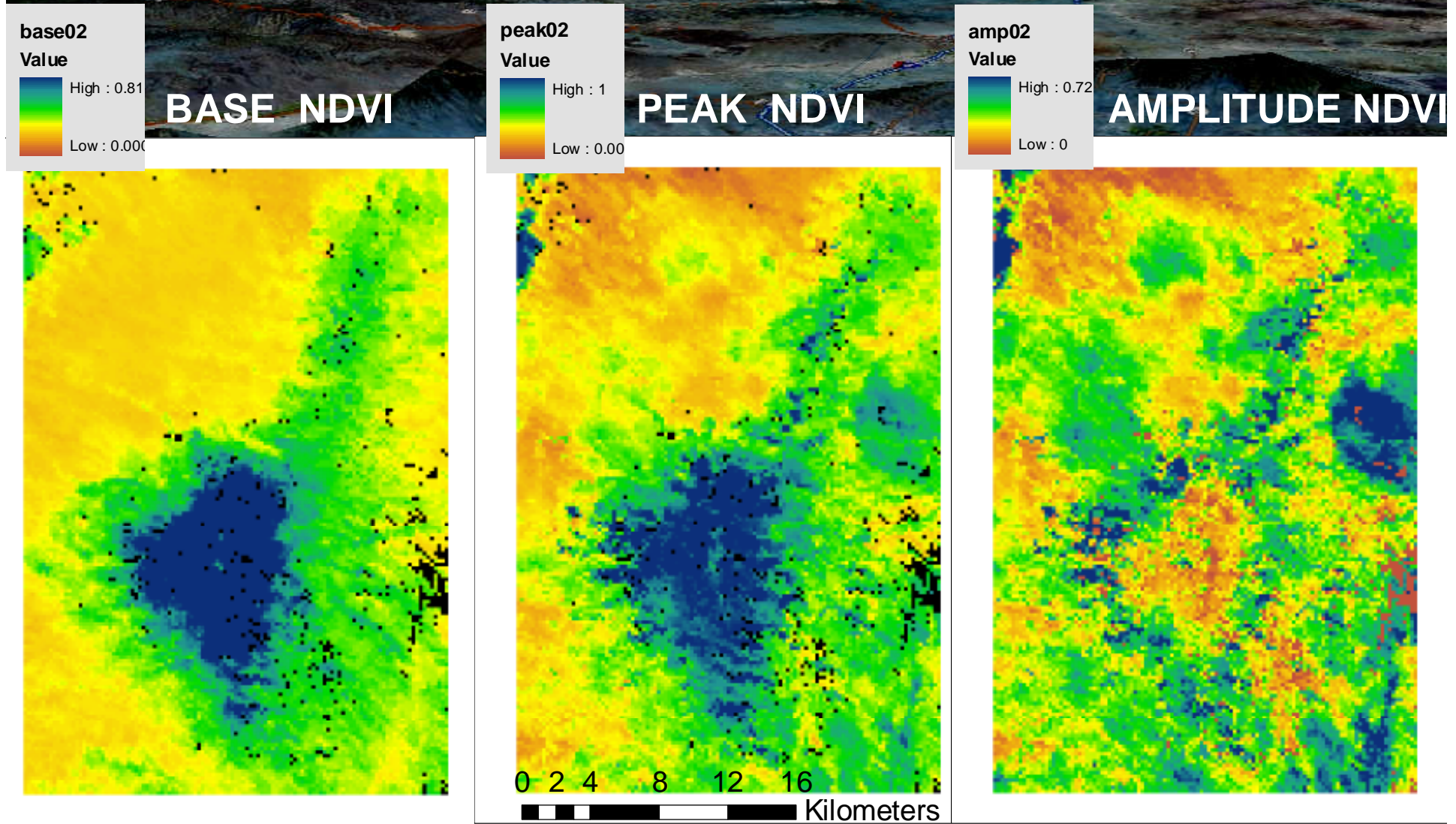
High : 365

**DOY**

Low : 0



# Spatial patterns of Pheno-metrics (growing season; 2002)



# Santa Rita Case Study Findings

- TIMESAT - good tool for extracting vegetation type specific phenological metrics
- Phenological data crosses calendar years
- Vegetation phenological metrics correlate with precipitation and temperature
- Need *in situ* observations (biophysical and meteorological) to validate the results (a phenology network!)
- Species Pheno-spectra library will be useful

# Next Steps

- Further characterize pheno-metrics for different landscapes and vegetation types and disturbance
- RS phenology model development
  - Ecological forecasting
  - Decision support tool development

**Thank You !**